Review of H7 Opex and Commercial Revenues: Final Assessment and Forecasts (Management Stretch Technical Annex)

Civil Aviation Authority

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1. INTRODUCTION AND SUMMARY

This technical annex details the econometric analysis that CEPA has undertaken to estimate HAL's historic ability to drive revenue generation that can be explained by factors other than the revenue drivers applied in our forecasts, capital expenditure, or one-off factors (e.g., Brexit related depreciation in GBP).

The aim of the analysis is to extend the quantitative evidence base that may be used to inform a decision on any management stretch target that is set for HAL in H7. The analysis uses data provided by HAL on retail revenues and a range of key revenue drivers, from 2007-2019. Our methodology is detailed below.

We acknowledge the significant limitations – notably data availability – with the analysis that we have undertaken. We do not consider that substantial weight can or should be placed on our results for the purposes of setting a management stretch target for the H7 price control. As discussed in this annex and our main report, we have instead used the analysis only in a confirmatory manner and as one of a number of possible sources of qualitative and quantitative evidence to inform the CAA's decision on a management stretch target in H7.

1.1. SUMMARY FINDINGS

In producing our updated forecasts of commercial and cargo revenues during H7, we have opted for a top-down approach, whereby we project commercial revenues using a mixture of revenue drivers and elasticities, and then perform step-adjustments to account for headwinds and tailwinds (see Section 2 of the main report).

It is important that our top-down forecasts account for all expected and measurable drivers, such that the resultant target can be considered a "fair bet" assessment of *efficient* revenues. That is, the level of commercial revenue generation that might be expected from the airport operating efficiently, including the expected rate at which HAL's management might be able to drive revenue growth each year, over and above what can be explained by our revenue drivers, or step-adjustments, and so otherwise would not be incorporated into our forecasts.

We have termed Heathrow's potential to improve revenue generation over time a "management stretch target" and can be considered akin, in principle, to the ongoing efficiency target that the CAA sets for opex.

We have developed several econometric model specifications to try to estimate the growth in HAL's retail revenues over time. These models control for key revenue drivers, such as retail floor space, which we have identified from first principles and representations made by HAL.[1] We include a time trend in these models to capture the trend in retail revenue growth after controlling for other revenue drivers, which we assume represents the management stretch.

As discussed above, we use the econometric analysis in a confirmatory manner, to determine whether historical evidence might justify a 2% management stretch target, as we adopted in our initial forecasts for the CAA's IPs, or whether this historical evidence is more consistent with a lower target, or indeed no target at all. We note that in the context of how CEPA has prepared its commercial revenue forecasts for H7, HAL can be considered to have implicitly assumed a management stretch target of 1% within its forecasts. As such, we have assessed the strength of the evidence from the econometric modelling supporting a 1% target or a 2% target.[2]

We do not consider it would be appropriate to use our analysis in isolation, to directly set a management stretch target, due to three key challenges and limitations with the modelling we have undertaken:

[1] HAL (2021), CAP2265 response, pp. 224-231.

[2] HAL maintain the use of RPI to index its commercial revenue forecasts in its RBP Update 2, which assume that it is able to maintain revenues constant in RPI real terms. This implies that if CPI is considered a better measure for inflation and basis for indexation of commercial revenues, as CEPA has adopted in our commercial revenue forecasts, that HAL implicitly apply a management stretch equal to the wedge between RPI and CPI, which has previously been estimated to be 1%. See OBR (2015) Revised assumption for the long-run wedge between RPI and CPI inflation. Available at obr.uk

- **Data availability**: The only data available to use is that provided by HAL, which results in only 13 observations for one airport.
    - This means that our attempt to estimate management stretch is based on a small and potentially unrepresentative sample of revenue generation and drivers.
    - Furthermore, the small sample size means that we must prioritise parsimonious econometric models; this therefore increases the risk of omitted variable bias. [3]

  This reduces the reliability of any management stretch estimate.

- **Multicollinearity**: Many commercial revenue drivers typically increase over time, leading to multicollinearity. Multicollinearity does not bias any estimate of management stretch in the modelling, but it will reduce the precision of any estimate.

- **Catch-up efficiency**: Over a short time horizon, it is possible that the time trend in our models captures ongoing efficiencies and catch-up efficiencies in revenue generation potential. Although HAL considers itself at the frontier of commercial revenue generation, we cannot definitively conclude that any econometric estimate of management stretch does not include any catch-up efficiencies.

Overall, we find that the analysis does not provide conclusive evidence in favour of a 2% management stretch target or a 1% management stretch target. Indeed, the limitations with the analysis and the results of the modelling mean that we would be cautious of placing any weight on a specific estimate of HAL's long term potential for retail revenue growth, while controlling for other factors.

However, we consider that the analysis does appear to confirm that, after seeking to control for drivers of revenues such as passenger growth and retail floor space, that HAL has historically been able to achieve revenue growth for reasons other than these key known revenue drivers. **As a result, we consider the analysis is at least supportive of the CAA considering a management stretch target for HAL in H7, particularly given the approach that CEPA has taken to index commercial and cargo revenues to forecasts of CPI not RPI inflation.**

To the extent any inference can be drawn from the modelling of an appropriate level of management stretch challenge for setting the H7 price controls, we would be minded to give reference to the results of Model 6 (see below) which would imply a target of at most 1%. **However, we consider that the choice of management stretch target is ultimately a judgement that the CAA must make in the context of the overall price control.**

We consider the following factors to be relevant to determining the choice of any management stretch target:

- The extent to which historic macroeconomic trends driving HAL's revenue growth can be expected to continue during H7.
- The extent to which HAL is exposed to known headwinds that are not explicitly accounted for in CEPA's forecasts (prior to the application of a management stretch).
- The extent to which management action can help mitigate headwinds, and the extent to which such mitigations are already captured elsewhere in our forecasts.
- The extent to which management action can drive new revenue growth, and the extent to which HAL may be exposed to further unknown headwinds.
- The extent to which the CAA provides a capex allowance to drive further revenue growth.

[3] Also due to data limitations, our analysis is based on HAL's historic *retail* revenues only during the period 2007-2019. The external validity of our findings on retail revenues for setting any management stretch assumption for commercial revenues in general, is discussed in subsequent sections of this document.

- A management stretch target being a relatively novel regulatory concept in the context of a single till price control. This might suggest a degree of caution is necessary in setting any target, particularly given the imperfect evidence base and the continued uncertainty of demand for air travel in the UK.

1.2. Document structure

The rest of this annex is structured as follows:

- Section 2 presents the context motivating the econometric analysis and discusses the purpose of the analysis.
- Section 3 outlines the econometric approach we have taken to the analysis and sets out the model specifications in light of our approach and the data used in our analysis.
- Section 4 presents the results of our analysis and discusses these in light of the broader commercial revenue forecast process.

