NERA
ECONOMIC CONSULTING

Cost of Equity for Heathrow in H7

A Report for Heathrow Airport

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Executive Summary

Heathrow Airport Ltd commissioned NERA Economic Consulting (NERA) to estimate the cost of equity for Heathrow airport for the H7 price control period, which will set charge caps at Heathrow airport for the period 1 January 2021 to 31 December 2025.

Overall, we estimate a real pre-tax cost of equity for HAL for H7 of 10.5 to 11.4 per cent, assuming no changes in the regulatory framework for H7 compared to Q6 and no investment in the third runway.

We rely on long-run historical realised returns to derive a TMR of 6.5 to 7.1 per cent, and combined with an RfR of -0.9 to 1.5 per cent, an implied ERP of 7.4 to 5.6 per cent

We use a TMR approach to estimating the RfR and ERP, recognising the substantial body of empirical and academic evidence supporting the inverse relationship between the two components of equity market returns. Our approach is consistent with the approach followed by UK regulators including the CMA.

We estimate a TMR based on long-run historical realised returns for the UK market, drawing on different holding periods and averaging techniques as considered by the CMA in its Northern Ireland Electricity (NIE) 2014 determination. This supports a real TMR range of 6.8 to 7.1 per cent (RPI-deflated). We apply a downward adjustment of 0 to 30 bps to the historical returns data to reflect 2010 changes to the ONS methodology of data collection ("formula effect"), which is expected to increase RPI inflation going forward relative to the historical period. Our adjustment takes into account the uncertainty around the magnitude of the effect of the change in data collection on RPI and the appropriateness of applying a single known adjustment, which ignores all other potential changes over the 100+ years of historical data.

We also consider forward-looking evidence on the TMR based on the dividend growth model (DGM) by the Bank of England, consistent with the CMA's approach in its 2014 NIE determination. The Bank of England DGM supports a real TMR estimate of 7.2 to 8.1 per cent (RPI-deflated) based on forward-looking data over the past five years. We recommend that forward looking DGM evidence should be treated with caution, given the sensitivity of the results to dividend growth assumptions. We therefore propose to rely primarily on long-run historical returns in estimating the cost of equity, although we consider that the DGM-based TMR might provide support for setting the TMR and allowed cost of equity in the upper-part of the range indicated by the historical TMR estimates.

Overall, we estimate a TMR in the range of 6.5 to 7.1 per cent, where the bottom end of our range is consistent with the TMR determined by the CMA in its 2014 NIE and 2015 Bristol Water determinations.

Our TMR estimates are higher than the range of 5.1 to 5.6 set out by PwC in its November 2017 report for the CAA on the WACC for H7, which relies on its own subjective forward-looking DGM and market-to-asset ratio (MAR) analysis. As set out in an earlier NERA report for Heathrow from October 2017, we find that PwC's DGM results are downward biased due to low assumptions regarding dividend growth rates based on UK GDP growth. This assumption ignores the fact that FTSE companies derive more than 70 per cent of their earnings from outside of the UK, where expected GDP growth is higher as well as ignores short run dividend forecasts from independent equity analysts, which the Bank of England uses in its DGM analysis. In relation to PwC's MAR analysis, we find that PwC fails to adjust stock market data for key drivers of water companies' valuations (unrelated to the cost of equity) which fully explain PwC's estimated MAR. We also note that PwC makes calculation errors when converting its "adjusted" MAR of 1.1 to an implied TMR, understating the result by 140-180 bps.

In its November 2017 report for the CAA, PwC also presents TMR estimates based on historical long-run returns, including downward adjustment for RPI formula effect and for investors' "good fortune" which are going to repeat itself in the future. PwC's adjustments for "good fortune" are not based on any empirical analysis, and are entirely subjective.

We estimate a risk-free rate (RfR) of – 0.9 to +1.5 per cent. The lower bound is based on current yields of index-linked gilts adjusted to take into account expected increases in gilt yields over the H7 period based on evidence from forward markets. The upper bound is based on long-run evidence, adjusted for current market conditions and recent precedent. We estimate an ERP of 5.6 to 7.4 per cent as the residual, that is, calculated as the difference between the TMR and RfR under our TMR approach.

We estimate an asset beta for HAL in a range between 0.55 and 0.6, drawing on betas for listed comparators Fraport and AdP

We estimate an asset beta for Heathrow for H7 drawing on betas for listed airport comparators Fraport and AdP, which include Frankfurt airport and Charles de Gaulle (CDG) airports as the largest airports in the group, which we consider the closest available comparators for Heathrow, in line with the CAA approach in Q6 (see Table 1).

Table 1
Asset beta estimates for Fraport and AdP

	1Y beta	2Y beta	5Y beta
AdP	0.71	0.55	0.51
Fraport	0.59	0.50	0.44

Source: NERA analysis of Bloomberg and annual reports data. Estimation date: 19 January 2017.
Note: The asset betas are calculated by regressing stock returns against the local index (Eurostoxx) assuming 0.05 debt beta and annual reports net debt.

We first consider to what extent the Fraport and AdP group betas reflect the risk of the large hub airports, Frankfurt and Paris airports respectively, within the group. For Fraport, we find that the share of Frankfurt airport in the overall group is around 80 per cent (measured as share in revenues EBITDA and group assets). For AdP, we find that the overall share of Paris airports is around 64 per cent based on passenger numbers, and increases to over 80 per cent if we include other hub airports such as AdP's share in Schipol or Istanbul Ataturk airports. We also find that beta proxies for the remaining secondary airports are no higher than the respective group betas, and therefore we conclude that the beta of Fraport and AdP is a reasonable proxy of the beta for Frankfurt and Paris airports.

To estimate an asset beta for Heathrow based on Fraport and AdP betas, we assess the relative risk of Heathrow versus its comparators along the dimensions of demand and revenues risk, cost recognition risk and quality of service incentives. We conclude Heathrow is higher risk compared to Frankfurt, as Frankfurt has the right to request a re-determination of revenues of its choosing, e.g. where demand and cost risk deviates from expectations, and has limited exposure to quality of service incentives. We conclude that Heathrow is at least as risky as CDG, and reasonably higher risk given both are subject to a five-year price cap, but CDG benefits from additional demand risk sharing mechanisms, and also faces smaller quality of service incentives compared to Heathrow. Our assessment of relative risk is consistent with our empirical beta estimates, which show that Fraport beta is lower compared to AdP's beta.

We note that in its November 2017 report for the CAA, PwC concluded that Heathrow is lower risk than Frankfurt and CDG airports based on its analysis of demand volatility at the three airports. We explain that PwC's analysis is based on selective evidence and crucially ignores the impact of the regulatory regime on mitigating demand risk at Frankfurt and CDG.

Given the relative risk positioning of Heathrow, the asset beta for H7 should therefore be higher than the beta for Fraport and at least as great as the beta for AdP. We conclude on an asset beta of 0.55 to 0.6 for H7, where the lower bound is towards the upper end of the range for Fraport, reflecting our conclusion that HAL is greater risk than Fraport, while the upper bound is consistent with the broad evidence base for AdP, reflecting our conclusion that HAL is at least as risky as AdP.

<u>Overall, we estimate a real (RPI-deflated) pre-tax cost of equity of 10.5 to11.4 per cent</u>

Based on the above CAPM parameters, and assuming a notional gearing of 60 per cent (in line with Q6) and a tax rate of 17 per cent (in line with latest government proposals), we estimate a real pre-tax cost of equity for HAL for H7 of 10.5 to 11.4 per cent (as shown in Table 2 below).

Our cost of equity estimate is higher than CAA's estimate of 7.1 to 9.5 real pre-tax at Q6. The main reason is our higher beta range of 0.55 to 0.6 (based on 0.05 debt beta) compared to CAA's point estimate of 0.5 (based on 0.1 debt beta), as well as our higher TMR range of 6.5 to 7.1 per cent compared to CAA's determination of 6.25 per cent. As we set out in this report, there are compelling reasons for the CAA to increase its beta estimate from Q6, given the evidence that HAL is higher risk than Fraport, and at least as risky as CDG, contrary to the CAA's conclusions at Q6, as well as increase its TMR for consistency with long-run market evidence.

Table 2
We estimate a real post-tax cost of equity for Heathrow for H7 of 10.5 to 11.4 per cent

	Low	High
Tax rate	17%	17%
Gearing	60%	60%
Total market return	6.5%	7.1%
Risk-free rate	-0.9%	1.5%
Equity risk premium	7.4%	5.6%
Asset beta	0.55	0.60
Debt beta	0.05	0.05
Equity beta	1.3	1.4
Real cost of equity (post-tax)	8.7%	9.5%
Real cost of equity (pre-tax)	**10.5%**	**11.4%**

Source: NERA analysis

1. Introduction

Heathrow Airport Ltd commissioned NERA Economic Consulting (NERA) to estimate the cost of equity for Heathrow airport for the H7 price control period, which will set charge caps at Heathrow airport for the period 2021 to 2025.

In our estimation of the cost of equity, we have assumed the following:

- We estimate the cost of equity assuming Heathrow operates the two existing runways, i.e. our estimate does not account for risk arising from a potential third runway investment;
- We assume that there are no changes to the regulatory regime relative to the Q6 price control period; and,
- We assume H7 will cover a period of five years starting from 1 January 2021, in line with the latest proposals from the CAA.[1]

1.1. Methodology

Our methodology for estimating the cost of equity for Heathrow relies on the application of the Capital Asset Pricing Model (CAPM). The CAPM sets out that the investor's required return on equity can be calculated from two components:

- A Risk-free Rate: which compensates investors for the time value of money, i.e. the fact that they commit capital today to an investment that is expected to pay off in the future; and
- A risk premium – which compensates investors for the fact that the future return on their investment is uncertain. Under the CAPM framework, the only risk that investors are compensated for is the company's non-diversifiable or systematic risk, referred to as beta risk. The premium for risk is calculated as beta times the equity risk premium, defined as the expected return on the market portfolio less the risk-free rate.

Algebraically, CAPM can be written as :

$$R_e = RfR + \beta * (TMR - RfR)$$

where R_e is the return on equity, RfR is the risk-free rate, β is the measure of the systematic risk of the company's equity and TMR is the total return on the market portfolio.

The rest of the report is structured as follows:

- Section 2 sets out our estimate of the Total market Return (TMR) and its constituent elements the risk-free rate (RfR) and the equity risk premium (ERP);
- Section 3 sets out our estimate of the asset beta for Heathrow Airport;
- Section 4 sets out our approach to gearing;

[1] CAA (June 2017), Consultation on core elements of the regulatory framework to support capacity expansion at Heathrow, para 23.

- Section 5 draws conclusions on the cost of equity for Heathrow during H7.

2. Total Market Return

In this section, we set out our estimate of the total market return (TMR) for the H7 period and its constituent elements the risk-free rate (RfR) and the equity risk premium (ERP).

