# Cost of capital issues for the H7 price control

Prepared for
Heathrow Airport Limited

15 December 2021

Final

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# Figures and tables



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# Executive summary

On 19 October 2021, the CAA published its Initial Proposals for the H7 price control, in which it set out its response to evidence from Heathrow Airport Ltd (HAL) and other stakeholders on various issues relating to the estimation of the cost of capital.[1]

In this context, HAL asked Oxera to provide theoretical and empirical evidence in response to the Initial Proposals, on specific cost of capital issues including asset beta and the point estimate in the cost of equity (CoE) range.

**Asset beta**

This report covers a range of issues related to the estimation of asset beta for H7, including the choice of beta comparators, the relative risk of HAL and these comparators, and the treatment of COVID-19 beta impacts.

For the choice of comparators, we agree with the view of the CAA and Flint that Vienna and Sydney airports are materially different from HAL in terms of regulatory framework and operational features, while also exhibiting low liquidity in the equity market. We find it appropriate to exclude these airports from the analysis.

On the relative risks associated with traffic mix, we find that compared to comparator airports, HAL has demonstrated much higher vulnerability to the ongoing and future pandemics, due to its higher exposure to international traffic. This analysis shows that it is conservative to anchor forward-looking asset beta estimates on Aena and the average across comparators.

Dissecting the key assumptions underlying Flint's beta estimation methodology, we find that the use of these assumptions and how they integrate into Flint's methodology may not be appropriate. This issue is particularly concerning given that the Flint methodology of reweighting the historical data contradicts the assumption that capital markets are efficient and that share prices and returns drawn from the most recent period best reflect market expectations of future risks and returns. The asset beta measured over the 21 months since the beginning of the pandemic is around **0.80–0.94**.

Furthermore, even if it were possible to create a forecast of risk that were more accurate than the forecast implied directly from recent market data, the long-term steady-state scenario adopted by Flint for asset beta estimation could result in significant error in the estimate of the beta for the H7 price control. This is because it underweights the ongoing effects of the COVID-19 pandemic. As an alternative to Flint's approach, we used option-implied volatility to estimate forward-looking asset betas. In contrast to the ranges of 0.54–0.74 ('unmitigated') and 0.52–0.67 ('mitigated') proposed by the CAA, this analysis points to a forward-looking asset beta of **0.66–0.81**. Compared to the corresponding pre-pandemic IV-based betas of 0.54–0.70, the lower bound of the most recent IV-based betas has increased by 0.12 and the upper bound by 0.11.

This increase from the pre-pandemic asset beta is likely to persist into the H7 price control, as evidenced by the sustained increase in airport stock IVs relative to index IVs. This view is further supported by the persistently high betas following unexpected shocks in other sectors such as information technology

[1] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October.

and communication services— the asset betas for these sectors were materially higher for several years after the 2001 dotcom crisis when compared with their levels before the crisis.

While the traffic risk sharing (TRS) mechanism does help to reduce HAL's asset risks during and possibly beyond H7, its impact is overestimated as the CAA has not accounted for the in-period increases in cost of capital during and after pandemic-magnitude events. This leads to under-compensation of revenue losses by the TRS mechanism, which needs to be corrected by either setting a higher allowed WACC (e.g. through asset beta) than proposed by the CAA, or increasing the revenue allowance for asymmetric risk, or a combination of both.

**Point estimate**

We applied a similar Monte Carlo simulation to that adopted by the Competition and Markets Authority (CMA) in its PR19 redetermination for appellant water companies—which used the 77th percentile of the simulated CoE estimates as a cross-check for its selection of the CoE point estimate—to assess the likely scale of the point estimate for HAL's CoE in H7. Consistent with the CMA's approach, we assumed a normal distribution for the asset beta parameter and uniform distributions for other CoE parameters.

Based on the CAA's estimates of the each CoE parameter, **the 77th percentile of the simulated CoE estimates for HAL is 9.7%**. This is around 0.5% higher than the 9.2% mid-point of the CAA's estimated CoE range of 6.6–11.8%. Under the CMA's PR19 framework, this indicates that the risk of setting the CoE too low for HAL would be limited to below 25% if a 9.7% point estimate were to be adopted. We note that such a point estimate for HAL's CoE is also broadly in line with HAL's proposed **50bps uplift** to the mid-point of the CAA's CoE range.[2]

We have also simulated HAL's CoE estimate based on our asset beta estimates while keeping other parts of the simulation unchanged. The resulting uplift is largely consistent with the uplift estimated using the CAA's estimates of asset beta.

[2] Heathrow Airport (2021), 'H7 Revised Business Plan – Update 1', June, p. 217.

# 1 Introduction

Heathrow Airport Limited (HAL) submitted its Initial Business Plan (IBP) to the CAA in December 2019 for the next five-year regulation period ('the H7 price control').[3] It engaged on the IBP with airlines and wider stakeholders throughout 2020 and published its Revised Business Plan (RBP) in December 2020,[4] followed by a further update in June 2021 (RBP v1).[5]

On 19 October 2021, the CAA published its Initial Proposals for the H7 price control, in which the CAA set out its response to evidence from HAL and other stakeholders on various cost of capital issues.[6]

Against this background, HAL asked Oxera to provide theoretical and empirical evidence in response to the Initial Proposals, on specific cost of capital issues including asset beta and the point estimate in the cost of equity (CoE) range.

The rest of this report is structured as follows.

- Section 2 sets out our response to the CAA on issues related to asset beta, together with supporting analysis on HAL's beta and asset risks. Specifically, we discuss the CAA's and Flint's choice of comparators (section 2.2), HAL's relative traffic risks associated with the proportion of international flights (section 2.3), the explicit and implicit assumptions underlying Flint's analysis (section 2.4), and present evidence on how asset betas in other sectors evolve over time (section 2.5). We also introduce an alternative method of using option-implied volatility to estimate forward-looking asset betas, and compare the results under this alternative method to those under the conventional Ordinary Least Square (OLS) regressions on stock and market returns (section 2.6). Finally, we explain why the traffic risk share (TRS) mechanism, under its current design, is likely to under-compensate HAL for future losses of traffic (section 2.7).
- Section 3 discusses the choice of point estimates in recent Competition and Markets Authority (CMA) precedents, and presents results of Monte Carlo simulation for the CoE parameters in the H7 price control.

[3] HAL (2019), 'Heathrow's initial business plan – detailed plan', December.
[4] HAL (2020), 'Heathrow Airport H7 revised business plan (detailed)', December.
[5] HAL (2021), 'Heathrow Airport H7 revised business plan – update 1', June.
[6] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October.

# 2 Risk and asset beta

## 2.1 The CAA's view

In the Initial Proposals, the CAA relied on a consultancy report prepared by Flint Global, which estimated the asset beta for H7 by adopting key assumptions on the frequency of pandemics (from once per 20 years to once per 50 years), and the length of the pandemic (from 17 months to 30 months).[7] For the comparator set, the Flint report recommended placing the greatest weight on AENA, some weight on ADP, Fraport and Zurich; and limited weight on Sydney and Vienna, on the basis of comparability of regulatory frameworks, business risks and share liquidity.

Based on the Flint report, the CAA concluded that the pandemic had increased HAL's asset beta by **0.04–0.14**, resulting in an 'unmitigated' asset beta of 0.54–0.74. The CAA estimated that the new TRS mechanism proposed in April 2021[8] would mitigate 64% of HAL's total cash-flow losses in the event of a future downturn. It assumed that the TRS would reduce the asset beta by roughly half of the increase due to the pandemic, or **0.02–0.07**. On this basis, the CAA concluded that HAL's asset beta amounted to **0.52–0.67**, after applying the TRS.

## 2.2 Choice of comparators

This sub-section discusses the selection and weighting of the comparator sample adopted by the CAA and Flint. Specifically, they started with a group of eight airport groups—AENA, ADP, Fraport, Zurich, Vienna, Copenhagen, Sydney and Auckland—which were shortlisted by the CAA in its April 2021 Way Forward consultation document.[9] Their assessments covered the reliability of comparator airports' share price data (i.e. liquidity) and the comparability of these airports to HAL.