2. CONTEXT AND OBJECTIVES OF THE ANALYSIS

In this section we set out the context and purpose of the econometric modelling we have undertaken. This forms the underlying basis for the analysis that is set out in subsequent sections of this annex.

2.1. Definition of Management Stretch

The commercial revenue earned by Heathrow is driven by observed drivers, such as the number of passengers and volume of retail floorspace, which we have incorporated into our commercial revenue forecasts. It is also driven by drivers that we have not incorporated into our forecasts. As such, it is possible that HAL maybe able to improve revenue generation without any changes in the modelled drivers.

As discussed above, the concept of management stretch can be considered akin to the ongoing efficiency target for opex. If observable drivers were to remain constant, the airport's commercial revenues may be expected to change over time due to factors and initiatives that are not captured by our forecasting approach. It is important that this potential for revenue generation growth is at least considered in our analysis such that any forecast of commercial revenues can be considered a fair assessment of the airport's *efficient* revenue generation potential.

For the purposes of our work, we define the management stretch as follows:

> *The **Management Stretch** is an efficiency challenge which defines the percentage rate at which HAL's commercial revenues are expected to increase over time in the long-run, controlling for the key observed drivers of commercial revenue and any catch-up efficiencies.*

In this application, the management stretch accounts for commercial revenue drivers that have not been recognised by the modelling approach used in our forecasts. This includes unobservable drivers such as innovation, and observable drivers such as GDP per capita.

As noted by Frontier Economics in their report for HAL in responding to the CAA's IPs, there is a key distinction that must be drawn between ongoing efficiency, and catch-up efficiency:[4]

- **Ongoing Efficiency** is the result of long-term trends in commercial revenue drivers that all airports experience.
- **Catch-up Efficiency** is a short / medium-term process in which an airport improves its commercial revenue generation relative to other airports.[5]

The management stretch target should consider only the long-run increase in commercial revenue generation over time, and as such only captures ongoing efficiencies/ growth potential.

2.2. Context

CEPA / Taylor Airey Initial Forecasts

At the IP stage of the H7 process, we adopted a management stretch target of 2% per annum in our initial revenue forecasts. The 2% figure was a mid-point between:

- **HAL RBP Update 1 (1%)**: In HAL's RBP Update 1, it proposed no explicit management stretch. However, it indexed both its commercial revenue and opex forecasts to RPI, in contrast to our use of CPI. If CEPA's choice of CPI is considered a better measure of inflation for commercial revenues, HAL may be considered

[4] Frontier Economics (2021), H7 IP Commercial Revenue Review, p.5.

[5] For example, by adopting innovations from airports that are at the frontier of commercial revenue generation.

to implicitly have applied a management stretch target in its forecasts, equal to the wedge between RPI and CPI, which has been estimated to be ~ 1%.[6]

- **CEPA iH7 review (3%)**: In our review for the CAA of HAL's proposals for iH7, we observed that HAL's commercial revenues per passenger increased by roughly 3% per annum in real terms, between 2008 and 2017.

In our initial forecasts, we saw a 2% target as a high-level estimate capturing several factors:

- Potential for partial mitigation against the downside step changes presented in our forecasts.
- Returns from recent capital investments aimed at increasing revenue generation.
- Our switch from RPI indexation for future revenues to CPI indexation.

We applied our management stretch target to all commercial revenue income but recognised that any assumption adopted at final proposals would need to be underpinned by further evidence, including from HAL. [7]

HAL CAP2265 response and RBP Update 2

HAL presented two broad arguments for why our management stretch proposals were not appropriate:[8]

- There was no regulatory precedent for applying a management stretch target to a company at the efficiency frontier.
- HAL's historical outperformance of the regulatory settlement was due to reasons that are unlikely to be replicated.

HAL and Frontier Economics also argued that our 2% estimate was insufficiently substantiated. PA,[9] in its advice to the AOC, agreed that the 2% management stretch proposal was insufficiently substantiated.

HAL maintain the use of RPI to index its forecasts in RBP Update 2, and so the implicit 1% management stretch is maintained. It has acknowledged that its forecasts assume that it is able to maintain revenues constant in RPI real terms. This means that, if CPI is indeed a better measure for inflation, HAL may be said to continue to implicitly apply a management stretch target equal to the wedge between RPI and CPI.

Our assessment of the issues

In response to the review of the representations made by HAL, Frontier Economics and PA, we have sought to undertake an econometric analysis to provide an additional source of evidence to inform a decision on a long-run management target at Final Proposals, alongside the information submitted by HAL at IPs.

In summary (see Section 3 for a more detailed description of our approach) we have developed a number of alternative econometric model specifications where we seek to estimate the growth in Heathrow's retail revenues over time, controlling for key revenue drivers such as retail floor space and passenger numbers. We include a time trend in these econometric model specifications with the objective that this can capture the trend in retail revenue growth after controlling for other key revenue drivers of the airport.

We have used the analysis to seek to answer whether the historical data on HAL's commercial revenues is more consistent with a 1% or 2% management stretch target taking into consideration the values proposed by HAL in RBP Update 1 and 2, and used by CEPA in our initial forecasts.

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[6] OBR (2015) Revised assumption for the long-run wedge between RPI and CPI inflation. Available at obr.uk

[7] Except for Other Regulated Charges, which was outside the scope of our analysis.

[8] HAL (2021), CAP2265 response.

[9] PA Consulting (2021) Review of CEPA/Taylor Airey review of H7 Opex and Commercial Revenues.

We note that given data and other limitations with the analysis (see discussion below) any findings from this econometric modelling need to be treated with significant caution.

In addition, we would consider any findings that may result from the econometric analysis to be only one of a number of sources of evidence that might be used to inform an overall judgement on the justification for, and level of, a management stretch target. This includes the qualitative and quantitative information and analysis that HAL and Frontier have presented in response to CAP2265 (CAA H7 IPs).

2.3. PURPOSE

We consider there are three key challenges with using econometric modelling to inform the management stretch target which mean we do not consider it would be appropriate to use the analysis to directly set the target. These challenges also mean there are risks in drawing any firm conclusions from the modelling:

- **Data availability**: The only data available to use is that provided by HAL, which results in only 13 observations for one airport.
    - This means that the management stretch is estimated on a small and potentially unrepresentative sample of revenue generation and drivers.
    - Furthermore, the small sample size means that we must prioritise parsimonious econometric models; this therefore increases the risk of omitted variable bias.