2.1. We use a TMR approach to estimate the cost of equity

2.1.1. Empirical evidence supports stability of TMR over long time-frame

There are two principal approaches to estimating the risk-free rate and ERP components of the CAPM: (i) estimate the risk-free rate and ERP parameters separately, and in combination derive the market cost of equity; (ii) estimate the TMR directly, and the risk-free rate, and derive the ERP as the residual (referred to as the "TMR approach"). As we discuss in this section, we adopt the second approach, consistent with the approach used by the CMA and other UK regulators.

The reason for adopting a TMR approach is the inverse relationship between the RfR and ERP elements of the TMR. Estimating the two parameters separately therefore creates the risk of combining inconsistent estimates, e.g. an RfR based on low short-term market data with a long-run historical ERP, providing an overall TMR which is biased downwards.

Finance theory explains that the negative relationship between the RfR and the ERP is associated with increased risk aversion and the so called "flight to safety" effect during periods of economic and financial crisis. At times of economic uncertainty, investors dispose of risky assets such as equity in favour of risk-free assets such as government bonds. This reduces the price of equities and increases the premia for holding risk while reducing yields on risk free assets, giving rise to the negative correlation between the ERP and the RfR.[2] Empirically, a number of studies find a positive relationship between volatility and expected equity returns and a negative relationship between the RfR and ERP while the TMR remains stable over time.[3] As an example, some of the most compelling evidence is provided by Siegel (1998), who analysed 200 years of US stock market data, which shows a remarkable degree of stability in equity returns over time, in contrast to the risk-free rate and by extension the ERP:[4]

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[2] See for example: (1) Campbell and Cochrane (1999), By force of habit: A consumption-based explanation of aggregate of stock market behaviour, Journal of Political Economy, 107, 205-51; (2) Wright, S. et al. (September 2006), Report on the Cost of Capital – provided to Ofgem, Smithers & Co Ltd; (3) Harris, Robert, and Marston, Felicia (1999) , The Market Risk Premium: Expectational Estimates Using Analysts' Forecasts, Darden Business School Working Paper No 99-08; (4) Maddox, F., D. Pippert and R. Sullivan (1995), An Empirical Study of ex ante Risk Premiums for the electric Utility Industry," Financial Management, 89-95.

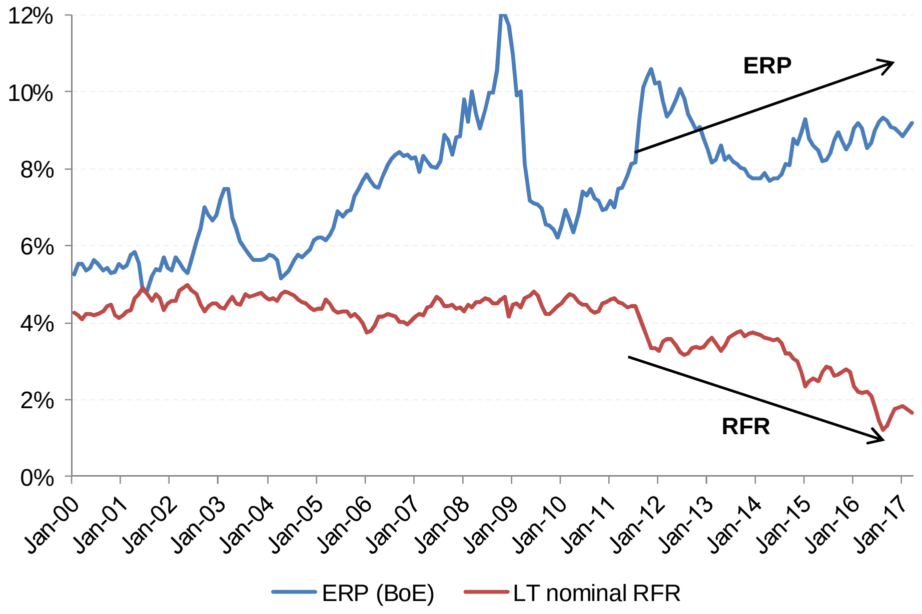
[3] See for example: (1) Graham and Harvey (2010), The equity risk premium in 2010. (2) Cochrane and Piazzesi (2008), Decomposing the yield curve, Graduate School of Business, University of Chicago. Working Paper; (3) Wright, Mason, Miles (2003), A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the UK, Smithers & Company Limited.; (4) Scruggs (1998), Resolving the puzzling intertemporal relation between the market risk premium and conditional market variance: A two‐factor approach. The Journal of Finance, 53(2), 575-603.; (5) Siegel W(1998), Stocks for the Long Run McGraw Hill, Second Edition.

[4] Siegel (1998), Stocks for the Long Run. McGraw-Hill, second edition, p.11, 13.

"the growth of purchasing power in equities not only dominates all other assets but ***is remarkable for its long-term stability****. […] This remarkable stability of long-term real returns is a* ***characteristic of mean reversion****, a property of a variable to offset its short-term fluctuations so as to produce far more stable long-term returns. […]As stable as the long-term real returns have been for equities, the* ***same cannot be said of fixed-income assets****."*

Consistent with financial literature, prominent economic institutions such as the Bank of England have recognised that low interest rates and economic uncertainty have led to increased ERPs.[5] Indeed, the Bank of England's estimates of the ERP derived from its dividend growth model (DGM) have increased markedly with the recent fall in interest rates (see Figure 2.1).

Figure 2.1
Bank of England DGM shows reduction in RfR offset by increases in ERP over recent period



Source: NERA analysis of Bank of England data

The German Bundesbank also noted that there is a strong negative correlation between ERP and risk free rates: [6]

"[…] the correlation between returns from stocks and long-term government bonds is a suitable measure of risk aversion... In times of heightened risk aversion, it is therefore often possible to observe that investors demand higher equity risk premiums or undertake shifts

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5 See for example, Bank of England, (August 2017), Inflation Report, p.1; Bank of England, (August 2016), Inflation Report. The report states: ""*There remains, however, substantial uncertainty about the nature of the UK's future trading arrangement and the implications for competitiveness. This may have increased the risk premium required by investors to hold sterling-denominated assets.*""

6 Deutsche Bundesbank, (Nov 2007), Monthly Report.

from stocks into secure government bonds (safe haven flows). The resulting contrasting price developments of stocks and government securities are accompanied by a negative correlation."

2.1.2. GB regulators use TMR approach

The CMA and other UK economic regulators have acknowledged the negative correlation between the ERP and RfR and the relative stability of the TMR as the principal reason for estimating the TMR directly. For example, the CMA explained that its reason for adopting such an approach is that it provides more stable estimates: [7]

"*Our preferred approach is to deduct our estimate of the RFR from our estimate of the equity market return* [TMR] *to derive the ERP. There are two principal reasons for preferring to calculate the ERP in this manner: first ERP estimates can vary depending on the class of risk-free instruments used in the calculation; second the market return has tended to be less volatile than the ERP […], and there is some evidence of the ERP being negatively correlated with Treasury bill rates over the short term.*"

The CMA and other UK regulators made extensive reference to the analysis of Mason, Miles and Wright in their 2003 study of the cost of capital, commissioned by a consortium of GB regulators ("Smithers report").[8] Drawing on a wide body of research, Smithers & Co noted that there was strong evidence that the realised aggregate stock market return, and by implication the expected market return, has been remarkably stable both over long historical samples and in a wide range of markets. The authors confirm that given the body of evidence on the stability of the TMR, the best approach for estimating future TMR is to draw on realised long term historical averages.

2.1.3. Ofgem re-affirmed use of TMR at most recent GB review (RIIO-ED1)

As part of Ofgem's review of the cost of equity in 2014, Ofgem asked Smithers & Co to review their earlier methodology for estimating the TMR. The authors argued, as they had in 2003, that realised returns are made up of expected returns and a "surprise factor", and over a long enough period, the surprises should cancel out, to give the average expected return. The report recognised that long run averages should be updated for the latest market evidence (which was up to 2000 for its 2003 report), and for certain changes to the ONS calculation of RPI. However, the authors did not consider any further downward adjustment was required for current market evidence, e.g. lower risk-free rates:

"*We conclude that there is no plausible case for any further downward adjustment in the assumed market cost of equity based on recent movements in risk-free rates (or indeed any other "recent market evidence").*"

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[7] CMA (March 2014), NIE Limited price determination, p. 13-16, para. 13.82.

[8] Mason, Miles and Wright (February 2003), A study into certain aspects of the cost of capital for regulated utilities in the UK.

In light of the Smithers review, Ofgem concluded, drawing on Smithers & Co., that the long-run history of realised returns remains the best approach to assessing the equity market return.[9]

Overall, we support a "TMR approach" for estimating the RfR and ERP components of the CAPM cost of equity, consistent with regulatory precedent by the CMA and other UK regulators as well as financial literature which supports an inverse relationship between the RfR and the ERP with the TMR being relatively stable over time. In the next section, we consider latest empirical estimates of the TMR.

2.2. Latest evidence on the TMR

There are two principal approaches to estimating the TMR: to draw on long run historical evidence, or to draw on forward looking estimates based on dividend growth model (DGM). We discuss current estimates of the TMR based on the two approaches in the following sections.

2.2.1. Historical estimates of the TMR

The most common approach to estimating the TMR is to draw on historical realised returns. This approach assumes that historical realised returns provide an unbiased estimate of the expected return over long time periods. As discussed in the previous section, the relative stability of the TMR over time supports the use of long run historical returns as a basis of estimating the expected TMR going forward.

We present long-run historical estimates of the TMR based on data from Dimson, Marsh and Staunton (DMS) database, which provides long-term time series data on returns on stocks, bonds, bills as well as inflation over the period since 1900, i.e. including 117 years of data in the latest publication. The DMS database is the standard reference point for UK regulators including the CMA as well as financial practitioners.[10]

The simplest approach to estimating the TMR based on historical data is to calculate the arithmetic average of historical returns over the longest available period. The use of arithmetic averages is appropriate when the forecasting period is short relative to the observation period and there is no auto-correlation in returns, which appears justified in the context of estimating the TMR for the H7 period.[11] The use of arithmetic mean is also supported by Brealey & Myers, authors of the pre-eminent "Corporate Finance" textbook,

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9 Wright and Smithers (2014), The cost of equity capital for regulated companies: a review for Ofgem, p.2

10 See e.g. CMA (March 2014), NIE Limited price determination, para 13.139

11 DMS finds limited auto-correlation in returns over short time-frames concluding that "*the mean reversion effect is, at best, of modest magnitude" (…),*implying that *"for forecasting the long-run equity premium, it is hard to improve on extrapolation from the longest history that is available…."* E. Dimson, P. R. Marsh and M. Staunton, (2002):"Triumph of the Optimists: 101 Years of Global Equity Returns", Princeton University Press, and E. Dimson, P. R. Marsh and M. Staunton, (2012): "Credit Suisse Global Investment Returns Yearbook 2012", Credit Suisse Research Institute (DMS 2013 Yearbook), Table 10, p. 28 and p. 38.

who state: *"If the cost of capital is estimated from historical returns or risk premiums, use arithmetic averages, not compound annual rates of return.*[12]

Using updated data from the DMS 2017 database, the simple average provides an estimate of the TMR for the UK market of 7.1 per cent (real RPI).[13]

In its 2014 NIE decision, the CMA also presented additional alternative historical TMR estimates using a number of different averaging techniques and holding periods.[14] Table 2.1 below shows an update of the CMA calculations using data over the period 1900-2016 from the latest DMS 2017 publication.