First, with respect to the reliability of share price data, the CAA and Flint excluded Copenhagen and Auckland from the sample, on the basis of the extremely small percentage of free float (i.e. 1%) for the former, and the undiversified home market for the latter (where Auckland makes up 6% of the NZX exchange).[10] While Flint also commented on the lack of diversification for Sydney and the relatively small percentage of free float for Vienna (i.e. 10%), it retained the option to place some weights on these airports.

Next, with respect to the comparability of their selected airport groups to HAL, the CAA and Flint focused on two areas: regulatory regimes and operational features.

On regulatory regimes, Flint assessed the similarities between the selected airport groups' regulatory arrangements and response to COVID-19. It concluded that, while Aena was the closest comparator to HAL, AdP and Zurich still remained comparable. Flint also considered the regulatory frameworks of Vienna and Sydney to be less comparable to that of HAL. In particular, it noted that Sydney is not subject to formal regulatory price controls.

[7] Flint (2021), 'Estimating Heathrow's beta post covid-19', August.
[8] CAA (2021) 'UK Civil Aviation Authority publishes update on economic regulation of Heathrow Airport Limited', 27 April.
[9] See Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 18; and CAA (2021), 'Appendices to Economic regulation of Heathrow Airport Limited: Consultation on the Way Forward', April, p. 69.
[10] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 19.

On operational features, Flint briefly considered some aspects of traffic profile and group activities, without providing any detailed quantitative analysis. It concluded that Aena, AdP and Fraport were the closest comparators to HAL, while also acknowledging that Vienna was significantly smaller than HAL, and that 'the evolution and impact of COVID-19 has been very different in Australia [and Sydney airport]'.[11] Overall, Flint recommended placing the greatest weight on AENA; some weight on ADP, Fraport and Zurich; and limited weight on Sydney and Vienna.

Although the CAA and Flint acknowledged the significant differences in regulatory framework and asset risks between HAL on the one hand and Vienna and Sydney on the other, and the liquidity constraint of the latter two airports, they did not remove these two airports from their beta analysis. As shown in Flint's own analysis, the asset betas of these two airports are notably lower than those of the other four comparators, resulting in six-company averages that are always lower than the four-company average.[12] For illustration, this can be observed in Table 2.1, which is based on Table 3 of the Flint report.

**Table 2.1 Reweighted asset beta for different frequencies of COVID-like events of 30 months duration**

| Frequency of pandemic | AENA | ADP | Fraport | Zurich | Vienna | Sydney | AENA | Four company | Six company |
|---|---|---|---|---|---|---|---|---|---|
| 5 | 0.89 | 0.89 | 0.72 | 0.82 | 0.77 | 0.58 | 0.89 | 0.83 | 0.78 |
| 7.5 | 0.85 | 0.86 | 0.72 | 0.81 | 0.68 | 0.58 | 0.85 | 0.81 | 0.75 |
| 10 | 0.81 | 0.82 | 0.70 | 0.79 | 0.62 | 0.57 | 0.81 | 0.78 | 0.72 |
| 15 | 0.77 | 0.77 | 0.67 | 0.77 | 0.54 | 0.57 | 0.77 | 0.74 | 0.68 |
| 20 | 0.74 | 0.73 | 0.64 | 0.75 | 0.48 | 0.57 | 0.74 | 0.72 | 0.65 |
| 50 | 0.67 | 0.63 | 0.58 | 0.71 | 0.36 | 0.56 | 0.67 | 0.65 | 0.59 |
| 100 | 0.64 | 0.59 | 0.55 | 0.69 | 0.31 | 0.56 | 0.64 | 0.62 | 0.56 |
| N/A | 0.60 | 0.54 | 0.51 | 0.67 | 0.25 | 0.56 | 0.60 | 0.58 | 0.52 |

Source: Based on Table 3 of Flint (2021), 'Estimating Heathrow's beta post covid-19', August.

As discussed in section 2.4, Flint's approach presumes a long-term post-COVID steady-state scenario, which is inappropriate given the ongoing effects of the pandemic. Should Flint update its analysis to reflect the current asset beta levels, which remain materially above the pre-pandemic levels, the choice of comparators would be likely to have a significant impact on the asset beta level estimated for the H7 price control.[13]

## 2.3 Asset risks associated with traffic mix

As mentioned in section 2.2, the CAA and Flint placed different weights on HAL's listed comparators, based on their comparability with HAL in areas including regulatory regimes and operational features. In drawing these comparisons, the CAA and Flint have not fully accounted for the differences in traffic mix—a factor that has a significant influence over an airport's vulnerability in the face of a pandemic.

[11] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 21.
[12] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 23.
[13] On a practical level, Flint's decision to include Vienna and Sydney did not materially affect its estimates of the impact of pandemics on asset betas, which is based on the difference between the probability-weighted asset betas and pre-pandemic asset betas. Specifically, it appears that the low betas of Vienna and Sydney in both the reweighted sample and the pre-pandemic sample cancelled out when calculating the 'delta'.

Specifically, as observed in the ongoing COVID-19 pandemic, the recovery of domestic traffic has significantly outpaced the recovery of international traffic. In particular, Flint commented in its report that 'international traffic may plausibly take longer to recover than domestic traffic as domestic restrictions are relaxed ahead of international', and concluded that 'this may affect Heathrow's recovery'.[14] Similar commentary can be observed in the financial updates of comparator airports. For example, in its Q3 2021 interim release, Fraport stated that:

> [Frankfurt Airport's] European traffic, including domestic connections within Germany, showed growth of 3.7%, while travel warnings and restrictions continued to have a negative impact on intercontinental traffic (-13.5%).[15]

On a group level, it observed that:

> the Group's tourist oriented sites in Turkey, Greece, and Bulgaria showed high growth due to increased demand during the holiday months. There was also a clear recovery trend at the Group's airports that are **mainly dependent on domestic passenger traffic**.[16] [emphasis added]

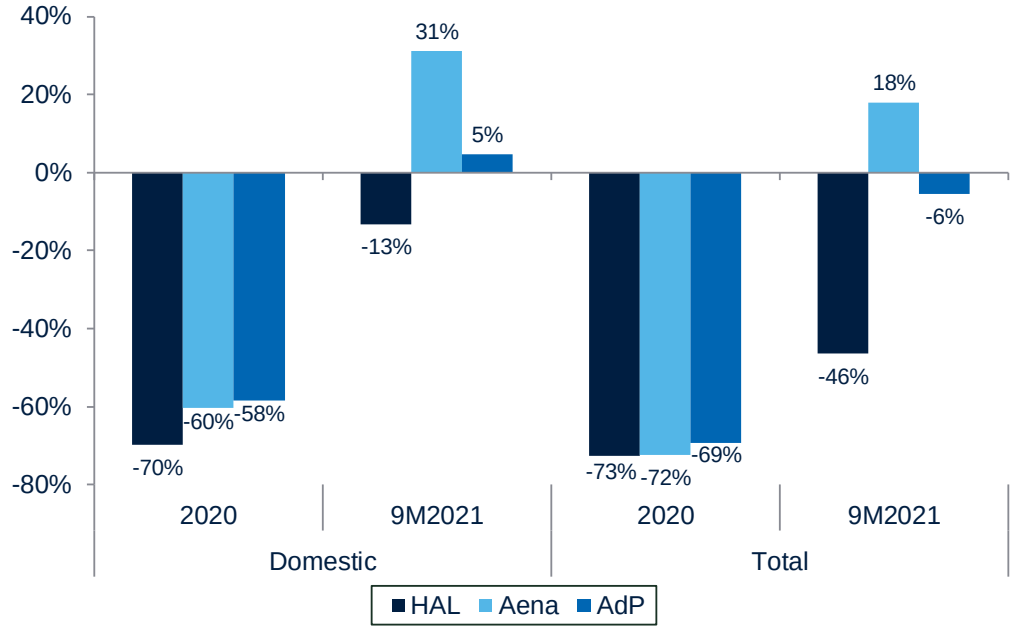
Similar, Aena stated in its Q3 2021 consolidated interim management report that

> By geographical areas, it is worth highlighting the **improved performance observed in domestic traffic** (46.7% share) compared to international traffic (53.3% share). The recovery of the domestic market compared to the nine-month period of 2019 was 54.6%, compared to 27.5% in the international market.[17] [emphasis added]

These statements are consistent with the traffic growth figures set out in Figure 2.1, which shows the domestic traffic figures for HAL (-70%), Aena (-60%) and AdP (-58%) dropping less than their respective total traffic figures in 2020, the year in which the COVID-19 pandemic was declared by the World Health Organization. Similarly, in the first nine months of 2021, the year-on-year growth for domestic traffic was consistently more positive (or less negative) compared to total traffic.