  This reduces the reliability of our management stretch estimate.
- **Multicollinearity**: Many commercial revenue drivers typically increase over time, leading to multicollinearity. Multicollinearity does not bias the estimate of the management stretch, but it does reduce the precision of our estimate.
- **Catch-up efficiency**: Over a short time horizon, it is possible that the time trend estimated captures ongoing efficiencies and catch-up efficiencies. Although HAL considers itself at the frontier of commercial revenue generation, we cannot convincingly conclude that the econometric estimate of the management stretch does not include any catch-up efficiencies.

Given the context and key econometric challenges faced, we have decided to use econometric analysis in a *confirmatory manner*; that is, we do not believe that the econometric analysis should be used to define HAL's management stretch challenge over H7. Instead, we consider analysis is more appropriate as a cross-check to the existing evidence base, in order to support or challenge our and HAL's position on any management stretch.

Specifically, we use the econometric analysis to answer the following key question:

> *Is the evidence on historical revenue growth – after controlling for other key revenue drivers – more consistent with a 1% or 2% target for the H7 period?*

The econometric analysis is intended to provide an estimate of the rate of change of retail revenues over time, controlling for a set of factors that are either outside HAL's control and can be expected to average to zero (e.g. exchange rate movements), or are accounted for elsewhere (e.g. passenger mix, capex). This will incorporate factors that are:

- within HAL management control (e.g. innovation); and
- factors that are out of HAL's management control (e.g. GDP growth).

In the next section we set out our approach to the analysis.

3. APPROACH TO THE ANALYSIS

3.1. APPROACH IN THEORY

As discussed in the previous section, we consider it is important to create a set of parsimonious model specifications under a limited data size.

We use the following econometric model specification using a log functional form with HAL's *retail* revenue per passengers as the dependent variable:

$$\ln\left(\frac{Rev_t}{Pax_t}\right) = \boldsymbol{x_t\beta} + \beta_{\mathrm{H}} Time_t + \epsilon_t$$

Where:

- $\ln()$ denotes the natural logarithm.
- Rev_t denotes the retail revenues of an airport at time *t*
- Pax_t denotes the number of passengers at time t
- x_t denotes a vector of revenue drivers at time *t*
- $Time_t$ denotes the year at time *t*
- ϵ_t denotes the error term, at time *t*

The use of retail revenues as opposed to total commercial revenues (and retail revenues per passenger) as the dependent variable in the models, reduces the number of drivers that we need to consider[10] helping to improve the precision of our results and improve internal validity. The corresponding effects of this choice of model specification on the external validity of our results are discussed in Section 3.2 below.

$\boldsymbol{\beta}$ depicts the impact of the control variables on the outcome variable, and β_H denotes an estimate of management stretch.[11] If $\beta_H > 0$, then there is evidence that commercial revenues have increased over time, even when observable revenue drivers have been accounted for. In other words, there is evidence that the airport has become more efficient in its revenue generation over time. If $\beta_H < 0$, then there is evidence that the airport has become less efficient in its revenue generation over time.

Of course, the strength of conclusion that can be inferred from estimating β_H in terms of management stretch potential will depend on the degree to which the other control variables in the model specification adequately capture the key drivers of HAL's commercial revenues.

3.2. VALIDITY OF APPROACH

The modelling approach set out above in theory makes a number of assumptions that may bring into question the internal and external validity of using the modelling results to inform a management stretch target in a forecast of HAL's commercial revenues for H7. These are discussed in the subsections below.

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[10] Given that passenger volumes are a key driver of an airport's commercial revenues.

[11] Due to the use of a logarithmic dependent variable and linear independent year variable, the exact impact of a change in time on commercial revenues is depicted by $e^{\Delta time \beta_H} - 1 \approx \beta_H$ for small β_H. Given the confirmatory purpose of our modelling, the precise estimation of the management stretch is not needed.

Internal validity

We note the following two key assumptions underpinning the validity of the econometric approach set out above:

- **The approach assumes the airport's position relative to the frontier does not systematically change over time in order to claim that β_H implies a management stretch.** As discussed above, an airport's efficiency in generating commercial revenues (β_H) may increase over time for two reasons:
    - Firstly, an airport may become more efficient over time as the frontier of efficient revenue generation increases (this captures the idea of management stretch).
    - Secondly, an airport may become more efficient over time if it improves its efficiency relative to the frontier (this can be referred to as *catch-up efficiency*).

  Therefore, β_H will accurately capture management stretch only if an airport's position relative to the frontier does not systematically change over time. Evidence of the efficiency of Heathrow's commercial revenues from Steer Davies Gleave,[12] KPMG,[13] and Pragma[14] suggest that Heathrow's position relative to the frontier has been stable since at least 2011.

- **The approach assumes that the elasticity of retail revenues with respect to passenger volumes is equal to 1.** The functional form used will estimate the change in growth of retail revenues per passenger over time. This is equivalent to the change in growth in retail revenues over time if and only if the elasticity of retail revenues with respect to passengers is equal to 1. This is consistent with evidence from Frontier Economics, who use a meta-analysis of literature to estimate an elasticity of commercial revenues with respect to passengers of 0.97,[15] and KPMG, who use econometric benchmarking to estimate a range of the elasticity of retail revenues with respect to passengers, of 0.98-1.35.[16]

External validity

The models we have estimated provide an estimate for the growth in *retail* revenues over time, controlling for certain other factors, in the period 2007-2019. There are thus two key considerations underpinning the external validity of the econometric analysis presented:

- **To the extent the findings from the analysis are used to inform a management stretch target for all commercial revenues, this assumes that management stretch potential is equal among retail and non-retail revenue categories for which a management stretch is applied.** As discussed in our main report, in addition to retail revenue categories, we apply the management stretch to the revenue categories we consider HAL has an ability to control. The assumption of an equal stretch target across these categories is a strong assumption but is necessary to facilitate a more parsimonious model.
- **The utility of the econometric results depends on the extent to which historical drivers of the management stretch are applicable to H7.** A management stretch estimate from the econometric analysis we have undertaken will be expected to incorporate factors that are within HAL management control (e.g. business innovation), and factors that are out of HAL's management control (e.g. GDP growth). As HAL has represented, certain historical factors may not be replicable and a judgment is likely to be needed on what factors might be considered applicable and replicable in H7.

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[12] Steer Davies Gleave (2013), Assessment of Commercial Revenues at Heathrow Airport, and Steer Davies Gleave (2017) Heathrow Airport –Review of Commercial Revenues.

[13] KPMG (2019) Airport Commercial Revenue Efficiency Benchmarking Report for Heathrow Airport Limited

[14] Pragma (2019) Heathrow Airport Limited: Commercial Benchmarking 2019.