Table 2.1
The latest long-run DMS' TMR estimates lie in range of 6.2 to 7.7 per cent, a slight increase relative to evidence presented by CMA at NIE 2014

	Simple		Overlapping		Blume		JKM	
1Y holding	7.1	+0.0↑	7.1	+0.0↑	7.1	+0.0↑	7.1	+0.1↑
2Y holding	7.5	+0.0↑	7.0	+0.0↑	7.1	+0.0↑	7.1	+0.1↑
5Y holding	7.2	+0.5↑	6.8	+0.0↑	7.0	+0.0↑	6.9	+0.1↑
10Y holding	6.7	+0.3↑	6.7	-0.1↓	6.9	+0.0↑	6.7	+0.1↑
20Y holding	7.7	+1.0↑	6.8	-0.1↓	6.8	+0.0↑	6.2	+0.1↑

Source: NERA calculations using DMS (February 2017),Credit Suisse Global Investment Returns Yearbook 2017 (DMS data since 1988 converted to real RPI-deflated figures as explained in footnote 13), CMA (2014), Northern Ireland Electricity price determination, Final Determination, p. 13-27, Table 13.7.
Note: The figures in black in the table represent different historical estimates considered by the CMA for NIE (2014), calculated using updated DMS data up to 2016.[15] *The figures circled in green represent the difference between the updated estimates and the estimates presented by the CMA in NIE (2014).*

As shown in Table 2.1 , the historical TMR estimates lie in a range between 6.2 and 7.7 per cent, depending on the averaging technique and holding period. The figures circled in green represent the difference between the updated estimates and the estimates presented by the

[12] Brealey. & Myers (2007), Principles of Corporate Finance, 8th ed., p. 151.

[13] Dimson, Marsh and Staunton (February 2017), Credit Suisse Global Investment Returns Yearbook 2017, p.217-220. We note that the 2017 DMS publication includes real returns for the UK market since 1988 which have been calculated using CPI as opposed to RPI inflation. (See DMS (February 2017), Credit Suisse Global Investment Returns Yearbook 2017, p.212.*)* As a result, the DMS reported historical real return for the UK market of 7.3 per cent over the period 1900-2016 should not be interpreted as a real RPI deflated measure. To ensure consistent treatment of inflation, we have re-calculated the real UK historical returns to be based on a RPI deflated basis. This provides an estimate of historical real returns of 7.1 per cent for the UK market over the period 1900-2016.

[14] CMA (March 2014), NIE Limited price determination, p. 13-27, Table 13.7.

[15] The simple approach calculates the arithmetic mean for successive time periods (and therefore there are few observations for long holding periods) and the overlapping approach is identical other than it allows for overlapping time periods. For holding periods greater than 1 year, the simple approach first calculates the compounded nth period return (e.g. for a 5-year holding period, it calculates the 5-year compound return earned in the consecutive periods 1-5, 6-10, 10-15 etc.), and then takes an average of these 5-period compound returns. The overlapping approach is identical other than it allows that the compound 5-year return is calculated for periods 1-5, 2-6 etc. The Blume adjustment takes a weighted average of the arithmetic and geometric returns, and the JKM is a statistical approach that provides efficient estimates for small samples, but this adjustment also effectively produces unbiased estimates of the nth period return as a weighted average of the geometric and arithmetic averages over the observation period.

CMA in the NIE 2014 determination. On average, the updated estimates show a marginal increase relative to the estimates presented by the CMA in 2014. At the NIE 2014 decision, the CMA concluded that the long run historical data supported a TMR range of 6 to 7 per cent.[16]

Table 2.1 shows that the assumed holding period is an important factor in estimating the TMR. We consider evidence supports the use of relatively short averaging periods for the following reasons:

- GB regulators such as Ofgem and Ofwat have typically considered the TMR for a holding period of 1 year.
- The use of short-term holding periods is consistent with evidence from a survey of equity market participants by the CFA Institute UK that suggests that the average holding period is between 1-2 years.[17]
- Helm and Tindall (2009)[18] find that most utilities are held by private equity or infrastructure funds, where the former have an average holding period of 4-5 years while the latter tend to be more long-term.

Overall, we consider the historical evidence supports a TMR range of 6.8 to 7.1 per cent. The top end of our range is based on the simple average of historical realised returns, as used by regulators in the past and supported by financial literature. For the bottom end of our range, we draw on the range of alternative averaging techniques and holding periods considered by the CMA in its NIE 2014 decision but with the exception of: i) simple average estimates based on long holding periods, as these estimates are based on a small number of observations; ii) very long holding periods of 10 and more years which are not supported by empirical evidence on investor behaviour. This supports a bottom end of the TMR range of 6.8 per cent.

2.2.1.1. Changes to the calculation of RPI, and conclusions on historical TMR

At recent reviews regulators have discussed changes to how RPI inflation is measured and the implications for setting real RPI allowed rate of return going forward. In 2010 the ONS modified the way certain clothing and footwear price indices were collected. The change in data collected raised the variation of the relevant samples and had an impact on the relative difference between RPI and CPI, because they are calculated using different formulae at the lowest level of aggregation: arithmetic and geometric means respectively. The ONS concluded that, going forward, the wedge between RPI and CPI attributed to differences in the formulae ("the formula effect") increased by about 32bps as a result of this change.[19]

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[16] CMA (March 2014), NIE Limited price determination, p. 13-27, para. 13.141.

[17] Kay Review of UK Equity Markets and Long-Term Decision Making, Interim Report, Feb 2012I; CFA UK response to the Kay Review of UK Equity Markets and Long-Term Decision Making – Call for Evidence

[18] Helm and Tindall (November 2009), The evolution of infrastructure and utility ownership and implications, *Oxford Review of Economic Policy,* Vol 25, pp 411 – 434

[19] ONS (December 2010), CPI and RPI: Increased impact of the formula effect in 2010, p. 1.

We have considered whether there is a clear rationale for an adjustment to the real historical realised return data to reflect the relative increase in RPI post 2010. Primarily, we note that the 2010 change in the way RPI is measured represents only one of potentially many changes to RPI over the historical period since 1900. Indeed, the DMS returns data relies on RPI as a measure of inflation only from 1962 onwards with an "index of retail prices" used for earlier years.[20] If the CAA makes a change for the 2010 adjustment, for consistency, it needs to analyse and correct for all other historical methodological changes to RPI and its predecessor indices, some of which may have had large quantitative effects. For example, the ONS publishes a new Consumer Price Indices Technical Manual every year detailing many other changes, which may have opposite and off-setting effects.

However, it is not practicable for the CAA to consider all changes to RPI and its predecessors. To take a recent example, a 2015 OBR report shows that the OBR has revised downwards its estimate of the RPI-CPI wedge because of a downward revision to the "weights effect" from 0 to -0.4 per cent.[21] As OBR notes, part of this difference *"represents interactions between categories, in particular between the formula and weights effect"*. This shows the change in the weights effect may have potentially offset an increase in the "formula effect" arising from the 2010 changes to the method for collecting clothing, as identified by ONS as 32 bps. In practice it is simply not possible for the CAA to review every change in RPI over the past 100 years and adjust the historical real returns data accordingly, not least due to data limitations. Furthermore, the CAA would also need to be informed about every quantitatively important change to RPI in the future to avoid "cherry-picking" a single negative adjustment. The ONS has an ongoing programme of reviewing price index collection, which may reverse the formula effect in the future.

In the absence of a detailed review of all historical changes to the RPI (and its predecessors), we consider 30bps to be the maximum value for any adjustment.[22] Given that the RPI has undergone other structural changes in the past, and will continue to do so in the future, it would be selective to adjust for this effect without considering the possible effect of other changes to the way RPI is (or will be) calculated. To reflect the uncertainty over other adjustments and the impracticality of identifying all changes, we consider that it is reasonable to make no adjustment at all.

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[20] Dimson, Marsh and Staunton (February 2017), Credit Suisse Global Investment Returns Yearbook 2017, p.212.

[21] OBR (March 2015), Economic and fiscal outlook, p.62. Link: http://obr.uk/docs/dlm_uploads/March2015EFO_18-03-webv1.pdf

[22] Our estimate is based on the difference between RPI and RPIJ at the time of the change to the structure of RPI. As we explain in a previous NERA report, a comparison of RPI and RPIJ is a more appropriate method for estimating the increase in RPI due to the methodological change that ONS implemented in 2010. By contrast, the "formula effect", as defined and calculated by ONS, can be summarised as "the difference between the CPI and RPI" arising from different formulae used to aggregate price changes. However, the formula effect measures the difference between the actual CPI and a recalculated CPI using the RPI formula. Put simply, it is the effect of the RPI formula on the CPI, not the effect of the RPI formula on the RPI. Since the two indices differ in other ways (e.g. they include different items and place different weights on the items they both include) these two effects may not be identical. See: NERA (2014) Review of Ofgem's Estimate of the RPI Formula Effect, Section 2. Link: https://www.spenergynetworks.co.uk/userfiles/file/App14_201408_NERA_ReviewOfOfgemEstimateRPIFormulaEffect.pdf

In conclusion, assuming the maximum value for the adjustment for the RPI formula effect of 30 bps, we conclude historical data supports a lower bound TMR of 6.5 per cent, equal to the 6.8 per cent lower bound historical TMR minus 30 bps for the RPI effect. We make no adjustment to our upper-bound value of 7.1 per cent to reflect the uncertainty over other off-setting adjustments.