[14] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 21.
[15] Fraport (2021), 'Fraport Interim Release Q3/9M 2021', 9 November, p. 4.
[16] Fraport (2021), 'Fraport Interim Release Q3/9M 2021', 9 November, p. 4.
[17] Aena (2021), 'Consolidated Interim Management Report for the nine-month period ended 30 September 2021', p. 6.

**Figure 2.1 Percentage traffic growth by geography**




Note: Domestic geography is defined as the UK for HAL, Spain for Aena airports and France for AdP. Traffic mix for HAL is based on Heathrow Airport only. Traffic mix for AdP is based on Paris-CDG and Paris-Orly only.

Source: Oxera analysis based on company annual reports and published traffic volume data.

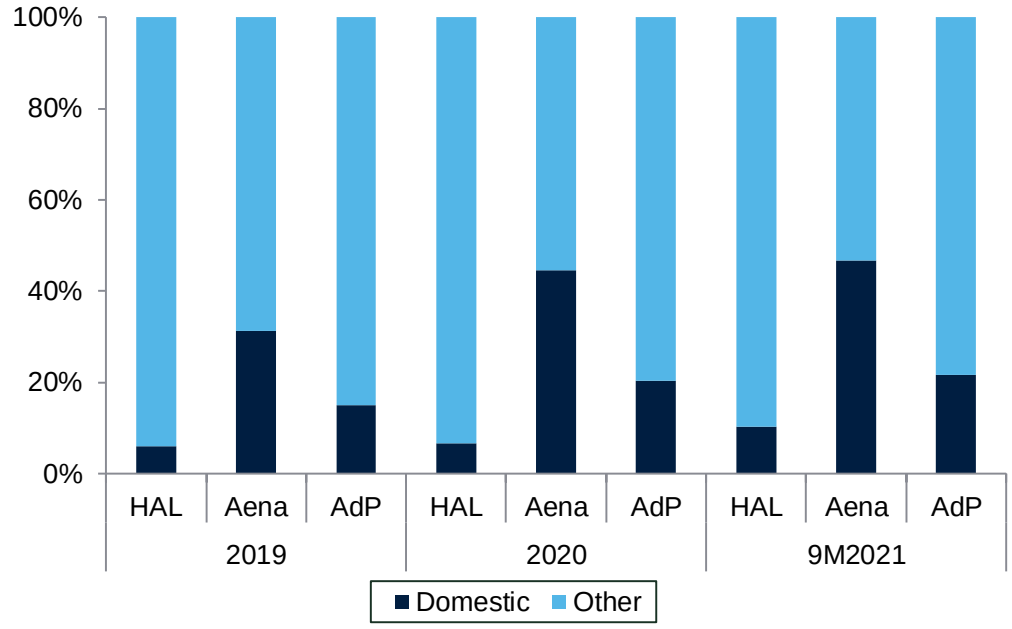
While HAL suffered similar overall traffic losses to Aena and AdP in 2020, its recovery in 2021 was much slower due to its smaller share of domestic traffic, where more rapid recovery was made possible when lockdowns were eased. The traffic mix by geography for these airports is set out in Figure 2.2 below. For Fraport, where the traffic breakdown by geography is not disclosed in trading updates, the Q3 2021 interim report also shows positive year-on-year traffic growth for all affiliated airports with the exception of Frankfurt Airport, where the traffic growth was slightly negative at -2.2%,[18] which is still significantly higher than HAL's contemporaneous traffic reduction of -46%.

These figures are consistent with HAL's own analysis in its RBP, which stated that HAL is 'reliant on international traffic resuming and does not have a strong domestic market'.[19] This statement is further supported by the empirical evidence set out in the RBP, which showed that HAL had experienced a greater reduction in both traffic volume and revenue than comparators.[20]

In summary, compared to comparator airports, HAL has demonstrated much higher vulnerability to the ongoing and future pandemics, due to its higher exposure to international traffic. This factor points towards an asset beta higher than the mid-point of the asset beta range for comparator airports.

[18] Fraport (2021), 'Fraport Interim Release Q3/9M 2021', 9 November, p. 4, https://report.flughafen-zuerich.ch/2021/hyr/en.
[19] RBP update 1, p. 87.
[20] RBP update 1, pp. 21 and 210.

**Figure 2.2 Traffic mix by geography, measured in number of passengers**




Note: Domestic geography is defined as the UK for HAL, Spain for Aena airports and France for AdP. Traffic mix for HAL is based on Heathrow Airport only. Traffic mix for AdP is based on Paris-CDG and Paris-Orly only.

Source: Oxera analysis based on company annual reports and published traffic volume data.

## 2.4 Assumptions underlying Flint's beta estimation methodology

This sub-section discusses the explicit and implicit assumptions underlying Flint's asset beta analysis, which the CAA is reliant on for the H7 price control over the next five years.

In essence, the Flint approach estimates the impact of pandemic-like events on airports' asset beta (i.e. 'COVID adjustment') by calculating the difference between a pre-pandemic 'baseline beta' and a probability-weighted pandemic beta.[21] This COVID adjustment is then reduced to account for the mitigative measure proposed by the CAA to reduce HAL's asset risks (i.e. the TRS mechanism), before being added back to the baseline betas to arrive at the asset beta allowance for the H7 price control.

The probability-weighted betas rely on two key assumptions, as follows.[22]

- **The frequency of pandemics**—this assumption determines how much of the stock and index returns data during the pandemic are included in the regression sample. For example, for 5-year beta estimations, and assuming a valuation date at June 2021, without any adjustments c.30% of the data in the sample falls during the COVID-19 period (17 out of 60 months). By assuming that pandemics occur every 20–50 years, Flint divided the 30% by 4 (calculated as 20 years ÷ 5-year estimation period) and by 10 (calculated as 50 years ÷ 5), and decided that the COVID period should make up 3% to c.7% of the sample.

[21] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 12.
[22] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, section 3.3.

- **The length of pandemics**—this assumption functions similarly to the frequency of pandemics. Using the example above, the length of pandemics determines how many of the 60 months are during the COVID-19 period. While 17 months represents the lower bound of the length of the pandemic (since the COVID-19 pandemic was 17 months old at the time of Flint's analysis), Flint assumed that the impact of COVID-19 and similar future events could last up to 2.5 years, which forms the upper bound of the length.

We note that in RBP v1, HAL provided evidence based on historical information, academic publications and data from the UK government's Risk Register to support an assumption that the expected return period for pandemics is approximately every 30 years.[23] In the context of Flint's analysis, this implies placing more weight on the 'once per 20 years' assumption for the frequency of the pandemic (as opposed to Flint's approach of placing equal weights on once per 20 years and once per 50 years), which would lead to higher asset betas than Flint's estimates.

The Flint methodology of reweighting the historical data contradicts the assumption that capital markets are efficient and that share prices and returns drawn from the most recent period best reflect market expectations of future risks and returns. In other words this methodology assumes it is possible to create a forecast of risk that is more accurate than the forecast implied directly from recent market data and reflected in beta estimates.

Furthermore, even if it was possible to create a forecast of risk that was more accurate than the forecast implied directly from recent market data, the time horizon adopted by Flint is inappropriate for the H7 price control. The Flint approach presumes a long-term post-COVID steady-state scenario, where the market assigns 'COVID adjustments' to the pre-pandemic betas to account for the systematic risks of future pandemics, which were unaccounted for prior to the COVID-19 pandemic. This approach could result in significant error in the estimation of the beta for the H7 price control because it overlooks the ongoing effects of the pandemic.[24]

Sections 2.5 and 2.6 present evidence that the CoE cannot be assumed to revert rapidly towards pre-pandemic levels. Our analysis leads us to recommend that the CAA and Flint give more consideration to the ongoing COVID-19 pandemic.