[15] Frontier (2019), Developing Opex and Commercial Revenue elasticities for H7.

[16] KPMG (2019), Airport Commercial Revenue Efficiency Benchmarking.

3.3. MODEL SPECIFICATION

Variables

We have conducted a series of OLS regressions to estimate the growth in retail revenues over time (our dependent variable), controlling for key revenue drivers (our independent variables). These revenue drivers capture one-off or random events that may have historically affected HAL's retail income (e.g. exchange rate movements), or other drivers that are already implicitly or explicitly accounted for in our forecasts (e.g. passenger volumes, capex). We have selected these drivers from economic first principles and from representations made by HAL.[17] We also include a time trend ("Year") variable, that is intended to capture the effects of other drivers of retail revenue that are not controlled for in our model: drivers such as GDP per capita, and management/ business innovation. The variables used in our econometric analysis are described in Table 3.1 below.

Table 3.1: Variables used in econometric analysis

Variable	Description
Dependent Variables	
Log of retail revenue per passenger (2018 CPI)	The log of total real retail revenues per passenger. We use this as our primary dependent variable for parsimony, under the assumption that retail revenues are perfectly elastic with respect to passengers (see discussion above).
Log of retail revenue (2018 CPI)	The log of total retail revenues. We run our set of model specifications on retail revenues as a sensitivity check, to test the validity of our assumption of perfect elasticity of retail revenues with respect to passengers.
Independent Variables	
Year	Categorical variable depicting the year observed. We use data from years 2007 – 2019.
Log of Effective Exchange Rate	The log of the Effective Exchange Rate (EER), taken from the Bank of England.[18] The EER takes a weighted average of bilateral exchange rates used in the index and expressed in an index form relative to a reference period. These weights are determined by the UK's bilateral trade flows with other countries.
Log of retail floorspace (m^2)	The log of the total retail floorspace available, in m^2.
1 / 2-year lag of log of retail floorspace (m^2)	The log of the total retail floorspace available, in m^2, from one / two years ago. We include two time lags of retail floorspace, as HAL provide evidence that growth in retail floorspace may have a lagged impact on retail revenue growth.[19]
Log of capex (2018 CPI)	Log of annual real capex expenditure.
Log of weighted average Income per Passenger	The log of weighted average of income per passenger. Income per passenger data is taken from HAL for 2019 only.[20] Weights are determined by the proportion of total passengers from each region. This measure provides a control for the passenger mix, taking into account the fact that passengers from some regions spend more than others. *We assume that the relative spend of passengers from each region is consistent over time.*
Log of Passengers	The log of total passengers. This is used as a control variable when total retail revenues are used as a dependent variable.

[17] HAL (2021), CAP2265 response, pp. 224-231.

[18] Accessed from https://www.bankofengland.co.uk/statistics/details/further-details-about-effective-exchange-rate-indices-data.

[19] HAL (2021), CAP2265 response, p. 224.

[20] HAL (2021), CAP2265 response, p. 224.

Source: CEPA analysis

Econometric models

In total, we ran 18 econometric models, using both the dependent variables listed above. The model specifications are depicted in Table 3.1 (overleaf). We test nine core econometric models (Models 1-9), using retail revenues per passenger as the dependent variable, and re-run these on total retail revenues as a sensitivity check, including passengers as a control variable (Models 10-18).

There are two opposing factors we considered when developing our models: on one hand, a small sample size means that model parsimony is important in preventing overfitting; on the other hand, there are a range of potentially important revenue drivers that we wished to account for, depicted above. We therefore include a mixture of parsimonious and non-parsimonious models to assess the effects of a large array of revenue drivers.

Throughout all models, we utilise a log-log regression model, so that the model coefficients represent percentage changes. In other words, a 1% increase in the independent variable (e.g., retail floorspace) leads to an x% increase in the dependent variable (e.g., retail revenue per passenger).

We note that, despite the importance of capex in driving revenues as emphasised by HAL, we only include capex in a few of our models as a robustness check. For our primary models, we forego capex as a control variable in favour of retail floorspace. This is for three key reasons:

- The primary channel through which capex has an impact on retail revenues is through increases in retail floorspace. The two variables are therefore highly correlated.
- Capex has an impact on retail revenues through other channels, but also is used to achieve increases in other revenue streams and reductions in costs. Therefore, although capex is an important driver of retail revenues, it is also a "noisy" control variable, compared to retail floorspace.
- The timing of impacts of capex on retail revenues are unclear, due to the fact that capex is incurred to develop a capital programme, which only has impact on retail revenues once completed. On the other hand, retail floorspace is likely to be a more instantaneous driver of retail revenues; intuitively, capex programmes lead to improvements in revenue drivers such as retail floorspace, and so the former will precede the latter. While retail floorspace is considered to be more instantaneous, we do still include its lags, as HAL argue that "*90% of the growth in income per passenger between 2008 and 2019 takes place in the first two full years following terminal openings at T5 and T2*."[21]

To test the econometric robustness of our models, we perform the following typical econometric tests:

- **Durbin-Watson test**: Tests the null hypothesis of no serial correlation among error terms, with the alternative hypothesis of positive serial correlation, at the 5% significance level. We denote a model with insufficient evidence of positive serial correlation as a "Pass", and with sufficient evidence of positive serial correlation as a "Fail". The Durbin-Watson test can also be "Inconclusive". Serial correlation among error terms does not bias results. However, positive serial correction may induce smaller standard errors of OLS regressions; this may lead us to conclude that a variable is significant when it is in fact not.
- **Ramsey RESET test**: Tests the null hypothesis of a correct model specification, against the alternative hypothesis that the model is incorrectly specified, at the 5% significance level. We denote a model with insufficient evidence of misspecification as a "Pass", and a model with sufficient evidence of misspecification as a "Fail". If a model fails the RESET test, a non-linear combination of the explanatory variables used may be better suited to explaining commercial revenue growth. In other words, our estimate for the management stretch would be incorrectly grounded in a mis-specified model.

[21] HAL (2021), CAP2265 response, p.224

- **Skewness-kurtosis test**: Tests the null hypothesis that the error terms are normally distributed, against the alternative hypothesis that they are not, at the 5% significance level. We denote a model with insufficient evidence of non-normally distributed errors as a “Pass”, and a model with sufficient evidence of non-normally distributed errors as a “Fail”. Normal distribution of error terms is a necessary condition for OLS estimators to be considered Best Linear Unbiased Estimates (BLUE).