2.2.2. Forward looking estimates

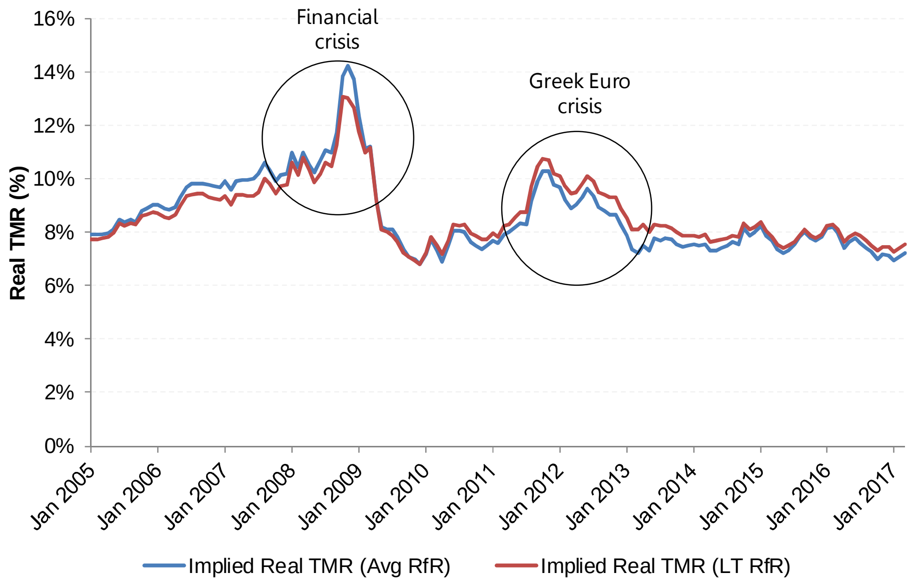
As an alternative to the long-run historical approach, the TMR can be calculated based on forward looking evidence, as derived using the dividend growth model (DGM). At previous reviews, the CMA as well as other regulators used evidence from the DGM as a cross-check on the TMR estimated from long-run historical data.[23]

The DGM solves for a discount rate which equates the present value of future expected dividends to the current stock price. If applied to the entire market index (e.g. FTSE 100), the discount rate implied by the DGM reflects the expected return on the whole market (i.e. the TMR).

Figure 2.2 below shows estimates of the TMR from the Bank of England. The Bank of England estimates the TMR for the FTSE 100 index, using equity analyst estimates of short-term dividend growth and a long-run dividend growth assumption based on long-run GDP growth estimates for the different regions from which FTSE 100 companies derive their earnings.

23 See e.g. Ofwat (January 2014), Setting price controls for 2015-20 - risk and reward guidance, section A1.4 or CMA (March 2014), NIE Limited price determination, para 13.137.

Figure 2.2
Bank of England DGM shows TMR has been relatively stable, with elevated values during GFC and Greek Euro crisis



Source: NERA analysis of Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.94 and Bank of England yield curve data.
Note: The Bank of England estimates the DDM using a time varying risk-free rate for all maturities (where available) and a long-run risk-free rate assumption. We calculate a TMR as the sum of the Bank of England's reported ERP and an i) average of the real risk-free rate for all available maturities and 2) the real risk-free rate at the longest maturity available.

As can be seen from Figure 2.2, the TMR estimate from the DGM has been relatively stable over time, with the exception of the global financial crisis period as well as the Greek euro crisis period where it showed elevated values. The relative stability of the TMR supports the theory that the recent reductions in the risk-free rate have been offset by increases in the ERP resulting in a stable TMR over time (as discussed in detail in section 2.1).

Table 2.2 below shows the current estimates of the TMR based on Bank of England DGM data. To smooth for volatility in equity markets, we present evidence of the forward-looking TMR for spot (March 2017 in line with latest data from the BoE) as well as 1 and 5 year historical averaging periods.

Table 2.2
Bank of England DGM support a real TMR in the range of 7.2 to 8.1 per cent

	Spot (Mar 2017)	1Y average (Mar 2017)	5Y Average (Mar 2017)
BoE TMR (average RfR)	7.2	7.3	7.8
BoE TMR (LT RfR)	7.6	7.6	8.1

Source: NERA analysis of Bank of England (2017), An improved model for understanding equity prices, Quarterly Bulletin 2017Q2, p.94 and Bank of England yield curve data using March 2017 as cut-off date (later data from BoE on the TMR not available)
Note: The Bank of England estimates the DDM using a time varying risk-free rate for all maturities (where available) and a long-run risk-free rate assumption. We calculate a TMR as the sum of the Bank of England's reported ERP and an i) average of the real risk-free rate for all available maturities and ii) the real risk-free rate at the longest maturity available.

Depending on the averaging period, the forward-looking estimates of the real TMR based on the Bank of England's DGM lie in a range between 7.2 and 8.1 per cent. The forward looking estimates are therefore higher compared to the historical estimates discussed in section 2.2.1.

2.3. TMR – conclusion

In deriving the TMR for HAL for the H7 period, we recommend to rely on long-run historical averages as the primary source of evidence, with forward looking estimates based on the DGM used only as a cross-check.

We consider forward looking evidence should be treated with caution, given the relative sensitivity of the results to the long-term dividend growth assumption, for which there are no equity analyst forecasts available. The use of historical evidence as a measure of the expected TMR is supported by the stability of the TMR over time as documented in financial literature.

In summary, we recommend a TMR in the range between 6.5 and 7.1 per cent for H7, in line with our estimates based on historical data. Forward looking evidence supports a higher TMR estimate between 7.2 and 8.1 per cent. We note that the bottom end of our TMR range is consistent with the latest precedent on TMR by the CMA from its 2014 NIE and 2015 Bristol water determinations.[24]

2.4. Comment on PwC estimates of the TMR presented for the CAA

In its November 2017 report prepared for the CAA, PwC presented a preliminary view of the cost of capital for H7 including a view of the TMR.[25] In its report, PwC argues that the low risk-free rate environment resulted in reductions in the TMR and recommends a real TMR

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[24] CMA (March 2014), NIE Limited price determination, p. 13-39, Table 13.11 and CMA (October 2015), Bristol Water plc, A reference under section 12(3)(a) of the Water Industry Act 1991, Report, p332, para 10.186.

[25] PwC (November 2017), Estimating the cost of capital for H7: A report prepared for the Civil Aviation Authority (CAA), link: http://publicapps.caa.co.uk/docs/33/PwC_H7InitialWACCrange.pdf.

estimate of 5.1 to 5.6 per cent (RPI-deflated) for H7 based on *current* approaches (DGM and market-to-asset ratio analysis). PwC's recommendations to the CAA on the TMR for H7 largely draw on PwC's earlier report prepared for Ofwat on cost of capital for water companies for PR19 (2020-2024) published in June 2017 and updated in December 2017.[26]

2.4.1. PwC current (forward-looking) estimates are unreliable

In our October 2017 NERA report for HAL, [27] we demonstrated that PwC's approach to estimating the TMR in its June 2017 report for Ofwat is flawed and leads to a substantial understatement of the TMR. Our criticisms apply equally to PwC's estimated TMR range for H7, which draws on the same methodology as applied by PwC in its June 2017 report for Ofwat.

In our October 2017 report, we demonstrated that there is no evidence that the TMR has declined in the current market environment as argued by PwC in its June 2017 report for Ofwat. PwC presents evidence seemingly showing a decline in *realised* equity or total market return over recent periods for the UK, which it considers demonstrates that investors' *expected* returns are lower in the current period of low interest rates. In our report, we showed that PwC's evidence is weak and selective, and that only slight changes to its approach, e.g. the period selected, can substantially change the results of the analysis. We also show that in most major equity markets the realised TMR has increased over the recent period, a direct contradiction of PwC's conclusions. We also note that it is unsafe to draw conclusions from short-term market data, given the volatility of stock market returns and the high standard errors of the means, an accepted point in the academic literature.[28]

In October 2017 report, we also highlighted errors in PwC's DGM and MAR calculations which result in a substantial understatement of the TMR recommended by PwC. As we explain below, PwC failed to address these errors in its November 2017 report for the CAA.

2.4.1.1. PwC has failed to correct for its errors in DGM

In our October 2017 report, we showed that PwC's DGM estimate of the TMR of 5.4 to 5.8 per cent (real RPI) is low compared to independent estimates from the Bank of England, which support a range of 7.2 to 8.1 per cent, as we set out in Table 2.2 above. We explained that PwC's DGM is understated, due to implausibly low assumptions around dividend growth rates, a key determinant of the implied TMR. PwC assumes that FTSE dividends grow in line with short-term and long-term nominal growth in UK GDP, but provides no basis for its assumption that UK GDP forecast growth rates are a good proxy for investors' expectations of dividend growth rates. PwC's assumption is flawed, not least because FTSE companies derive over 70 per cent of their earnings from outside of the UK, which have higher forecast

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[26] PwC (June 2017), Refining the balance of incentives for PR19, link: https://064f1d25f5a6fb0868ac-0df48efcb31bcf2ed0366d316cab9ab8.ssl.cf3.rackcdn.com/wp-content/uploads/2017/07/PwC-Balance-of-incentives-June2017.pdf and PwC (December 2017), Updated analysis on the cost of equity for PR19, link: https://www.ofwat.gov.uk/wp-content/uploads/2017/12/PwC-Updated-analysis-on-cost-of-equity-for-PR19-Dec-2017.pdf.

[27] NERA (October 2017), A review of PwC's approach to setting cost of equity in a "lower for longer" era.

[28] NERA (October 2017), op. cit., section 2.3

GDP growth than the UK. In addition, UK GDP forecast growth rates in the short term are somewhat depressed (e.g. due to Brexit) and are substantially lower than independent analyst forecasts of dividend growth rates for FTSE stocks, which are used by the Bank of England to forecast short-term dividend growth in its DGM[29]

In its December 2017 updated report for Ofwat, PwC acknowledged that FTSE companies derive a substantial portion of its earnings from outside of the UK but argued that its reliance on UK GDP growth as a proxy of future dividend growth is appropriate, as its objective is to derive a TMR for the UK market, as opposed to a world TMR.[30] PwC's approach is illogical: In drawing on a FTSE stock market value and FTSE dividend payments for its DGM, both of which reflect UK and foreign earnings, PwC must use a consistent dividend forecast, i.e. also based on UK and foreign GDP. The alternative would be to construct a UK only FTSE index and UK only dividend payments, to which PwC could then apply a UK only GDP growth rate.[31] But this is not PwC's proposed approach nor a reliable one.

2.4.1.2. PwC MAR's estimates also inconsistent with independent forecasts, and based on error

In relation to the MAR analysis presented by PwC in its June 2017 report for Ofwat, our October 2017 report showed that PwC fails to adequately adjust for important drivers of water companies' valuations, including value of non-regulated activities, value of regulated activities unrelated to wholesale, value of pension deficit/surplus, as well as expected outperformance. The value of these adjustments is subject to substantial uncertainty, but evidence from independent analyst reports suggests that the regulatory capital value (RCV) premium calculated by PwC is fully explained by these factors, and there is therefore no evidence that the "adjusted" MAR for listed water companies is different from 1.[32]

We also showed that even if we were to accept PwC's calculation of the "adjusted" MAR for listed UK water companies of around 1.1 (which we do not), PwC's calculations of the implied TMR of 4.7 to 5.2 per cent based on this MAR include two methodological errors, confusing real and nominal terms and ignoring real growth in RCV, which lead to PwC understating the implied TMR by 140-170bps.[33]

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[29] NERA (October 2017), op. cit., section 3.2.