### 2.5 How asset betas evolve over time

Building on section 2.4, this sub-section explores how the long-term asset betas of different sectors of the FTSE 100 have evolved over time. In particular, this analysis can be used to gain more understanding of whether the asset betas for airports are likely to revert to their pre-pandemic levels, and if so, at what speed.

Specifically, for this analysis, we have estimated the 2-year rolling asset betas and equity betas of the current FTSE 100 constituents from the 1990s to date.[25] The daily asset betas for each constituent are estimated as the $equity\ beta \times (1 - gearing) + debt\ beta \times gearing$, where gearing is calculated as $\frac{net\ debt}{market\ capitalisation + net\ debt}$. A constant debt beta of 0.05 is assumed, which is

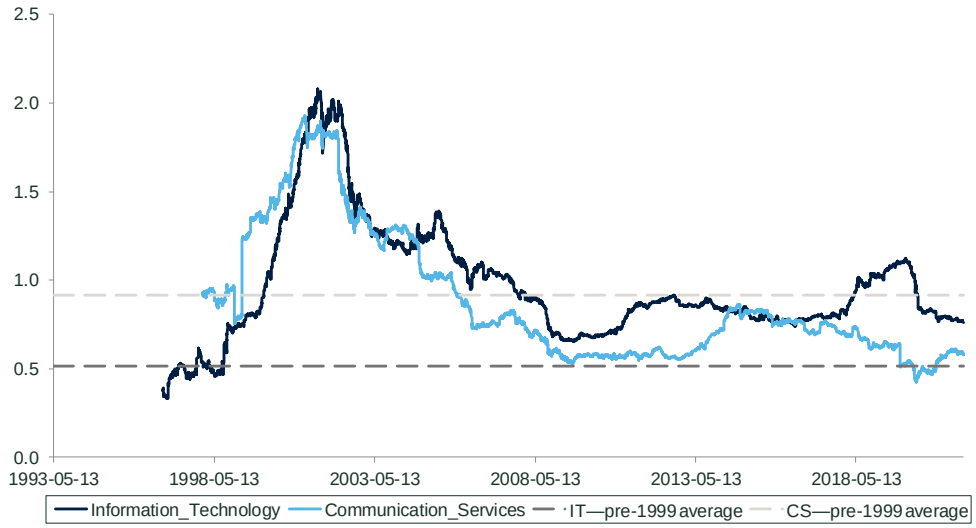
[23] RBP update 1, p. 212.
[24] See, for example, Flint (2021), 'Estimating Heathrow's beta post covid-19', August, Figure 2.
[25] As of 2000, data is available for 51 of the current 100 constituent companies.

consistent with a strong investment grade, and is the CAA's lower bound estimate in the Initial Proposals.[26]

For sectoral analysis, the FTSE 100 constituents are divided into 11 broad sectors, based on the Global Industry Classification Standard (GICS).[27] The sector asset betas are estimated as the enterprise-value-weighted-average asset beta, where enterprise value is calculated as market capitalisation plus net debt.

Overall, time variation in asset betas is observable across all sectors. In particular, sectors including communication services and information technology witnessed significant breaks in asset beta trends following unexpected external shocks. These are set out in Figure 2.3. The structural breaks for communication services and information technology occurred around the 2001 dotcom crisis, and the asset betas of both sectors were materially higher for several years after this event. The trends of equity betas for information technology are largely similar to those of asset betas, and it took equity betas of communication services more than six years to revert to the pre-dotcom bubble levels.

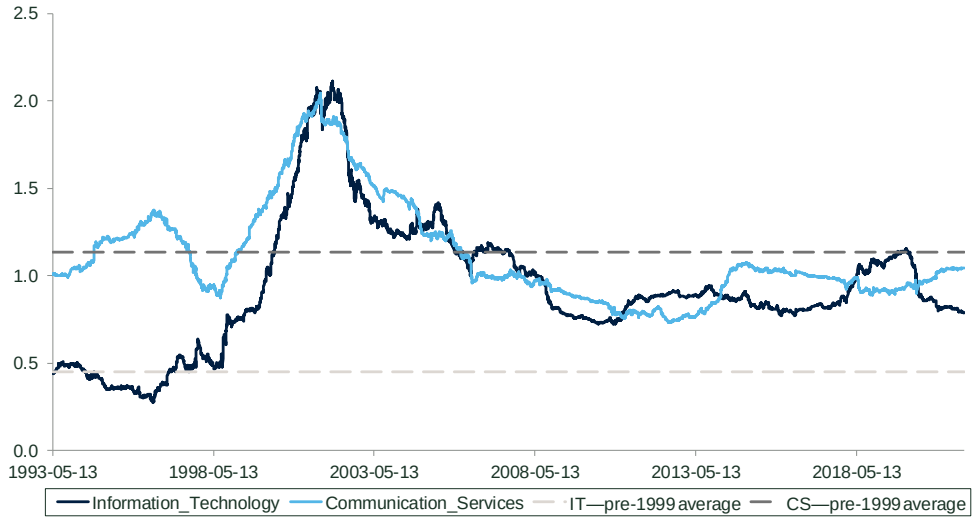
**Figure 2.3 Long-term asset beta of information technology and communication services (1990s to date)**




Source: Oxera analysis based on data from Bloomberg.

[26] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 2: financial issues, para. 9.99.
[27] These sectors include health care, consumer staples, financials, energy, materials, industrials, utilities, communication services, consumer discretionary, real estate and information technology.

**Figure 2.4 Long-term equity beta of information technology and communication services (1990s to date)**




Source: Oxera analysis based on data from Bloomberg.

The breaks observed for communication services and information technology show that significant shocks do lead to long-term or even permanent shifts in asset betas, even after the shocks have faded. The post-shock trends are unpredictable and do not follow the pattern of steady mean reversion.

## 2.6 Estimating forward-looking asset beta using option-implied volatility

This sub-section presents analysis of forward-looking asset betas based on option-implied volatilities, and compares them to the estimates of the pre-pandemic conventional OLS betas.

Option-implied volatilities (IVs) are derived from market prices of equity options, by inputting market parameters, such as risk-free rates (RFRs), underlying spot equity prices, strike prices and option time to maturity, to option-pricing models such as the Black–Scholes model.

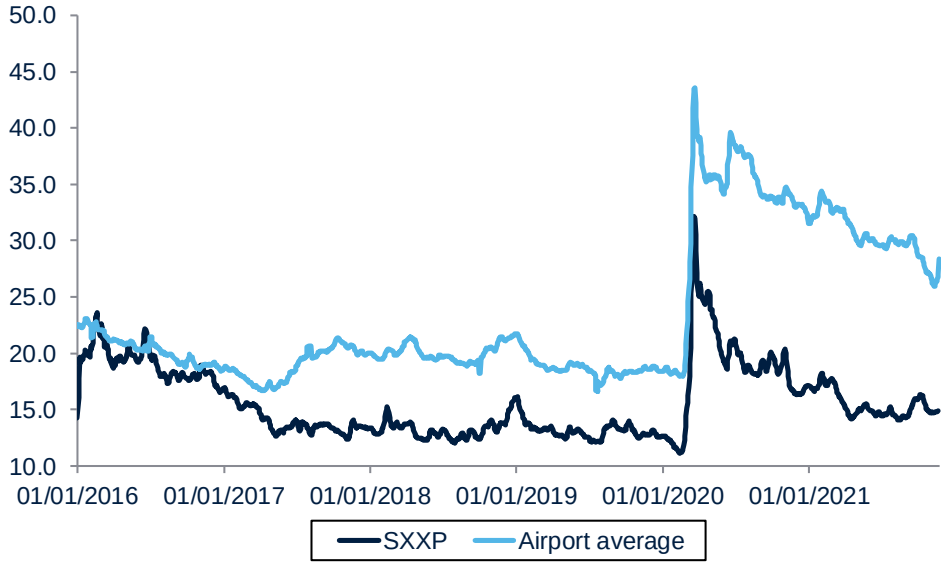
Since options are derivative instruments with uncertain pay-offs, IVs reflect investors' forward-looking expectations of the underlying share price volatilities. French, Groth and Kolari (1983) ('FGK') first combined historical correlations between stock returns and market returns with option-implied volatilities for beta estimation.[28] Buss and Vilkov (2012) tested the approach proposed by FGK, and found that it improved the risk–return relation compared to using historical betas (i.e. it was a better predictor of equity returns than historical betas).[29] While Buss and Vilkov (2012) also managed to improve FGK's approach by computing IV-implied correlations using structural models, their approach is computation-heavy and relies on additional modelling assumptions. As a result, FGK's approach is applied in this report.