Table 3.1: Model specifications

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Dependent Variable	**Log of Retail Revenue per passenger (2018 CPI)**								
Year	✓	✓	✓	✓	✓	✓	✓	✓	
Log of Effective Exchange Rate	✓	✓	✓	✓	✓	✓	✓		✓
Log of retail floorspace (m^2)	✓		✓		✓	✓	✓		✓
1-year lag of log of retail floorspace (m^2)					✓	✓	✓		✓
2-year lag of log of retail floorspace (m^2)						✓	✓		✓
Log of Capex (£m 2018 CPI)		✓		✓					
Log of weighted average Income per Passenger			✓	✓			✓		✓
Log of Passengers (millions)									

Source: CEPA analysis

Variables	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18
Dependent Variable	**Log of Retail Revenue (2018 CPI)**								
Year	✓	✓	✓	✓	✓	✓	✓	✓	
Log of Effective Exchange Rate	✓	✓	✓	✓	✓	✓	✓		✓
Log of retail floorspace (m^2)	✓		✓		✓	✓	✓		✓
1-year lag of log of retail floorspace (m^2)					✓	✓	✓		✓
2-year lag of log of retail floorspace (m^2)						✓	✓		✓
Log of Capex (£m 2018 CPI)		✓		✓					
Log of weighted average Income per Passenger			✓	✓			✓		✓
Log of Passengers (millions)	✓	✓	✓	✓	✓	✓	✓	✓	✓

Source: CEPA analysis

3.4. Data

Data summary

The econometric analysis presented uses data provided by HAL, on the level of retail revenues earned and a set of control variables, covering the period 2007-2019. Table presents some basic summary statistics for the data used.

Table 3.3: Summary statistics

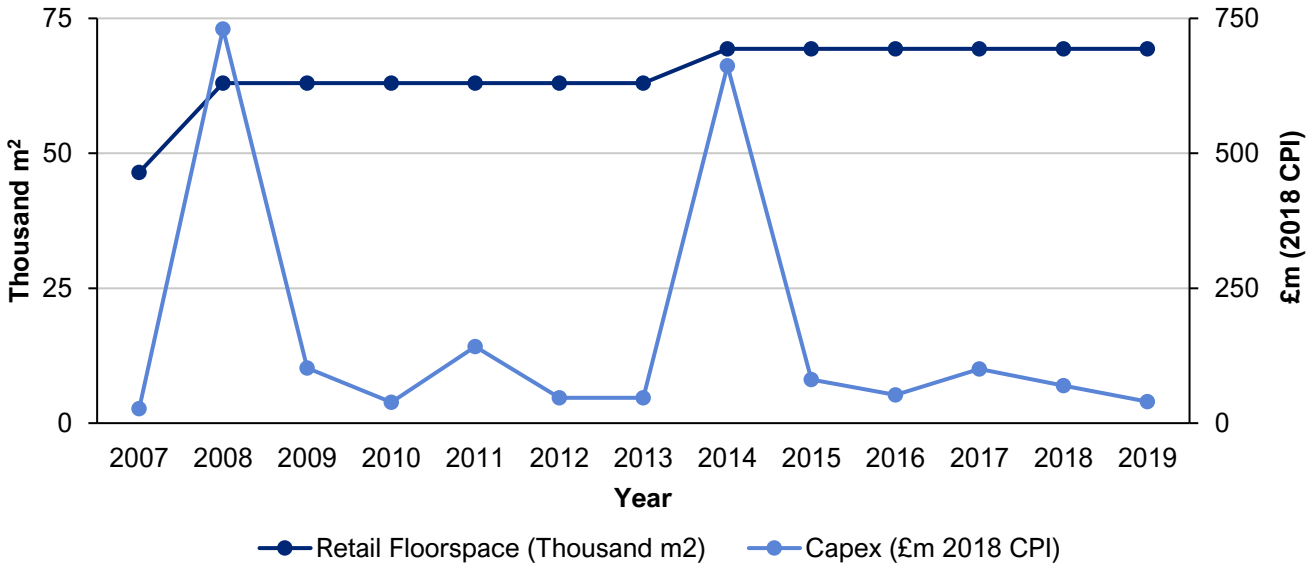
Variables	Observations	Mean	Standard Deviation	Minimum	Maximum
Retail Revenue (2018 CPI)	13	550.0	109.3	410.7	715.7
Retail Revenue per pax (2018 CPI)	13	7.536	0.968	6.137	8.934
Pax	13	72.41	5.263	65.76	80.89
Retail Floorspace	13	64,656	6,326	46,464	69,356
Effective Exchange Rate	13	84.17	7.453	77.30	103.7
Capex (2018 CPI)	13	164.5	238.6	26.57	730.5
Weighted average Income per pax (2019)	13	6.512	0.0301	6.460	6.569

Source: CEPA analysis of HAL data

Capex

We only include capex in a few of our models as a robustness check, in part because retail floorspace is itself driven by the capex programme (see discussion above). Figure 3.1Figure 3.1 demonstrates that large capex programmes coincided with increases in retail floorspace. This aligns with the opening of Terminal 5 in 2008, and the reopening of Terminal 2 in 2014, respectively.[22] One could therefore reasonably conclude that capex drives retail floorspace.