[30] PwC (December 2017), Updated analysis on the cost of equity for PR19, para 4.30-4.31.

[31] In other words, PwC uses the DGM to calculate an implied TMR for the UK stock market index (FTSE). This is done by calculating the discount rate which equates the current value of the FTSE index to the discounted stream of expected future dividends paid by FTSE companies. As acknowledged by PwC, FTSE companies derive a substantial portion of their earnings from outside of the UK. The value of the FTSE index is therefore, by definition, affected by companies' expected earnings from the UK and abroad. To forecasts future dividends for FTSE companies, it is therefore necessary to take into account both the evolution of expected earnings from their UK and foreign operations. Relying on UK GDP growth only, which is lower than forecast growth from abroad, results in an understatement of the implied TMR by PwC. This is because the value of the FTSE index, by definition, includes the effect of FTSE companies' foreign operations, while PwC's projections of dividends do not.

[32] NERA (October 2017), op. cit., section 3.3.

[33] NERA (October 2017), op. cit., section 3.4. Specifically, PwC incorrectly interprets the MAR to represent a ratio of the allowed rate of return and investors' expected cost of capital nominal as opposed to real terms, which is incorrect for UK water companies and leads to an understatement of the TMR by PwC. In backing out the implied expected cost of

In its December 2017 updated report for Ofwat, PwC argued that it did not ignore growth in RCV in its MAR analysis. Specifically, PwC stated that in estimating the present value of expected cost and incentive outperformance, its calculations included an assumption on future growth in the RCV and there is therefore no need for an adjustment to reflect RCV growth.[34]

Taking into account growth in RCV in calculating the value of cost and incentive outperformance only partially addresses the impact of a growing RCV on the observed MAR. RCV growth must also be taken into account when backing out the "implied" TMR from the "adjusted" MAR, even after having adjusted for RCV growth on cost and incentive outperformance. Any "outperformance" of the cost of equity will result in a higher observed MAR *the higher the expected real growth in RCV*, because the effect of this outperformance is compounded with the expected growth in the RCV. As we show in our report, PwC fails to take this RCV growth into account in backing out the TMR, resulting in its implied TMR being understated.

In our report, we concluded that PwC's errors in its DGM and MAR analysis result in a substantial understatement of the TMR under the current (forward-looking) approaches and conclude the only reliable approach is to draw on independent estimates by the Bank of England which support TMR of 7.2 to 8.1 per cent (as shown in Table 2.2).

2.4.2. PwC adjustments to long-run historical evidence are unjustified

In its November 2017 report for the CAA, PwC also presents TMR estimates based on long-run historical averages, but makes two adjustments to the long-run average historical returns:[35]

- RPI Formula effect: PwC adjust historical returns downward by 30 bps to reflect changes in how RPI is measured since 2010 (see section 2.2.1 for discussion of the RPI formula effect).
- Forward looking returns adjustment: PwC state that Dimson, Marsh and Staunton (the source for the long-run historical returns data) believe that half of long-run historical dividend growth for global equities arises from past "good fortune" embedded in long-run historical equity returns data. PwC argues this allowance for "good fortune" should not be reflected in forward-looking estimates of the TMR and estimates a 0.4 per cent downward adjustment to the long-run historical TMR for the UK.

As discussed in section 2.2.1, in the absence of a detailed review of all historical changes to the RPI (and its predecessors), we consider 30bps is the maximum plausible value for any adjustment to historical returns to reflect the 2010 ONS change to RPI. Given that the RPI has undergone other structural changes in the past, and will continue to do so in the future, it

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equity and TMR, PwC also implicitly assumes zero real growth in RCV, which results in an understatement of the implied TMR given expected positive real growth in the RCV for water companies.

[34] PwC (December 2017), Updated analysis on the cost of equity for PR19, para 5.8.

[35] PwC (November 2017), Estimating the cost of capital for H7: A report prepared for the Civil Aviation Authority (CAA), para 5.38-5.43.

would be selective to adjust for this effect without considering the possible effect of other changes to the way RPI is (or will be) calculated. To reflect the uncertainty over other adjustments and the impracticality of identifying all changes, we consider that it is also reasonable to make no adjustment at all.

On the forward looking adjustment, we consider that an adjustment for historical "good fortune" is not appropriate for estimating equity returns going forward. PwC's adjustment is based on Dimson, Marsh and Staunton, who argue that "***if we assume*** *that the historical real growth rate of dividends on the world index was at least half attributable to past good fortune, then the prospective premium on the world index declines*".[36] As demonstrated by the DMS quote, the adjustment for good fortune can only be considered as illustrative, rather than an objective adjustment based on evidence of historical good fortune. In the absence of any firm evidence that historical growth in dividends may be due to good fortune (equally, they may be understated by "bad fortune"), we do not consider an adjustment to historical realised returns is appropriate.

For these reasons, we do not consider that PwC's adjustments to long-run average historical returns are reasonable, and conclude that the historical evidence supports a TMR range of 6.5 to 7.1 per cent (real RPI), as we set out above.

2.5. Division of TMR between RfR and ERP

There are two broad approaches used by UK regulators to estimate the RfR (and therefore ERP) components of the TMR: i) relying on long-run historical averages or ii) relying on short-run market evidence, such as spot or forward rates.

2.5.1. Long-run estimates

Long-run estimates of the RfR based on UK government bonds yields as calculated by DMS over the period 1900-2016 suggest a long-run RfR estimate for the UK of 2.5 per cent.[37]

2.5.2. Short-run market evidence

Government bond yields in the UK and internationally have been falling steadily since the global financial crisis, reflecting the impact of central banks' unconventional monetary policy and quantitative easing aimed at stimulating economic recovery. In the UK, government bond yields have fallen further following the Brexit vote in 2016 and the Bank of England's reaction by further loosening of monetary policy, resulting in yields reaching historical lows around negative 2 per cent (real) since the summer of 2016.

However, current market expectations suggest a reversal in the trend of falling interest rates in the future in the UK and internationally, with faster than anticipated rate increases. In its November 2017 statement, the Bank of England announced the first increase in the base rate

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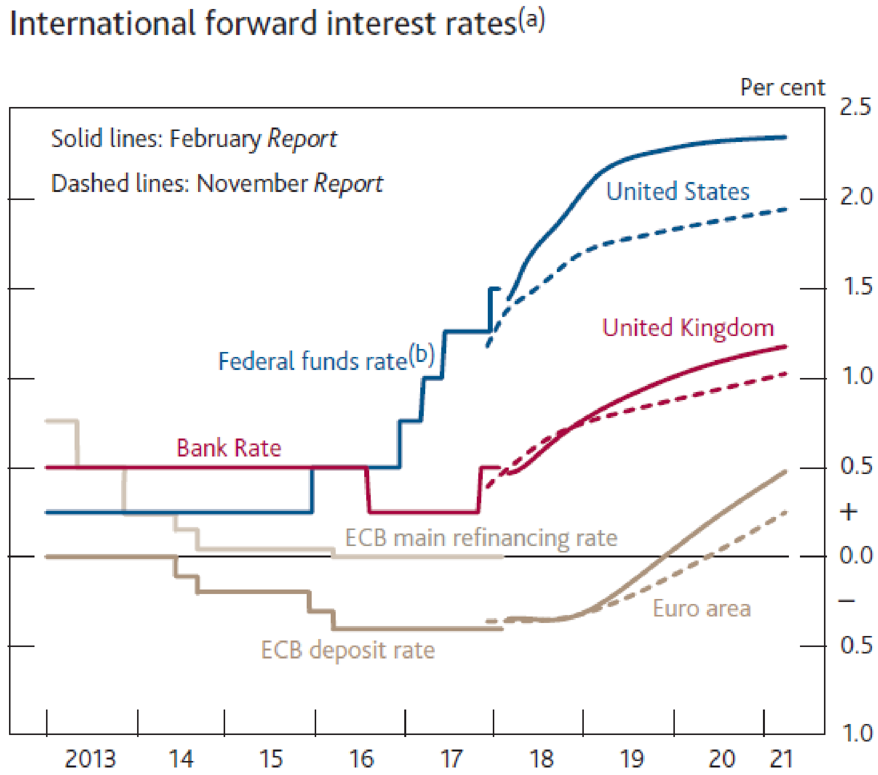
[36] Credit Suisse Global Investment Returns Yearbook 2017, p37.

[37] Calculated based on DMS bond returns data, adjusted post 1988 deflated using RPI inflation. See footnote 13 for details.

since 2007 from 0.25 to 0.5 per cent, with markets expecting further increases in the near future (as shown in Figure 2.3 below).[38]

Figure 2.3
Bank of England data shows markets expect further base rate increases in the near future



Source: Bank of England, (February 2018), Inflation Report, p.4.

Latest data from the Bank of England's February 2018 Inflation Report suggests that current market expectations imply faster than anticipated increases in UK interest rates compared to earlier forecasts.

Evidence from forward gilt rates suggests markets are expecting real yields to increase in the run-up to and during the H7 period. As shown in Figure 2.4 below, current yields on 10Y government bonds are around -1.8 per cent in real terms and forward rates indicate that the market expects these yields to increase to around -0.9 per cent on average over the H7 period.[39]

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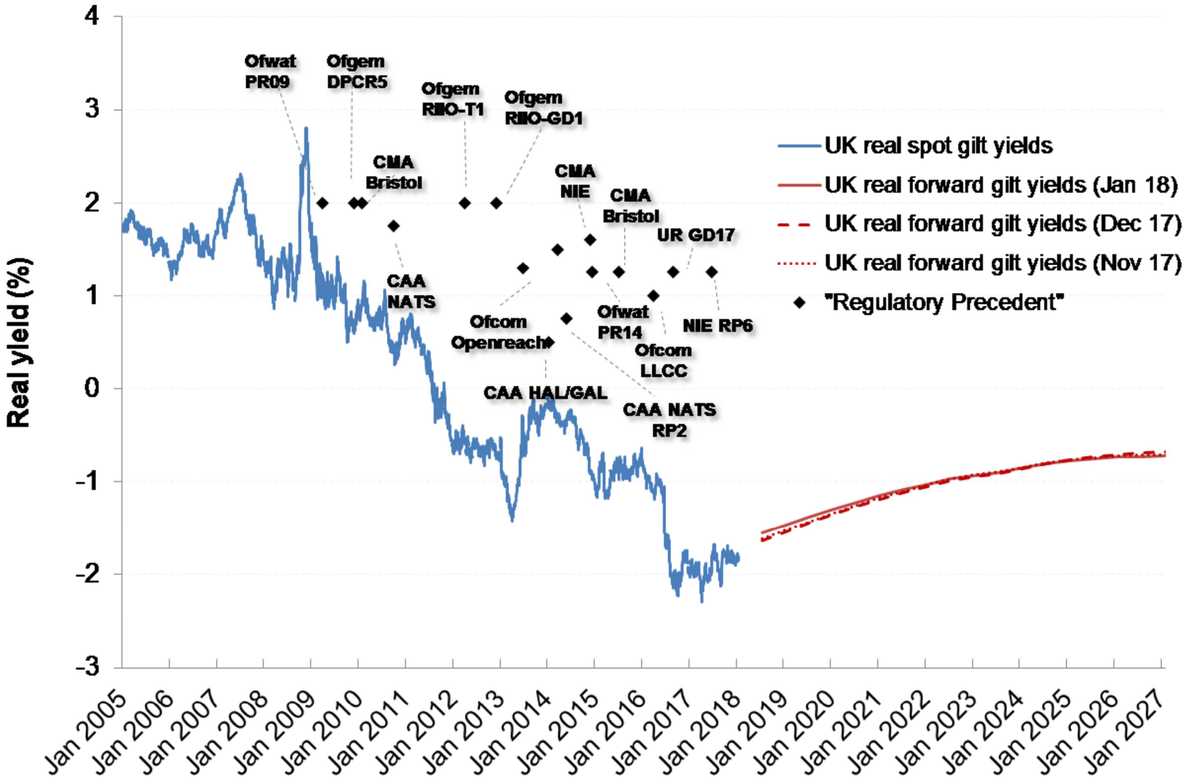
38 Bank of England (November 2017), Inflation report.