The asset betas derived from IVs provide additional information for setting the allowed returns for the upcoming H7 price control due to their forward-looking

[28] French, D.W., Groth, J.C. and Kolari, J.W. (1983), 'Current investor expectations and better betas', *The Journal of Portfolio Management*, **10**:1, pp. 12–17.
[29] Buss, A. and Vilkov, G. (2012), 'Measuring equity risk with option-implied correlations', *The Review of Financial Studies*, **25**:10, p. 3126.

nature, which is particularly valuable given the significant uncertainties resulting from the ongoing pandemic. As presented in Figure 2.5, the gap between the index IVs and airport stock IVs has increased substantially since the pandemic started, and continues to remain materially above pre-pandemic levels. This widening gap can be visualised as the increased ratio of average airport IVs to index IVs since the pandemic started, as set out in Figure 2.6.

**Figure 2.5 Implied volatilities of the STOXX European 600 index and airport comparators, based on prices of 1-year call options**




Note: Comparators include Aena, AdP, Fraport and Zurich.

Source: Oxera analysis based on data from Bloomberg.

**Figure 2.6 Ratio of average airport IVs to index IVs**


Note: Comparators include Aena, AdP, Fraport and Zurich.

Source: Oxera analysis based on data from Bloomberg.

The methodology adopted for this analysis is detailed below. We have used IVs of the European airport comparators, derived from the traded at-the-money call option prices with 6-month and 1-year maturities,[30] to estimate forward-looking asset betas. The mathematical expressions underlying these IV-based forward-looking asset betas are set out in Box 2.1.

### Box 2.1 Mathematical explanations underlying IV-based betas

**Mathematical explanation**

Mathematically, the forward-looking equity betas are estimated as follows:

$$\beta_e = \frac{Cov(r_m, r_i)}{Var(r_m)} = \frac{\sigma_i \sigma_m \rho_{im}}{\sigma_m^2}$$

where:

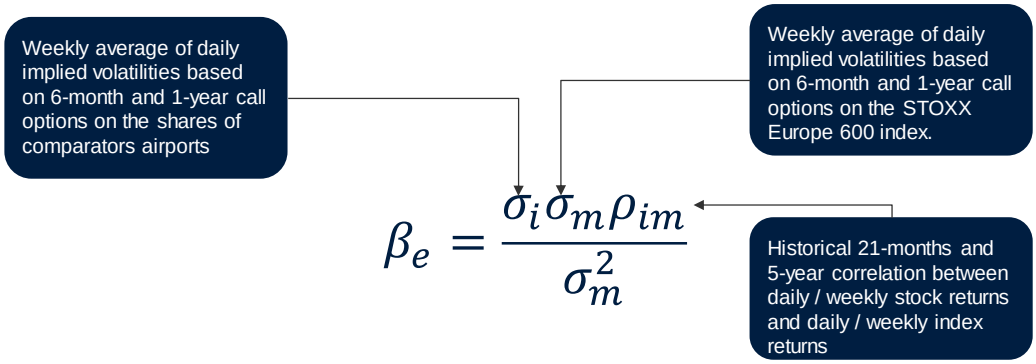
- $\sigma_i$ denotes the IV of comparator airports;
- $\sigma_m$ denotes the IV of the STOXX Europe 600 index;[1]
- $\rho_{im}$ denotes the historical correlation between the comparator airports' equity returns and the index returns.

Note: [1] The IVs of the STOXX Europe 600 index are used, as Bloomberg does not have IVs available for the STOXX Europe Total Market Index.

Source: Oxera based on French, D.W., Groth, J.C. and Kolari, J.W. (1983), 'Current investor expectations and better betas', *The Journal of Portfolio Management*, **10**:1, pp. 12–17.

Figure 2.7 below visualises the methodology and data used to estimate IV-based betas. To minimise the impact of any thin trading in options, the analysis uses an average of the daily IVs in the week leading up to the cut-off date, and combines it with the daily and weekly correlations to estimate the daily and weekly betas.

### Figure 2.7 Visualisation of methodology and data used to estimate IV-based betas



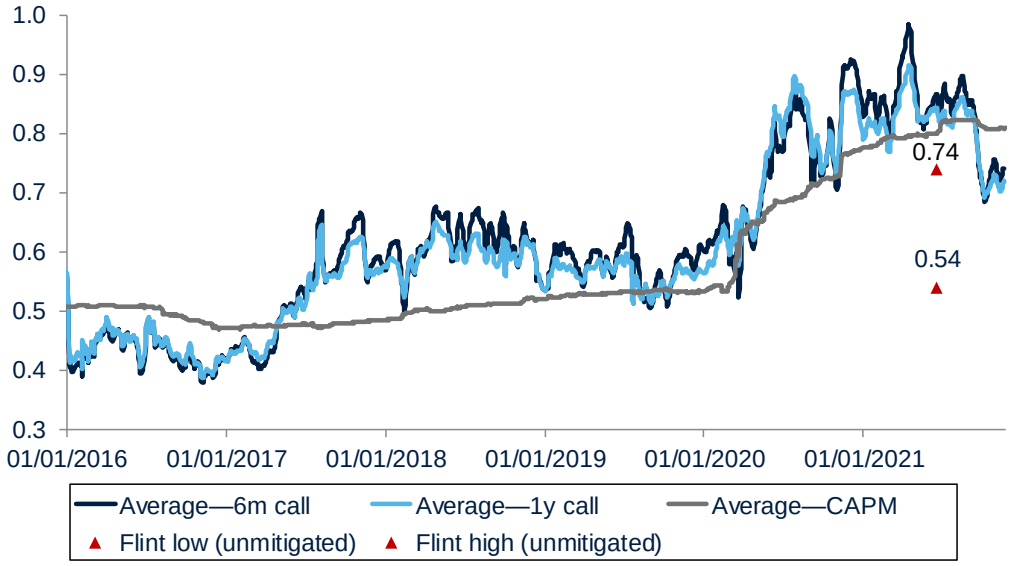

Source: Oxera.

To compare against IV-based betas, the conventional CAPM betas are calculated by applying standard OLS regression to stock returns and index returns. Figure 2.8 illustrates the simple average of 5-year rolling daily betas estimated using the IV-based approach and the conventional CAPM approach across comparators. The IV-based betas oscillate above and below the CAPM betas multiple times over the last five years, showing value as a leading indicator which moves ahead of the conventional CAPM betas. The latest 5-year IV-

[30] At-the-money means that the options' strike prices are close to the underlying share prices. At-the-money options generally have better liquidity compared to deep-in-the-money and out-of-the-money options, where the strike prices deviate significantly from the underlying share prices.

based betas remain close to the upper bound of Flint's estimate for the unmitigated asset beta (0.74).

**Figure 2.8 Simple average of 5-year rolling daily betas estimated using the IV-based approach and the conventional CAPM approach across comparators**




Note: Comparators include Aena, AdP, Fraport and Zurich.

Source: Oxera analysis based on data from Bloomberg.

To arrive at an asset beta range, the daily and weekly betas are calculated assuming a cut-off date of 29 November 2020. For further robustness checks, pre-pandemic historical correlations for the IV-based betas are also adopted, and the results compared against the conventional CAPM betas based on pre-pandemic stock returns and index returns. The results for daily and weekly betas are presented in Table 2.2. As the 1-year IV-based betas are similar to 6-month IV-based betas (see Figure 2.8), the analysis focuses on the former, which has a longer time horizon.