Figure 3.1: Retail floorspace and Capex



Source: CEPA analysis of HAL data

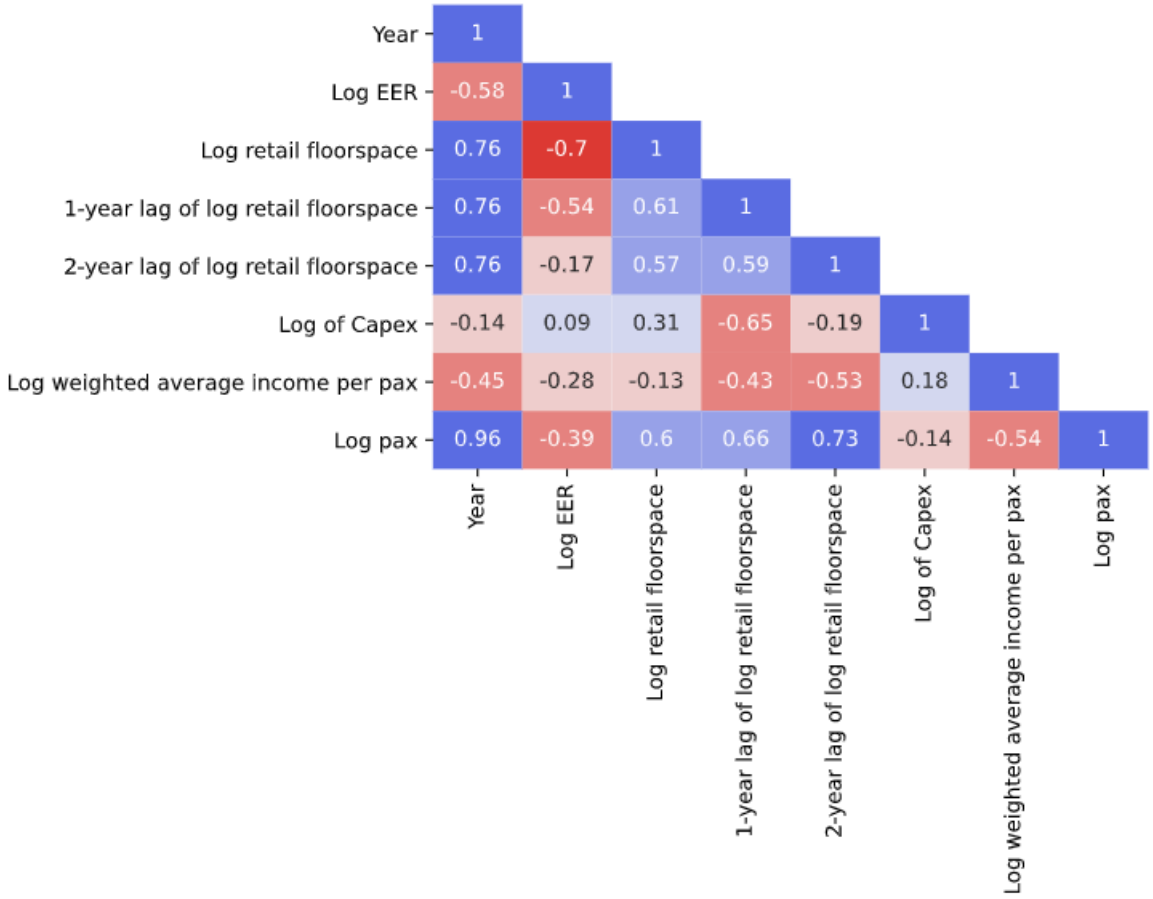
[22] HAL (2021), CAP2265 response.

Multicollinearity

A potential area for concern with time series data is the likelihood of multicollinearity. Strong collinearity between independent variables will not bias estimators from an OLS model, but will increase the variance of estimators, reducing the validity of the econometric models for informing management stretch potential.

Figure 3. below presents the correlation between the independent variables used in our analysis.

Figure 3.2: Correlation Matrix



Source: CEPA analysis

Figure 3.2 shows there are two variable pairs whose correlation is above 0.75:

- **Year and Passengers**: Passenger volumes have increased over time, leading to positive correlation between pax and year. The expected effect of this is to increase the variance of estimators in Models 10-18, relative to Models 1-9.
- **Year and Retail Floorspace:** Figure 3.1 demonstrates the positive trend in retail floorspace over time. As retail floorspace is a key control variable, we do not propose removing it. However, the high correlation between year and the retail floorspace will increase the variance of estimators for all models in which we include retail floorspace, especially in Models 6, 7, 15 and 16 in which we include retail floorspace and its lags.

In the next section of this annex, we set out the results from the analysis.

4. RESULTS AND DISCUSSION

This section sets out the results from the econometric modelling and a discussion of the results.

4.1. RESULTS

Table 4.1 and Table below present the findings from the econometric modelling. We highlight the following observations from the analysis.

The time trend variable is positive and statistically significant in the majority of model specifications. The point estimate is positive across all 16 models estimated in which the Year (time trend) variable is included and is significant in 10 models at the 5% significance level.

The directionality of coefficient estimates for the control variables are overall in line with expectations *a priori*, with the exception of the EER and Capex. The EER is overall insignificant and of mixed sign, contrary to an expected negative relationship. Capex has a small negative relationship with retail revenues in the four models where it is included; however, these are statistically insignificant.

The control variables are of mixed significance, due to the small sample size and presence of multicollinearity. Given that a priori, the control variables we have included in the models are considered key drivers of HAL's retail revenues, alongside passenger volumes, this leads us to question whether the estimated time trend in many of the models tested are in any way a true estimate of management stretch potential.

The estimated coefficient on the time trend variable ranges from 1.02% (Model 6) to 6.12% (Model 12). Figure 4.1 overleaf depicts the 95% confidence intervals of the different models. The results of Model 6 – highlighted in blue in Table 4.1 – are more consistent with an assumption of management stretch potential of 1% and the control variables in this model are also found to be significant, alongside the time trend (Year) variable. Other models where the Year variable is significant seem to imply a higher management stretch potential, but we note that in many of these cases the control variables are insignificant.

As anticipated in Section 3, the variance of the estimate of time trend (a proxy for management stretch) is much lower in Models 1-8, compared to Models 9-16.

Table 4.1: Econometric model results: Retail revenues per passenger

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Dependent Variable	**Log Retail Revenues per Passenger (2018 CPI)**								
Year	**0.033*** **	**0.031*** **	**0.033*** **	**0.033*** **	**0.023***	**0.010***	**0.015**	**0.033*** **	
	(0.004)	**(0.002)**	**(0.005)**	**(0.005)**	**(0.008)**	**(0.003)**	**(0.009)**	**(0.002)**	
Log Effective Exchange Rate	-0.096	-0.059	-0.077	-0.001	-0.166	-0.209*	0.013		-0.559***
	(0.123)	(0.072)	(0.211)	(0.175)	(0.141)	(0.067)	(0.287)		(0.073)
Log retail floorspace (m^2)	-0.069		-0.069		0.380	0.419*	0.231		0.811***
	(0.110)		(0.119)		(0.385)	(0.133)	(0.335)		(0.103)
Log capex (£m 2018 CPI)		-0.010		-0.011					
		(0.005)		(0.006)					
Log weighted average Income per Passenger			0.421	1.289			2.373		-3.259**
			(3.370)	(3.352)			(3.177)		(0.712)
1-year lag log retail floorspace (m^2)					0.190*	0.668***	0.638**		0.774***
					(0.079)	(0.047)	(0.088)		(0.052)
2-year lag log retail floorspace (m^2)						0.237***	0.261**		0.237***
						(0.026)	(0.031)		(0.023)
Log Passengers (millions)									
Constant	-62.873***	-60.972***	-64.670**	-66.3739**	-49.452**	-32.153**	-44.536	-63.505***	-9.598*
	(6.449)	(5.138)	(15.649)	(15.064)	(11.688)	(4.751)	(21.041)	(4.114)	(2.418)
Observations	13	13	13	13	12	11	11	13	11
Adjusted R-squared	0.951	0.958	0.945	0.954	0.958	0.988	0.986	0.958	0.979
Durbin-Watson: No serial correlation?	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Pass	Pass	Inconclusive	Pass	Pass
Ramsey RESET: Correct model specification?	Fail	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
Skewness -Kurtosis test: Normally distributed errors?	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Source: CEPA analysis