39 Calculated based on a 3-month average of forward rate evidence from Bloomberg.

Figure 2.4
Spot and forward evidence supports a RfR below zero per cent (real)



Source: NERA analysis of Bloomberg data, Bank of England data and regulatory precedent, cut-off date 19 January 2018.

As can be seen from Figure 2.4 and Table 2.3, at recent reviews, UK regulators generally placed greater weight on long-run evidence on the RfR, with some downward adjustment to long-run data to reflect the lower spot and forward yield evidence.

Table 2.3
Regulators have not generally drawn on low spot and forward yield evidence at recent reviews

Decision	Date	Real RfR
Ofwat PR09	April 2009	2.0%
Ofgem DPCR5	December 2009	2.0%
CMA Bristol	February 2010	2.0%
CAA NATS	October 2010	1.75%
Ofgem RIIO-T1	April 2012	2.0%
Ofgem RIIO-GD1	December 2012	2.0%
Ofcom Openreach	March 2013	1.3%
CAA Heathrow/Gatwick Q6	January 2014	0.5%
CMA NIE	March 2014	1.5%
CAA NATS RP2	June 2014	0.75%
Ofgem RIIO ED1	November 2014	1.6%
Ofwat PR14	December 2014	1.25%
CMA Bristol	October 2015	1.25%
Ofcom LLCC	April 2016	1.0%
UREGNI GD17	September 2016	1.25%
UREGNI NIE RP6	June 2017	1.25%

Source: NERA analysis of regulatory determinations

Taking into account the market evidence as well as regulatory precedent, we recommend an RfR range for H7 of -0.9 to +1.5 per cent. The upper bound of 1.5 per cent for the RfR is based on long-run historical evidence adjusted for current market conditions. The lower bound of - 0.9 per cent draws on current market evidence of low government bond yields but allows for an increase relative to the prevailing spot rate to reflect expected future increases in interest rates in the run up to and during H7 based on evidence from forward markets.

Table 2.4 summarises our recommendations on the TMR and how this should be split between the RfR and ERP components.

Table 2.4
We recommend a TMR of 6.5 to 7.1 per cent, with a RfR of -0.9 to 1.5 per cent and an implied ERP of 5. 6 to 7.4 per cent

	Lower bound	Upper bound
TMR	6.5 %	7.1 %
RfR	-0.9 %	1.5 %
ERP	7.4 %	5.6%

Source: NERA calculations

3. Beta

In this section, we present our estimate of the asset beta for HAL for the H7 period. As explained in the introduction, we estimate a beta for HAL assuming no investment in the third runway and no changes to the regulatory regime compared to the Q6 period.

The CAPM beta measures the systematic risk of a stock, i.e. the portion of risk that is correlated with the market portfolio. For publicly listed companies, betas can be estimated directly by regressing the stock return against the return on the market portfolio. However, following the de-listing of BAA stock in 2006, this approach is not possible for Heathrow. Instead, we estimate beta for Heathrow based on empirical evidence on betas for relevant comparator companies. We consider evidence on betas for listed airport comparators in section 3.1. Beta evidence for comparators also needs to be carefully interpreted taking into account differences in relative risk, as we discuss in section 3.2.

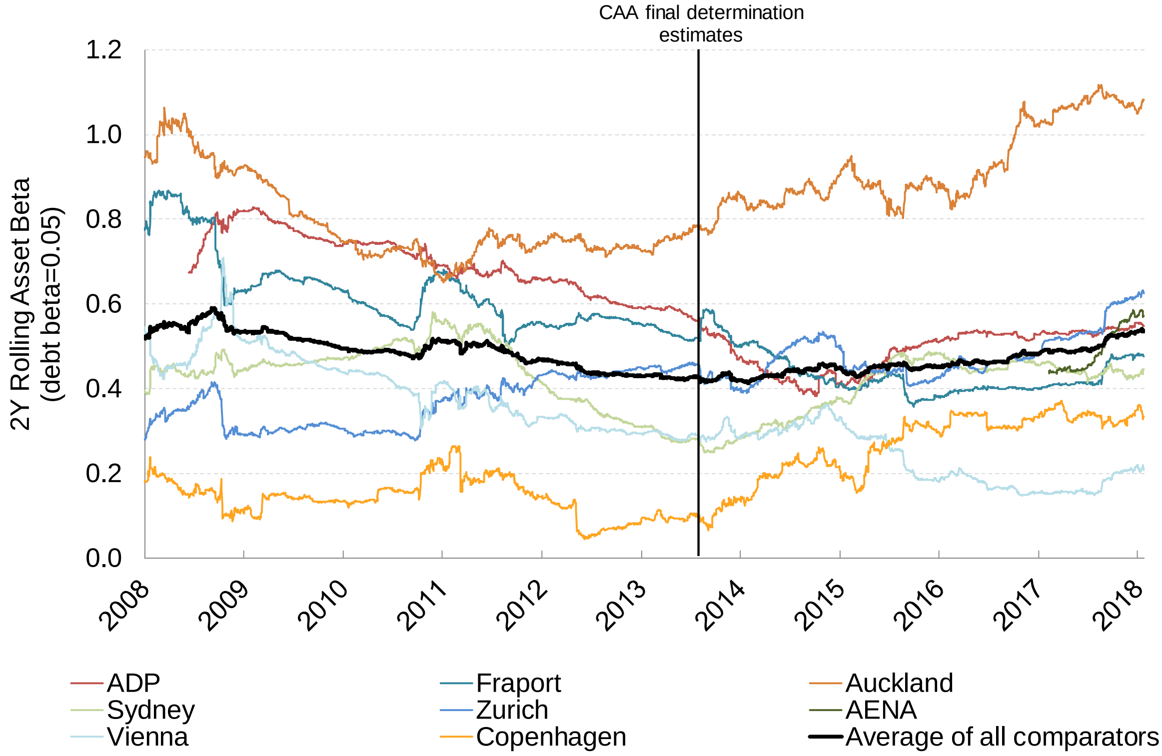
3.1. Comparator beta evidence

In this section, we present evidence on empirical betas for listed airport comparators, using the same comparator set as considered by the CAA and its advisors PwC in Q6.[40]

Figure 3.1 below shows 2-year rolling asset betas for the listed airport comparators.

[40] We exclude Rome and Florence airports which were de-listed in 2013 and 2015 respectively. We also include AENA, a European airport operator which manages airports in Spain and overseas, which was listed in February 2015.

Figure 3.1
2-year rolling asset betas for listed airport comparators



Source: NERA analysis of Bloomberg data
Note: The comparator asset betas are calculated against the local/regional index (Stoxx Europe for European airports and local indices for Australian/New Zealand airports), assuming 0.05 debt beta and Bloomberg net debt

As shown in Figure 3.1, on average, betas for listed airport comparators have on average increased slightly since the Q6 determination. This increase may potentially reflect the unwinding of the effect of "flight to safety" which depressed betas for regulated assets during the global financial crisis.[41]

We have estimated the betas for the wider set of comparators using the technical estimation techniques described below. We have also considered the sensitivity of beta estimates for AdP and Fraport, the principal comparators employed by CAA at the last review (as discussed in section 3.2), for a number of technical issues as follows:

- Data frequency: We estimate comparator betas using daily data. In estimating betas, there is a trade-off between data of higher frequency (e.g. daily), which provide greater number of observations and lead to statistically more robust beta estimates, and data with

[41] During times of financial crisis and heightened market volatility, asset betas for regulated assets such as utilities or indeed airports which are considered as "defensive" stocks are depressed, due to the reduction of relative volatility compared to the market. As the world economy normalises post-GFC and market volatility returns to normal levels, we observe betas for regulated assets return to their previous pre-crisis levels.

lower frequency, which may be more appropriate if the relevant stock is illiquid where the use of higher frequency data may result in understating the co-movement of the stock and the market due to asynchronous trading. As our comparator set includes major listed airports with bid-ask spreads below 1 per cent, we do not expect illiquidity to be an issue and therefore rely on daily data which produces more statistically robust beta estimates.

- Estimation window: We present betas 2 year estimation windows, but also consider 1 and 5 year estimation windows for AdP and Fraport, CAA's principal comparators. The choice of the estimation window should be sufficiently long to produce robust statistical estimates and should also take into account the impact of wider market conditions on beta estimates (e.g. the impact of the GFC) and to what extent these factors are expected to prevail over the next regulatory period.
- Market index: We present beta estimates using local or regional indices. For the European airports, we use a Europe-wide index (Stoxx Europe 600), reflecting the fact that a European investor is likely to diversify his portfolio across the European market given common currency in major countries and free capital movements, while for the other international airports we use a local index. However, we also show the sensitivities for AdP and Fraport betas with respect to the world index for which we use the FTSE all world.
- Gearing and debt beta: To convert the estimated equity beta into an asset beta, we assume a debt beta of 0.05, based on regulatory precedent in a range between 0 and 0.1 and consistent with PwC recommendations for H7.[42] We use net debt as reported by Bloomberg. For Fraport and AdP, our two main comparators, we also show the results using net debt as reported in the companies' annual reports, which reflects additional cash-holdings not taken into account by Bloomberg (particularly relevant for Fraport).

[42] For example, the CMA for Bristol water in 2010 used a debt beta between 0 and 0.1, for NIE in 2014 a debt beta of 0.05 and for Bristol water in 2015 a debt beta of 0. In its November 2017 report for the CAA on H7 WACC, PwC estimated betas for airport comparators assuming a debt beta of 0.05. Source: CMA (then CC) (August 2010), Bristol Water plc, A reference under section 12(3)(a) of the Water Industry Act 1991, Report, Appendix N, p N32, para 177; CMA (March 2014), NIE Limited price determination, p. 13-38, Table 13.10; and CMA (October 2015), Bristol Water plc, A reference under section 12(3)(a) of the Water Industry Act 1991, Report, p325, para 10.150.