**Table 2.2 Daily asset betas for comparators estimated using the conventional CAPM approach and the IV-based approach, assuming a cut-off date of 29 November 2021**

| Conventional CAPM betas | Including pandemic data | | Pre-pandemic data only (Feb 2020 cut-off)[2] | |
|---|---|---|---|---|
| **Regression period** | **21-month[1]** | **5-year** | **2-year** | **5-year** |
| ADP | 0.839 | 0.863 | 0.505 | 0.546 |
| Aena | 0.942 | 0.835 | 0.524 | 0.506 |
| Zurich | 0.816 | 0.848 | 0.712 | 0.597 |
| Fraport | 0.619 | 0.727 | 0.539 | 0.486 |
| Average | 0.804 | 0.818 | 0.570 | 0.534 |
| **IV-based betas (1y call)** | **21-month[1]** | **5-year** | **2-year** | **5-year** |
| ADP | 0.661 | 0.744 | 0.501 | 0.672 |
| Aena | 0.718 | 0.689 | 0.552 | 0.538 |
| Zurich | 0.735 | 0.776 | 0.605 | 0.666 |
| Fraport | 0.524 | 0.669 | 0.562 | 0.604 |
| Average | 0.659 | 0.719 | 0.555 | 0.620 |

Note: [1] Starting 1 March 2020, when the systematic impact of the COVID-19 pandemic became more pronounced. [2] These are the asset betas in February 2020, which is largely consistent with Flint's cut-off date for pre-pandemic data (January 2020). We did not set the cut-off date in January 2020, as Aena does not have enough data points for 5-year asset betas until February 2020.

Source: Oxera analysis using Bloomberg data.

**Table 2.3 Weekly asset betas for comparators estimated using the conventional CAPM approach and the IV-based approach, assuming a cut-off date of 29 November 2021**

| Conventional CAPM betas | Including pandemic data | | Pre-pandemic data only (Feb 2020 cut-off)[2] | |
|---|---|---|---|---|
| **Regression period** | **21-month[1]** | **5-year** | **2-year** | **5-year** |
| ADP | 0.822 | 0.882 | 0.725 | 0.575 |
| Aena | 0.868 | 0.812 | 0.590 | 0.478 |
| Zurich | 0.915 | 0.888 | 0.549 | 0.561 |
| Fraport | 0.787 | 0.893 | 0.586 | 0.510 |
| Average | 0.848 | 0.869 | 0.612 | 0.531 |
| **IV-based betas (1y call)** | **21-month[1]** | **5-year** | **2-year** | **5-year** |
| ADP | 0.686 | 0.782 | 0.692 | 0.715 |
| Aena | 0.779 | 0.763 | 0.700 | 0.551 |
| Zurich | 0.884 | 0.872 | 0.560 | 0.678 |
| Fraport | 0.673 | 0.835 | 0.665 | 0.694 |
| Average | 0.755 | 0.813 | 0.654 | 0.659 |

Note: [1] Starting 1 March 2020, when the systematic impact of the COVID-19 pandemic became more pronounced. [2] These are the asset betas in February 2020, which is largely consistent with Flint's cut-off date for pre-pandemic data (January 2020). We did not set the cut-off date in January 2020, as Aena does not have enough data points for 5-year asset betas until February 2020.

Source: Oxera analysis using Bloomberg data.

At the high level, the 21-month (second column) and 5-year (third column) IV-based betas are lower than the 21-month and 5-year conventional CAPM betas,

while the 2-year pre-pandemic betas (fourth column) are largely similar for both approaches.

The estimates are also sensitive to whether daily or weekly returns are used. The driver of the differences between daily and weekly returns is unclear, particularly as the airport stocks in the sample have been screened for liquidity. At this stage, we consider it appropriate to place weight on estimates from both daily and weekly returns.

Across the comparators, ADP, Aena and Zurich have similar betas under both the IV-based approach and the conventional CAPM, while Fraport appears to be an outlier with lower betas under both approaches. Consistent with the assessments by the CAA and Flint, our analysis shows that, despite the differences in traffic mix discussed in section 2.3, Aena remains the most comparable company to HAL in the sample, due to the similarity of regulatory framework and other operational features.[31] As such, we place the most weight on Aena's 21-month and 5-year betas, which are lower than those of Zurich and similar to or lower than those of ADP. We note that this decision on weighting is conservative, as HAL is likely to be riskier than Aena due to its significantly lower share of domestic traffic (Figure 2.2), which makes HAL less resilient in the face of pandemic-induced traffic shocks.

Based on daily and weekly betas for Aena and the average across all four comparators (highlighted in grey), an asset beta range of **0.80–0.94** would be appropriate under the conventional CAPM. On the same measurement basis, the IV-based betas yield an asset beta range of **0.66–0.81**. Compared to the corresponding pre-pandemic IV-based betas of 0.54–0.70, the lower bound of the most recent IV-based betas has increased by 0.12 and upper bound by 0.11. For comparison the CAA has proposed ranges of 0.54–0.74 ('unmitigated') and 0.52–0.67 ('mitigated').

In sum, the evidence discussed above supports the view that the CoE cannot be assumed to revert rapidly towards pre-pandemic levels. We recommend that the CAA and Flint give more weight to the ongoing COVID-19 pandemic when determining the asset beta for the H7 price control period.

### 2.7 Traffic risk sharing (TRS) mechanism

In its April 2021 Way Forward Document, the CAA first set out its intentions for introducing a TRS mechanism for the H7 price control. The CAA cited three main motivations for the proposed mechanism:[32]

- limiting the risks of windfall gains or windfall losses associated with the recovery in passenger traffic volumes;
- reducing upward pressure on HAL's cost of capital, which would lead to a direct and immediate increase in airport charges;
- facilitating the certainty and advantages for stakeholders of the H7 price control while helping to clarify the risks that HAL is expected to bear during that period.

In its Initial Proposals, the CAA formally proposed the TRS mechanism, which will update HAL's RAB at the beginning of the H8 price control to reflect a

[31] Flint (2021), 'Estimating Heathrow's beta post covid-19', August, p. 21.
[32] CAA (2021), 'Economic regulation of Heathrow Airport Limited: Consultation on the Way Forward', April, p. 60.

proportion of the cumulative impact of differences between the outturn and forecast levels of traffic used to calibrate the H7 price control.[33] Specifically, the proportion of the impact reflected in the RAB adjustment will be:

- 40–60% for differences in cumulative allowed revenues of up to 10%;
- 90–100% for differences in cumulative allowed revenues of more than 10%.

The CAA explained that the TRS mechanism would not affect the level of airport charges during the H7 price control, but would affect charges in future periods due to RAB changes. It also explained that with the TRS mechanism in place, the introduction of a formal reopener provision to HAL's licence would be likely to be difficult:

> the likelihood that the circumstances that might justify reopening a price control could be complex in nature and so difficult to enshrine in a formal licence condition, given that HAL will already have a reasonable degree of protection from traffic-related shocks.[34]

Following the proposal for the TRS mechanism, the CAA made downward adjustments to Flint's estimates of asset beta, on the grounds that the TRS would help to reduce the financial exposure of HAL to traffic risks in the future. Specifically, the CAA estimated the impact of another pandemic on HAL's returns with and without a TRS mechanism in place. Without providing any modelling details, the CAA stated that the TRS would mitigate 64% of HAL's total cash-flow losses for H7.[35]

Since there are uncertainties surrounding the regulatory framework of H8 and beyond, the CAA recognises that this 64% loss reduction is likely to have overstated the impact of TRS in the long term. Therefore, the CAA assumes that the TRS will reduce the increase in asset beta during the H7 period by 50%, or 0.02–0.07 based on Flint's estimates.[36]

The implementation of the TRS mechanism described in the Initial Proposals is likely to under-compensate the losses incurred during periods of low volume and high uncertainty.

Specifically, in times of extended market stress and volatility, such as the current pandemic, we see significant increases in both the CoE (mainly through betas) and the cost of debt, which are not reflected in the allowed cost of capital determined at the beginning of the price control. Therefore, as a compensation based on an ex ante underestimation of the true cost of capital, the TRS under-compensates revenue losses. As a result of this underestimation of the cost of capital, the deferral of revenue shortfalls to the future under the TRS will not be equivalent in net present value (NPV) terms to receiving the revenue today.