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1*

Table 4.2: Econometric model results: Retail revenues

Variables	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17	Model 18
Dependent Variable	**Log Retail Revenues (2018 CPI)**								
Year	**0.056*** **	**0.042*** **	**0.062** **	**0.047** **	**0.038**	**0.010**	**0.009**	**0.040*** **	
	(0.010)	**(0.009)**	**(0.016)**	**(0.013)**	**(0.025)**	**(0.015)**	**(0.018)**	**(0.008)**	
Log Effective Exchange Rate	0.057	0.053	0.168	0.173	-0.133	-0.203	0.122		0.121
	(0.127)	(0.120)	(0.242)	(0.261)	(0.155)	(0.095)	(0.499)		(0.427)
Log retail floorspace (m^2)	-0.202		-0.221		0.342	0.420	0.163		0.206
	(0.089)		(0.109)		(0.395)	(0.1820)	(0.461)		(0.401)
Log capex (£m 2018 CPI)		-0.010		-0.012					
		(0.005)		(0.005)					
Log weighted average Income per Passenger			1.990	2.168			3.758		4.046
			(3.190)	(3.464)			(5.817)		(4.678)
1-year lag of log retail floorspace (m^2)					0.111	0.669**	0.654*		0.696**
					(0.166)	(0.089)	(0.129)		(0.093)
2-year lag of log retail floorspace (m^2)						0.237**	0.292		0.318**
						(0.046)	(0.099)		(0.056)
Log Passengers (millions)	-0.055	0.463	-0.207	0.352	0.386	1.010	1.335	0.591	1.662*
	(0.476)	(0.444)	(0.548)	(0.475)	(0.922)	(0.505)	(0.8920)	(0.413)	(0.433)
Constant	-104.900***	-81.209***	-119.438*	-94.568*	-75.342	-31.726	-36.704	-76.434***	-22.432
	(18.840)	(15.845)	(34.891)	(30.226)	(43.611)	(24.975)	(28.714)	(14.247)	(8.280)
Observations	13	13	13	13	12	11	11	13	11
Adjusted R-squared	0.982	0.982	0.981	0.981	0.982	0.994	0.994	0.982	0.995
Durbin-Watson: No serial correlation?	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Inconclusive	Pass	N/A[a]	Inconclusive	Pass
Ramsey RESET: Correct model specification?	Fail	Fail	Fail	Pass	Pass	Pass	Pass	Pass	Pass
Skewness -Kurtosis test: Normally distributed errors?	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

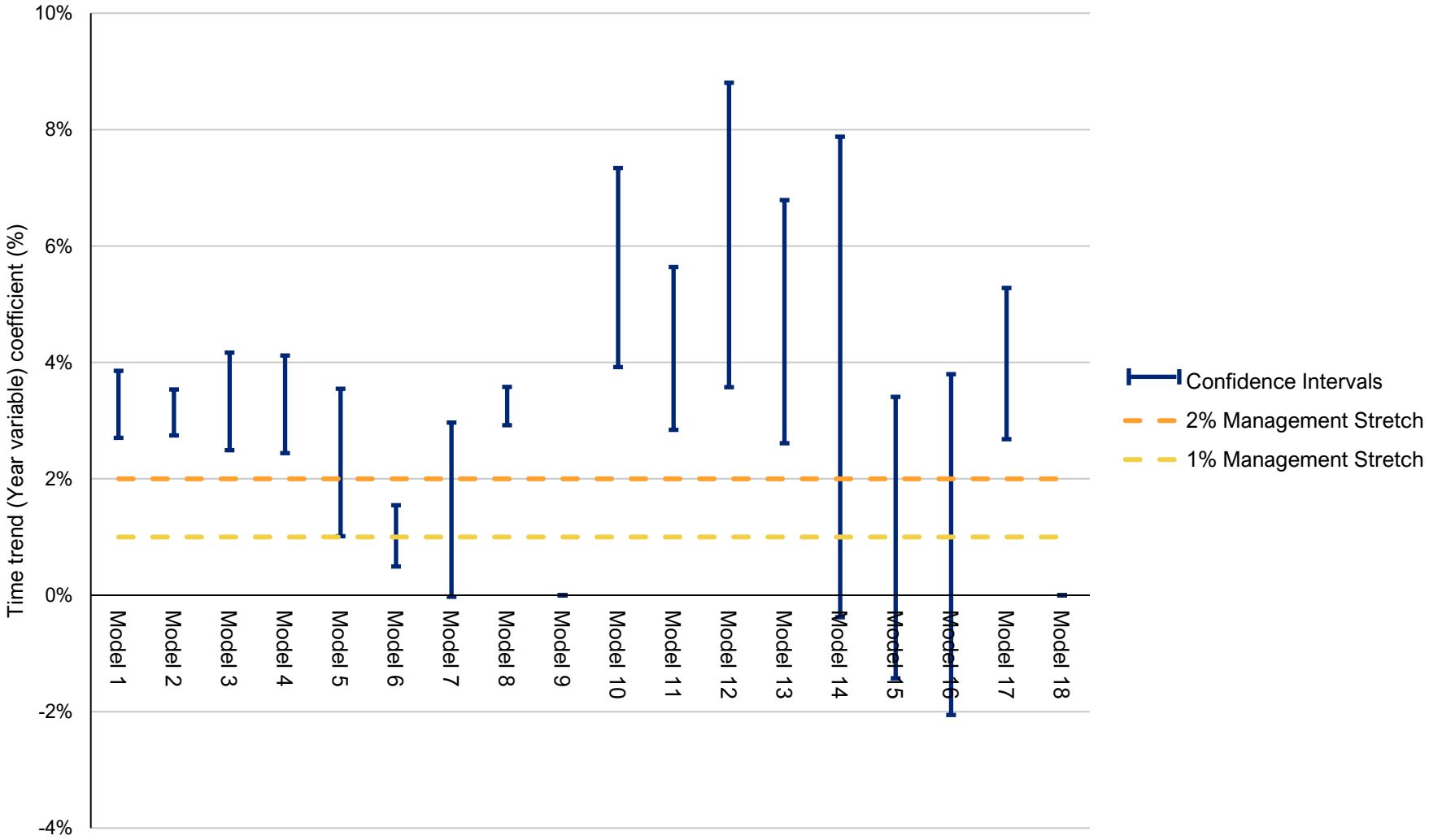
Source: CEPA analysis

Robust standard errors in parentheses.