Table 3.1
Sensitivity of asset beta estimates for AdP and Fraport, HAL's principal comparators

	European index			World index		
	1Y	2Y	5Y	1Y	2Y	5Y
Bloomberg net debt						
AdP	0.71	0.55	0.50	0.90	0.68	0.59
Fraport	0.57	0.48	0.42	0.75	0.66	0.56
Annual report net debt						
AdP	0.71	0.55	0.51	0.90	0.69	0.60
Fraport	0.59	0.50	0.44	0.77	0.69	0.59

Source: NERA analysis based on Bloomberg and annual reports data. Estimation date: 19 January 2018.

As can be seen from Table 3.1, the betas for the AdP and Fraport differ according to the specific approach. In terms of technical estimation issues, we propose to rely on the beta estimates highlighted in grey which provide a range of 0.51 to 0.71 for AdP, and 0.44 to 0.59 for Fraport. These estimates are based on regressions against the European index, although the world index provides for higher estimates, and asset betas derived using annual reported net debt for the following reasons:

- At the last review, PwC used net debt figures reported by Bloomberg to estimate comparators betas. We consider Fraport's annual report provides a better estimate of net debt compared to Bloomberg, given Fraport's accounting data shows that it has substantial liquidity not captured by Bloomberg. Conceptually, the calculation of net debt should deduct cash and other liquidity facilities which are not held for operational purposes but available for debt repayment. Failing to recognise additional funds held by Fraport that are available for debt repayment will overestimate Fraport's net debt, and understate its asset beta. For AdP, the use of accounting measures and Bloomberg provides broadly the same net debt figure and does not affect our beta estimates; but Fraport's beta is around 0.02 higher when we consider its actual net debt as stated in the financial accounts.
- We do not propose to place weight on estimates of betas using the world index as the reference market, due to evidence in financial literature on the existence of so called "home bias", i.e. the tendency for investors to hold a disproportionately high proportion of domestic equities, despite the benefits of global diversification. For example, recent evidence for the UK suggests a significant home bias of 76 per cent in 2012.[43] We therefore consider that the assumption of the relevant reference market for the marginal investor to be the world market does not appear justified.

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[43] Schoenmaker Dirk, and Chiel Soeter, (September 2014), New evidence on the home Bias in European Investment. DSF Policy Briefs, No 34.

In the next section, we discuss the relative risk of Heathrow versus the comparators to assess the appropriate beta for the H7 period.

3.2. Relative risk

In this section, we assess the systematic risk of Heathrow relative to the comparators considered in the previous section. Out of the full comparator set, we consider the two most relevant comparators are Fraport and AdP, which include Frankfurt and Paris Charles de Gaulle (CDG) airports respectively as the largest airports within the group. Both Frankfurt and CDG are large regulated European international hub airports, which appear most similar to Heathrow.

We compare Heathrow, Frankfurt and CDG airports along the dimensions of demand and revenue risk, cost recognition risk, and quality of service incentives, which jointly determine systematic risk exposure for Heathrow and its comparators. Out of the three risk dimensions, we place the greatest weight on demand and associated revenue risk, which we consider is the most important source of systematic risk for airports.

In Table 3.2, we summarise our assessment of the relative risk of the three airports. Based on our analysis, we conclude that Heathrow is riskier than Frankfurt airport and at least as risky as CDG airport.[44]

Table 3.2
HAL is riskier than Frankfurt, and at least as risky as CDG

	HAL	Frankfurt	CDG
Demand and revenue risk	**Medium** ▪ Hub status ▪ 5 yr price cap within no within period demand risk mitigants; asymmetric downside	**Low** ▪ Hub status ▪ Option to call for review when demand/revenues move adversely	**Medium/Low** ▪ Hub status ▪ 5 yr price cap but mitigation via demand risk sharing + re-determination
Cost recovery risk	**Medium** ▪ Recognition of efficient capex overspend, but limited upside ▪ Penalties for capex delays ▪ Allowed opex based on benchmarking ▪ No sharing of opex out/underperformance	**Low** ▪ Light-touch regime with Frankfurt proposing own cost-based charges	**Medium** ▪ Full recognition of capex overspend at review ▪ Bonus/penalty for early completion/delay in capex ▪ Allowed opex based on actuals in base-year ▪ No sharing of opex out/underperformance within period, penalty from overspend beyond dead-band for base-year
Incentives	**High** ▪ Asymmetric penalties ▪ Large revenue at risk	**Low** ▪ No material incentive arrangements	**Medium/Low** ▪ Asymmetric penalties ▪ Small revenue at risk

Source: NERA analysis of regulatory decisions

Demand and revenue risk

Heathrow is subject to a price cap regulatory regime, bearing the full risk of demand and revenue volatility within the regulatory period (typically lasts for 5 years). Demand risk at Heathrow may be mitigated due to the runway capacity constraint, although the existence of the capacity constraint also exposes Heathrow to asymmetric downside risk from negative shocks without any corresponding upside.

[44] We note that the description of the regulatory regime for CDG also applies to the second Paris airport Orly.

In contrast, Frankfurt is subject to a light-touch regulatory regime, with Fraport proposing its own cost-based charges and without a defined regulatory period. When the assumptions associated with the existing price levels change, Frankfurt can call for a tariff review, which is subject to user consultation and approval by the regulator.[45] Frankfurt has the option to call for a review at almost any time, and we would expect it to do so whenever demand falls below the assumptions associated with the existing price levels, thus mitigating the impact of demand deviations on revenues and profits.[46] Given this option, we conclude that Frankfurt's demand and revenue risk is considerably lower compared to Heathrow.

CDG, like Heathrow, is subject to a five-year price cap regulatory regime which exposes it to demand risk within period. However, CDG benefits from risk-sharing and re-openers where demand deviates from the regulator's demand projection made at review. Specifically, outside a dead-band around the central demand projection, demand risk is shared 50 per cent on the upside and 20 per cent on the downside. In the event of more substantive deviations of demand relative to the central projection, CDG can call for a re-set.[47] Given the benefits of risk sharing afforded to CDG under its regulatory regime, we conclude Heathrow is exposed to greater demand and revenue risk.

Cost recovery risk

Heathrow faces considerable risk in relation to cost recognition. In relation to operating costs, allowances are determined by the CAA based on benchmarking and Heathrow bears the full cost of out/underperformance within review. In relation to capital expenditure, any overspend within period is recognised in the RAB at the end of the review, subject to an efficiency review. Moreover, Heathrow faces penalties for delays via capex triggers.

In contrast, Frankfurt can call for a tariff review whenever the operating cost of capex assumptions associated with the existing tariff level change, and does not face any penalties from capex delays. Similarly to demand risk, the option to call a tariff review to mitigate the impact of changes in underlying costs implies that Frankfurt's risk in relation to cost recovery is substantially lower than Heathrow's.

CDG, like Heathrow, has a fixed operating cost and capex allowance for each year of its regulatory period. Operating cost allowances at review are determined using actual opex of

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45 See article on regulator's website on most recent price review: https://wirtschaft.hessen.de/verkehr/luftverkehr/jahresbericht-zur-genehmigung-der-entgeltordnung-2016-des-flughafens-frankfurt, accessed 8 November 2017.

46 The relevant German law ("Luftverkehrsgesetz") imposes some restrictions on the timing for calling a rate case (Art. 19b 3.1 & 3.2). Fraport has to consult with users six months before the start of new charging period and file proposal with regulator at least five months before (but shorter time period allowed in "extraordinary circumstances"). Link to law (in German): http://www.gesetze-im-internet.de/luftvg/__19b.html, accessed 8 November 2017.

47 CDG is subject to a price cap, with 50% upside demand risk sharing and 20% downside demand risk sharing outside a dead-band around the central scenario (dead-band is based on reference growth rates +/-0.5 percentage points), but the impact of risk sharing is capped at +0.2 and -0.5 per cent of the annual price cap. Where AdP or the French state requests a re-set, and the other party does not agree, the airport advisory commission will decide whether a re-set is necessary. See Contrat de Regulation Economique entre L'etat et Aeroports de Paris 2016-2020 ("**Contrat**"), III.2.3.3, V.2.1.

the last year of previous regulatory period as the starting point.[48] Like for Heathrow, there is no sharing of opex out or underperformance within period. In addition, CDG faces a penalty for opex underperformance in the base-year used for re-setting allowances at the next review (2018). If CDG overspends beyond 105 per cent of the allowed opex in 2018, this will lead to a reduction in the 2020 tariff level, but the absolute impact cannot exceed 1 per cent of the reference tariff level.[49] In relation to capex, any overspend within period is recognised at the next tariff review.[50] CDG retains the benefit of capex underspend within a deadband, beyond which underspend is shared with users.[51,52] CDG also faces an incentive mechanism that rewards capex completed in advance and penalises delays, but any net penalty cannot exceed -0.1 per cent of the tariff level.[53] Overall, we conclude that Heathrow appears to face similar risk in relation to cost recovery as CDG.

Incentives

Heathrow is exposed to incentive rewards/penalties under the service quality rebate and bonuses (SQRB) scheme, with a maximum penalty of around 7 per cent and a maximum reward of 1.44 per cent of airport charges, exposing Heathrow to asymmetric downside risk.[54]

In comparison, Frankfurt does not face material quality of service incentives and is hence lower risk compared to Heathrow.

Similarly to Heathrow, CDG is subject to asymmetric incentives in relation to quality of service, but the overall revenue at risk from these incentives is substantially lower than for Heathrow: the maximum penalty is 0.52 per cent, and the maximum reward is 0.24 per cent of airport charges.[55] As a result, we conclude that Heathrow is more risky than CDG in relation to quality of service incentives.

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48 AdP proposes an opex trajectory, which is reviewed by a consultative body. The regulator can decide to set the allowance below AdP's proposed level if they find that the trajectory is not ambitious enough. However, as the allowance will be re-set at the actual level at the next review, the regulator's view of the right opex trajectory does not prevail beyond the regulatory period.

49 The size of the reduction in the tariff level for 2020 will be 50 per cent of the difference between actual opex and 105 per cent of the planned amount in 2018. For the purpose of this adjustment, certain costs are excluded from opex (taxes, energy charges, de-icing and winter service, and treatment of persons with disabilities). See Contrat, III.2.3.6, Annex 7.

50 The RAB of AdP is calculated based on net book value, which implicitly reflects historical actual capex spend. Source: Economic Regulation Agreement between the Government and Aeroports de Paris 2016-2020, Appendix 8, p81.