To illustrate, consider the CAA's own calculation of HAL's net financial exposure to pandemic-magnitude events, which is restated in Table 2.4 below. The CAA stated that these figures were calculated as the difference in NPVs between HAL's possible revenue losses and the adjustment to RAB in H8, using the

[33] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 1, para. 1.37.
[34] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 1, para. 1.8.
[35] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 1, para. 9.71.
[36] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 1, para. 9.72.

allowed pre-tax WACC as discount rate.[37] The possible revenue losses were modelled by the CAA as the results of traffic losses associated with pandemic-magnitude events, which have a probability of happening in each year of the H7 price control. These revenue losses are compensated through the RAB adjustments under the TRS mechanism, which would be due in the H8 price control.

**Table 2.4 Net exposure to pandemic-magnitude events (£m, nominal prices)**

| | Upper quartile | Lower quartile |
|---|---|---|
| If an event were to recur in 2022 | 767 | 857 |
| If an event were to recur in 2023 | 840 | 1,011 |
| If an event were to recur in 2024 | 863 | 1,104 |
| If an event were to recur in 2025 | 769 | 966 |
| If an event were to recur in 2026 | 591 | 618 |

Source: Initial Proposals, section 2, Table 7.3.

Suppose that a pandemic-magnitude event were to happen during the H7 price control, the in-period pre-tax WACC would be likely to be materially higher than the allowed WACC, which would mean that the discount rate during and after the pandemic-magnitude event would be underestimated.

As a result, the NPVs of the H8 RAB adjustments would reduce more than the NPVs of revenue losses during the H7 price control, resulting in an underestimation of the net exposure estimated by the CAA. Therefore, we recommend that the CAA includes the in-period increases in WACC in its modelling for cash-flow loss mitigation of the TRS, which is likely to be lower than the 64% estimated. We note that this underestimation would need to be corrected by either setting a higher allowed WACC (e.g. through asset beta) or increasing the revenue allowance for asymmetric risk, or a combination of both.[38]

## 2.8 Conclusions

This section has covered a range of issues related to the estimation of asset beta for H7, including: (i) the choice of comparators; (ii) the relative risks associated with traffic mix; (iii) the explicit and implicit assumptions underlying Flint's analysis; (iv) how asset betas in other sectors evolve over time and after unexpected shocks; (v) using option implied volatilities to estimate forward-looking betas; and (vi) the TRS mechanism and how it would lead to under-compensation of revenue losses.

For the choice of comparators, we agree with the view of the CAA and Flint that Vienna and Sydney airports are materially different from HAL in terms of regulatory framework and operational features, while also exhibiting low liquidity in the equity market. We find it appropriate to exclude these airports from the analysis.

On the relative risks associated with traffic mix, we find that compared to comparator airports, HAL has demonstrated much higher vulnerability to the ongoing and future pandemics, due to its higher exposure to international traffic. The analysis presented in this report shows that it is conservative to anchor the

[37] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 1, para. 7.32.
[38] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, section 2, Table 7.5.

forward-looking asset beta estimates on Aena and the average across comparators.

Dissecting the key assumptions underlying Flint's beta estimation methodology, we found that the use of these assumptions and how they integrate into Flint's methodology may not be appropriate. This issue is particularly concerning given that the Flint methodology of reweighting the historical data contradicts the assumption that capital markets are efficient and that share prices and returns drawn from the most recent period best reflect market expectations of future risks and returns. The asset beta measured over the 21 months since the beginning of the pandemic is around **0.80–0.94**.

Furthermore, even if it was possible to create a forecast of risk that was more accurate than the forecast implied directly from recent market data, the long-term steady-state scenario adopted by Flint for asset beta estimation could result in significant error in the estimate of the beta for the H7 price control. This is because it underweights the ongoing effects of the COVID-19 pandemic. As an alternative to Flint's approach, we used option-implied volatility to estimate forward-looking asset betas. In contrast to the ranges of 0.54–0.74 ('unmitigated') and 0.52–0.67 ('mitigated') proposed by the CAA, this analysis points to a forward-looking asset beta of **0.66–0.81**. Compared to the corresponding pre-pandemic IV-based betas of 0.54–0.70, the lower bound of the most recent IV-based betas has increased by 0.12 and the upper bound by 0.11.

This increase in pre-pandemic asset beta is likely to be persistent over the H7 price control, as evidenced by the increase in airport stock IVs relative to index IVs. This view is further supported by the persistently high betas following unexpected shocks in other sectors such as information technology and communication services—the asset betas for these sectors were materially higher for several years after the 2001 dotcom crisis when compared with their levels before the crisis.

While the TRS mechanism does help to reduce HAL's asset risks during and possibly beyond H7, its impact is overestimated as the CAA has not accounted for the in-period increases in cost of capital during and after pandemic-magnitude events. This leads to under-compensation of revenue losses by the TRS mechanism, which needs to be corrected by either setting a higher allowed WACC (e.g. through asset beta) than proposed by the CAA, or increasing the revenue allowance for asymmetric risk, or a combination of both.

# 3 Point estimate

In its April 2021 Way Forward Document, when discussing the choice of point estimate for HAL's WACC, the **CAA** noted the considerations set out by the CMA in the PR19 determinations, and proposed that '[it] will consider each of the factors referred to by the CMA in the context of […] [its] H7 regulatory framework'.[39]

In its June 2021 RBP, **HAL** noted that the CMA implemented Monte Carlo simulations for the CoE estimate and arrived at a point estimate 25bps above the mid-point of the CoE range corresponding to the 77th percentile of the simulation outcomes. Based on this, HAL proposed adopting a similar approach to that adopted by the CMA and 'include an explicit adjustment for aiming up'. According to HAL's assessment, such an 'explicit adjustment' would be 'an uplift of 0.5% [from the mid-point of the CoE range]'.[40]

In its October 2021 Initial Proposals, the **CAA** noted that two factors might warrant setting a point estimate of the CoE above the mid-point. These factors were the need to promote investment and the financing challenges faced by HAL in H7 even on a notional basis. Nonetheless, the CAA also stated that the application of a TRS mechanism would substantially reduce HAL's risk exposure, which might lead to a point estimate of WACC that is below the mid-point. The CAA plans to use its regulatory judgement to determine the point estimate in its final decision.[41]

This section first summarises the CMA's determinations on the CoE point estimate in PR19 and its adoption of Monte Carlo simulations as a cross-check (section 3.1), before applying a similar Monte Carlo simulation to that adopted by the CMA in PR19 to assess the likely point estimate for HAL's CoE in H7 (section 3.2).

## 3.1 The CMA's CoE point estimate determination in PR19 and its use of Monte Carlo simulation as a cross-check

In its PR19 determinations, the CMA considered that 'there are a number of benefits from choosing a point estimate of the cost of equity above the middle of the range', and determined the CoE point estimate to be 4.73%, which corresponds to 'a cost of equity point estimate 0.25% above the middle of […] [its] 3.76% to 5.21% range'.[42]

In arriving at such a determination, the CMA considered the 'Monte Carlo-style analysis' on the CoE estimate submitted by Ofgem in response to its Provisional Findings.[43] Although the CMA recognised that 'the cost of equity calculation [is] largely incompatible with Monte Carlo-type analysis' due to the uncertainties and judgement involved in estimating the range for each CoE parameter, it considered that 'Monte Carlo analysis may provide a useful cross-check' and was 'a useful illustration of the scale of risk of setting the cost of equity too low'.[44]

[39] CAA (2021), 'Economic regulation of Heathrow Airport Limited: Consultation on the Way Forward', April, pp. 90–93.
[40] Heathrow Airport (2021), 'H7 Revised Business Plan – Update 1', June, pp. 216–217.
[41] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, pp. 85–86.
[42] CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, p. 1098.
[43] CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, p. 1072.
[44] CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, pp. 1074–1075.