*** p<0.01, ** p<0.05, * p<0.1*

[a] *Durbin Watson statistical tables do not present critical values for the given sample size and number of independent variables.*

Figure 4.1: Modelled 95% Confidence Intervals for the Year coefficient



Source: CEPA analysis

Note: Models 9 and 18 do not contain a Year control variable, so do not have any Confidence Intervals to report.

4.2. Discussion

Interpreting the modelling findings

The model results appear to imply a wide range of management stretch estimates. We have set out above the significant limitations and issues with the modelling approach adopted and the results, and for these reasons **we do not consider that significant weight can or should be placed on them for the purposes of directly setting a management stretch target for H7.**

Any conclusions one might or can draw about the consistency of the evidence with a particular level of management stretch potential depends on which models one places the most emphasis on.

We consider that Models 1-9 (using retail revenues per passenger) are preferred over Models 10-18 (using retail revenues). The estimators for the prior models have a lower variance due to the exclusion of passengers as a control variable with a high degree of multicollinearity with the year variable.

Models 1-4 are appealing for their parsimony, which is important under a small sample size. The models have low variance, and all estimate a consistent confidence interval for the time trend variable. However, they do not include all the factors identified by HAL as important revenue drivers, namely the lags of retail floorspace.

Models 5, 6 and 7 are appealing because they control for the factors identified by HAL as important drivers of commercial revenues. Of the models that we have tested, we have the highest confidence in the results from Model 6 given its specification and the modelling outputs. In the H7 context, this might suggest any management stretch target for forecast commercial revenues – i.e., after accounting for other retail revenue drivers such as retail floorspace and passenger volumes – should be relatively conservative, potentially no more than 1%.

Implications for setting an H7 management stretch target

For the reasons set out, we are not confident that our modelling is robust to infer a specific estimate of HAL's management stretch potential, *after* having controlled for factors that are known to impact HAL's historic revenue generation potential and which have already been captured in our H7 forecasts.

We find that the analysis does not provide conclusive evidence in favour of a 2% management stretch target or a 1% management stretch target. Indeed, as set out above, the limitations with our analysis and the results mean that we would be cautious of placing any weight on a specific estimate of HAL's long term potential for retail revenue growth, while also controlling for other factors.

However, we consider that our analysis does appear to confirm that, after seeking to control for drivers of revenues such as passenger growth and retail floor space, that HAL has historically been able to achieve revenue for reasons other than these key known revenue drivers.

As a result, we consider the analysis is at least supportive of the CAA considering a management stretch target for HAL in H7, particularly given the approach that CEPA has taken to index commercial and cargo revenues to forecasts of CPI not RPI inflation. To the extent any inference can be drawn from the modelling of an appropriate level of challenge for H7, we would be minded to give reference to the results of Model 6 which would imply taking a relatively cautious approach to any management stretch target.

We acknowledge that the appropriate management stretch target is dependent on several overlapping issues and ultimately is a judgement that the CAA must make in the context of the overall price control. We believe the CAA should consider the following factors when determining its choice of management stretch target (if any):

- **The extent to which historic macroeconomic trends driving HAL's revenue growth can be expected to continue.** Increases in disposable income per passenger provide opportunities for revenue generation, either through more spending, or a shift towards higher yielding products and services. Similarly, reductions in the strength of GBP relative to other currencies provide short-term boosts to retail revenues.

  However, the extent to which historic increases in disposable income can be expected to continue, or the extent to which we envisage GBP to depreciate further, is uncertain. While qualitative and quantitative

evidence can help inform this consideration, it ultimately requires a regulatory judgement, including judgements on the prospects for the UK economy which we note are relatively uncertain at this time.

- **The extent to which HAL is exposed to known headwinds not explicitly accounted for in our forecasts.** HAL has identified some specific headwinds that they have not explicitly accounted for in its forecasts, including a slowdown in GDP growth and a broader shift towards online shopping instead of in-person shopping, both of which are expected to affect retail income.

  While we consider the former should be considered by the CAA, we are sceptical around the effect of the latter on HAL. Heathrow Airport's retail proposition operates with a largely captive market and is, therefore, in our view less exposed to broader retail trends in the same way that high streets are. While a broader shift towards online shopping may affect retail footfall, it does not necessarily follow that the shift would translate into less spending by those who do visit shops. However, we acknowledge that these are relevant factors in forming a judgement on the level of management stretch potential in H7.

- **The extent to which management action can help mitigate headwinds, and the extent to which such mitigations are already captured elsewhere in our forecasts.** Our forecasts of commercial revenues include several downward overlays for headwinds related to the pandemic, unfavourable tax changes, and the introduction of competing services such as the Elizabeth Line.

  A choice of management stretch target might consider the extent to which these could be mitigated by HAL's management – in ways that are not captured in our modelling – through a change in strategy, contract negotiations, additional marketing spend, etc. However, it would be important to ensure there is not double counting of initiatives implicitly or explicitly accounted for elsewhere.

- **The extent to which management action can drive new revenue growth, and the extent to which HAL may be exposed to further unknown headwinds.**

  Similar to above, management action could be used to exploit new revenue generation opportunities that may arise during H7. This would need to consider whether, on a fair bet basis, the unknown opportunities that may arise during H7 are likely to outweigh the unknown headwinds.

- **The extent to which the CAA provides a capex allowance to drive further revenue growth.** While it is possible for HAL to invest in some smaller capital projects with short pay-off periods without CAA approval, larger capital projects with longer pay-off periods require a specific CAA allowance.

  We have not captured enhancement capex elsewhere within our commercial revenue forecasts, though we understand that the CAA is considering allowing such projects to proceed through the existing capex governance process. Therefore, if the CAA were to allow said enhancement capex plans, it might simultaneously want to consider applying a more stretching target.

- **A management stretch target is a novel regulatory concept in the context of setting a single till price control.** This might suggest a degree of caution is necessary in setting any target, particularly given the imperfect evidence base and the continued uncertainty of demand for air travel in the UK, a point that was highlighted in Frontier Economics' report for HAL.[23] However, as we discuss in the main report, it is important that this point of principle is not over stated given we consider there is precedent of the objective that any management stretch target is seeking to achieve in this context.

[23] Frontier Economics (2021) H7 IP Commercial Revenue Review: A report prepared for Heathrow.

UK

Queens House

55-56 Lincoln's Inn Fields

London WC2A 3LJ

T. **+44 (0)20 7269 0210**

E. **info@cepa.co.uk**

www.cepa.co.uk

Australia

Level 20, Tower 2 Darling Park

201 Sussex Street

Sydney NSW 2000

T. **+61 2 9006 1308**

E. **info@cepa.net.au**

www.cepa.net.au

cepa-ltd @cepaltd