Accordingly, the CMA implemented a Monte Carlo analysis on its CoE estimate and concluded that:

> a cost of equity of around 25bps above the mid-point would in practice be around the 77th percentile on a probability-weighted basis. […] if we chose a value 25bp above the midpoint, that there would be only around a 25% risk of the cost of capital being set too low.[45]

Table 3.1 sets out the distribution assumptions adopted by the CMA for each CoE parameter in its Monte Carlo simulation.

**Table 3.1 The distribution for each CoE parameter assumed in the CMA's Monte Carlo Simulation**

| CoE parameter | Range | Assumed distribution | Mean | Standard deviation |
|---|---|---|---|---|
| TMR | 6.15% to 7.46% | Uniform | n.a. | n.a. |
| RFR | -1.63% to -1.05% | Uniform | n.a. | n.a. |
| Debt beta | 0.10 to 0.05 | Uniform | n.a. | n.a. |
| Unlevered beta[1] | 0.28 to 0.30 | Normal | 0.29 | 0.0033 |

Note: [1] The mean of the unlevered beta estimate is assumed to be the mid-point of its range, and the standard deviation of the unlevered beta is assumed to be 'one third of the difference between the mean and the end of the range'.

Source: CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, footnote 3169.

## 3.2 The likely scale of the point estimate for HAL's CoE based on the Monte Carlo simulation similar to that adopted by the CMA in PR19

As noted by the CAA, the CMA considered multiple factors when setting the CoE point estimate in PR19, and the determination of the CoE point estimate based on these factors in the context of H7 is subject to the CAA's regulatory judgement.[46] Nonetheless, a Monte Carlo simulation similar to that adopted by the CMA in PR19 for the CoE point estimate could be used to inform the likely scale of HAL's CoE point estimate that would not overly risk setting HAL's CoE too low.

To apply a similar Monte Carlo simulation to that adopted by the CMA in PR19 to the CoE estimate for HAL, we first built a simulator to replicate the CMA's analysis and reach the same result as the CMA.[47] This ensures that the analysis follows a similar framework to that implemented by the CMA.

We then inputted CAA's estimates for HAL's CoE parameters into the simulator and assumed similar statistical distributions for each parameter as those assumed by the CMA, with the following minor adjustments.

- **RFR**: unlike the CMA's range estimate for RFR, the CAA has proposed a single point estimate for RFR of -1.8%.[48] Therefore, the CAA's RFR

[45] CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, p. 1074.
[46] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, pp. 84–86.
[47] In particular, our replication of the CMA's simulation gives the same results as those presented by the CMA, i.e. the 77th percentile of the CoE estimate corresponds to a 25bps uplift to the mid-point of the CMA's CoE range or 4.73%. See [Oxera analysis]; CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, para. 9.1306.
[48] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, Table 9.9.

estimate was inputted in our simulator as a single point estimate with no statistical distribution assumed.

- **Notional gearing**: unlike the CMA's single point estimate for notional gearing, the CAA has proposed a notional gearing range of 62% and 61% for HAL under its low and high CoE estimates.[49] In line with the CMA's distribution assumption for most of the CoE parameters, we have assumed that the CAA's notional gearing estimate follows a uniform distribution.

- **Asset beta**: we note that, in PR19, the CMA first estimated the unlevered beta and then converted the unlevered beta to the asset beta by adding the product of its estimates of the debt beta and the observed gearing.[50] However, the CAA has estimated the asset beta for HAL directly.[51] Therefore, we have assumed that the CAA's asset beta estimate follows the same distribution as that assumed by the CMA for the unlevered beta estimate, i.e. the normal distribution.

Table 3.2 sets out the assumed distribution for the CAA's estimates of HAL's CoE parameters.

**Table 3.2 Assumed distribution for the CAA's estimate of HAL's CoE parameters**

| CoE parameter | Range based on the Initial Proposals | Assumed distribution | Mean | Standard deviation |
|---|---|---|---|---|
| TMR | 5.2% to 6.5% | Uniform | n.a. | n.a. |
| RFR | -1.8% | n.a. | n.a. | n.a. |
| Debt beta | 0.10 to 0.05 | Uniform | n.a. | n.a. |
| Notional gearing | 62.0% to 61.0% | Uniform | n.a. | n.a. |
| Asset beta[1] | 0.52 to 0.67 | Normal | 0.60 | 0.025 |

Note: [1] Similar to the assumptions adopted by the CMA for the unlevered beta in PR19, the mean of the asset beta estimate is assumed to be the mid-point of its range, and the standard deviation of the asset beta is assumed to be 'one third of the difference between the mean and the end of the range'.

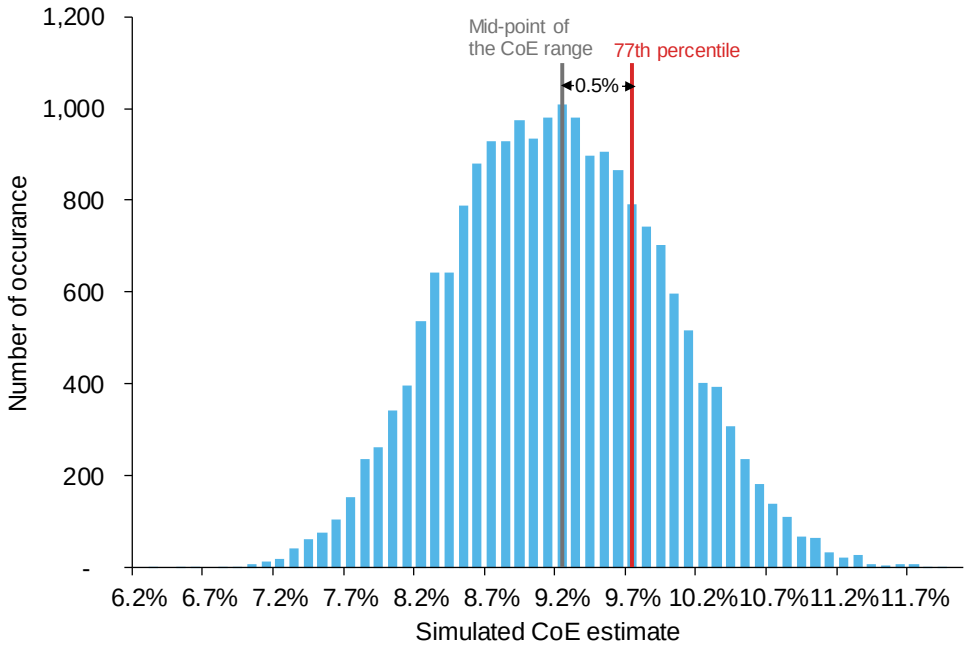
Source: Oxera analysis; CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, footnote 3169.

Based on the CoE parameter inputs detailed above, we performed 20,000 simulations. Each simulation estimates HAL's CoE based on a set of CoE parameter estimates randomly generated according to their assumed statistical distributions. In other words, the results of our simulation analysis are 20,000 estimates for HAL's CoE. Figure 3.1 below shows the distribution of our simulated CoE estimates for HAL. We note that **the 77th percentile of our simulated CoE estimates is 9.7%**, which is around 0.5% higher than the 9.2% mid-point of CAA's estimated CoE range of 6.6% to 11.8%. Under the CMA's framework in PR19, this indicates that the 77th percentile of HAL's CoE estimate is likely to be 0.5% above the mid-point of CAA's CoE range 'on a probability-weighted basis', and that the risk of setting the CoE too low for HAL would be limited to below 25% if a 9.7% point estimate were to be adopted. We also note

[49] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, Table 9.9.
[50] CMA (2021), 'Anglian Water Services Limited, Bristol Water plc, Northumbrian Water Limited and Yorkshire Water Services Limited price determinations – Final report', 17 March, footnote 2600.
[51] CAA (2021), 'Economic regulation of Heathrow Airport Limited: H7 Initial Proposals', October, Table 9.9.

that such a point estimate for HAL's CoE is also broadly in line with HAL's proposed 50bps uplift to the mid-point of CAA's CoE range.[52]

**Figure 3.1 The distribution of the simulated CoE estimate for HAL based on the CAA's estimates of CoE parameters**




Source: Oxera analysis.

[52] Heathrow Airport (2021), 'H7 Revised Business Plan – Update 1', June, p. 217.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