51 If actual capex over 2016 to 2018 does not fall below 85 per cent of planned capex for this period, there is no sharing of outperformance with users. If actual capex is less than 85% of planned capex over 2016-2018, 70% of the difference in capex (with respect to both depreciation expenses and the return component) over the contract period will be deducted from the price-cap in year 2020. Contrat, III.2.3.5, Annex 6.

52 In addition, if CDG wants to make capital expenditures beyond the planned projects, it can request an increase in its allowance during the period, but this will be subject to approval by the French state. Adjustments will take into account the difference between actual demand and reference demand at the time. CDG can only request an upward adjustment if 50 per cent of any upside from higher demand does not cover the additional capex. This rule is symmetric: a downward adjustment can only be made if the decrease relative to planned capex exceeds 50 per cent of the reduction from any shortfall in demand. Contrat, III.4.4.

53 Contrat, III.2.3.5, Annex 6.

54 CAA (2013), Economic regulation at Heathrow from April 2014: final proposals, p195, 198.

55 Contrat, III.2.3.4.

In summary, we conclude Heathrow is higher risk compared to Frankfurt, because Frankfurt regime allows it to propose its own cost-based charges and the regulatory regime allows it to mitigate demand and cost risk by requesting tariff re-sets, and it does not face material risk from quality of service incentives. We conclude that Heathrow is at least as risky as CDG, and reasonably higher risk: both are subject to a five-year price cap, but CDG benefits from additional demand risk sharing, and also faces smaller quality of service incentives compared to Heathrow (and similar risk in relation to cost recovery).

3.3. Decomposition of AdP and Fraport group betas

In this section, we consider the evidence on whether the group betas for Fraport and AdP are representative of the risks for the main airports within the group, Frankfurt and CDG, which we consider as the closest comparators to Heathrow. To do this, we first discuss the share of Fraport and CDG in the overall group beta and then consider evidence on the riskiness of the other airports included within the group.

For Fraport group, the annual reports data show a breakdown of revenues, EBITDA as well as assets for Frankfurt airport compared to the rest of the group. According to all these measures, Frankfurt airport accounts for around 80 per cent of the overall group.[56] The key other airports included in the rest of the Fraport group include Lima airport (Peru) and Antalaya (Turkey), with around 8 and 3 per cent share in overall revenues, with the remainder including a number of airports in Europe and Asia.[57]

For AdP group, the annual report data does not provide a breakdown which allows us to estimate the share of CDG in the overall group revenues, EBITDA or assets. The only comprehensive information on share of different airports in the AdP group includes breakdown by number of passengers. Drawing on passenger share data is likely to understate the weight of CDG in the group beta, given that we expect revenues and therefore profits per passenger at CDG to be higher than at the smaller airports in the group. Nevertheless, we use passenger shares as the only comprehensive measure available. Based on passenger share, the Paris airports (CDG and Orly) account for around 64 per cent of the overall passengers in the AdP group.[58] However, the AdP group also includes shares in other large European international hub airports, Istanbul Ataturk and Amsterdam Schiphol airports which in the top five busiest airports in Europe together with Heathrow, Fraport and CDG.[59] These two airports are also likely to have comparable risk to Heathrow, e.g. they are both regulated hub airports, and their inclusion does not compromise the use of AdP group beta to inform HAL's risk. Taking together, the passenger share for the Paris, Ataturk and Schiphol airports represents an 82 per cent share in the AdP group (when measured by passenger numbers). The remainder of the group includes a number of airports across the world, with the greatest

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56 NERA calculations based on Fraport Annual Report 2016, pp.56 and 107.

57 NERA calculations based on Fraport Annual Report 2016, pp.56.

58 NERA calculations based on ADP Group Annual Report 2016, p.86 and Schiphol website https://www.schiphol.nl/en/schiphol-group/page/facts-and-figures/

59 Groupe ADP (2016): Strategy & Results. 2016 Report on activity and sustainable development, pp 09.

share of Turkish airports Ankara and Izmir (around 6 per cent) and Santiago de Chile (around 5 per cent) when measured on a passenger basis.[60]

In summary, we find that the overall share of Frankfurt airport in the Fraport beta is around 80 per cent when measured by share of revenues, EBITDA and group assets. For AdP group, we find that the overall share of Paris, Schiphol and Ataturk airports (large European hub airports included in AdP group which are relevant comparators for Heathrow) is around 82 per cent when measured in passenger numbers (which is likely to understate the overall share in the group beta given we expect average revenue/profit per passenger to be higher for large international airports). We also find that the remainder of the airports in the Fraport and AdP groups includes airports in South America (Peru and Chile) as well as Turkey.

3.3.1. Empirical evidence on comparator betas for secondary airports in AdP/Fraport Groups

Notwithstanding the low share of secondary airports in the wider groups betas, we have also considered the evidence on whether the betas for the South American and Turkish airports are different from the AdP and Fraport group betas. We identified three listed comparator airports in South America (Grupo Aeroportuario del Pacifico SAB de CV, Grupo Aeroportuario del Sureste SAB de CV, and Grupo Aeroportuario del Centro Norte SAB de CV) and one in Turkey (TAV Havalimanlari Holding A.S.). In addition to airport comparators, we also consider betas for airlines, specifically Turkish Airlines and LATAM airlines. Table 3.3 sets out the beta estimates for the South American and Turkish airport/airline as composite estimates.

60 NERA calculations based on ADP Group Annual Report 2016, p.86 and Schiphol website https://www.schiphol.nl/en/schiphol-group/page/facts-and-figures/

Table 3.3
Asset beta estimates for secondary airport comparators lower than AdP and Fraport Group betas:
Implies CDG and Frankfurt betas at least as high as Group estimates

	1Y	2Y	5Y
South American airport comparators	0.30	0.23	0.25
Turkish comparators (airport/airline comparators)	0.56	0.52	0.48

Source: NERA analysis based on Bloomberg data. Estimation date: 19 January 2017.
Note: The asset betas are calculated by regressing stock returns against the S&P Latin America 40 for South American comparators and Borsa Istanbul 100 for Turkish comparators;, assuming 0.05 debt beta and Bloomberg net debt [61]

As can be seen from Table 3.3, the evidence from comparator airports as well as airlines for South America and Turkey does not support the conclusion that the betas for the rest of the Fraport and AdP group airports are higher than the average beta estimated for the group as a whole. Indeed, the empirical beta estimates tend to be lower than those reported in Table 3.1 for the group.

Taking this evidence together with the fact that the share of Frankfurt airport and Paris plus other large European hub airports in the Fraport and AdP group betas is more than 80 per cent, we conclude that the beta of Fraport and AdP is a reasonable proxy of the beta for Frankfurt and CDG+Orly airports.

3.4. HAL asset beta for H7

As discussed in the previous section, we consider the most relevant comparators for estimating the asset beta for Heathrow at H7 are Fraport and AdP and which in turn we consider represent reasonable approximations of the betas for Frankfurt airport and CDG airport. Table 3.4 summarises our asset beta estimates for Fraport and AdP for the European index and based on financial account net debt estimates (a sub-set of the wider estimates shown in Table 3.1 above).

[61] The individual asset betas are as follows:

	1Y	2Y	5Y
Grupo Aeroportuario del Pacifico SAB de CV	0.35	0.24	0.25
Grupo Aeroportuario del Sureste SA de CV	0.27	0.22	0.25
Grupo Aeroportuario del Centro Norte SAB de CV	0.27	0.25	0.25
TAV Havalimanlari Holding A.S.	0.65	0.67	0.52
Turkish airlines	0.48	0.38	0.44
LATAM airlines	0.57	0.46	0.48

Source: NERA analysis of Bloomberg data. Estimation date: 19 January 2017

Table 3.4
Asset beta estimates for Fraport and AdP

	1Y	2Y	5Y
AdP	0.71	0.55	0.51
Fraport	0.59	0.50	0.44

Source: NERA analysis of Bloomberg and annual reports data. Estimation date: 19 January 2017.
Note: The asset betas are calculated by regressing stock returns against the local index (Eurostoxx) assuming 0.05 debt beta and annual reports net debt.

As discussed in the previous section, we conclude that Heathrow is more risky than Frankfurt airport and at least as risky as CDG, and reasonably higher risk. Our assessment of relative risk is consistent with our empirical beta estimates, which show that Fraport beta is lower compared to AdP's beta. Given the relative risk positioning of Heathrow, the asset beta for H7 should therefore be higher than the beta for Fraport and at least as great as the beta for AdP.

Drawing on the asset beta estimates for the two principal comparators set out in Table 3.4, we conclude on an asset beta for HAL in a range of 0.55 to 0.6. The lower bound of 0.55 is towards the upper end of the range for Fraport (0.44 to 0.59), reflecting our conclusion that HAL investors face far greater risk than Fraport. For our upper-bound, we assume a value of 0.6, consistent with the broad evidence base for AdP, reflecting our conclusion that HAL is at least as risky as AdP.

3.5. Comment on PwC beta and relative risk analysis presented for the CAA

In its November 2017 report, PwC presents evidence on relative demand risk exposure for HAL, Frankfurt and CDG and concludes that HAL is exposed to lower risk compared to the other two comparators.[62] PwC's conclusions are based on its analysis of peak-to-trough variation in demand during the 2008 financial crisis period, sensitivity of passenger growth to GDP growth, and revenue growth at the three airports. PwC concludes that HAL experienced the lowest peak-to-trough demand reduction during the financial crisis, lowest passenger demand elasticity relative to GDP and greatest revenue growth.

PwC's analysis and conclusions are flawed. In assessing relative risk, PwC considers demand volatility only, ignoring the impact of the regulatory regime on how demand volatility translates into volatility of profits and cash-flows at the three airports, which ultimately determine risk to investors.[63] When assessing relative risk, it is therefore critical to

62 PwC (November 2017): Estimating the cost of capital for H7, p49-p51.

63 PwC also considers growth in revenues, as reported in companies accounts, which is also not a directly relevant metric for assessing relative risk. Growth in revenues is driven by a number of factors, e.g. changes in allowed costs, regulatory re-sets, differences in the regimes (e.g. indexation of the RAB for HAL) as well as systematic demand risk (but only as one element). In addition, it is the measure of net profit/cash-flow growth (or net profit/cash-flow variation) that is relevant to measuring the beta risk. PwC

consider the specific regulatory regime and how it mitigates or accentuates the impact of demand volatility on profits and cash-flows.

As explained in section 3.2, Frankfurt airport is exposed to a light-touch regulatory regime which allows it to call for a tariff review in the event demand falls below expectations, thus mitigating the impact of demand deviations on profits and cash-flows. As a result, underlying demand volatility at Frankfurt is not relevant for assessing relative risk, as the impact of demand volatility on profits and cash-flows is mitigated by the regime. Due to the effect of demand mitigation offered by the regime, we conclude Frankfurt is lower risk compared to Heathrow.

In relation to CDG, PwC compares demand volatility at HAL and CDG considering peak-to-trough passenger numbers associated with the 2008 financial crisis as well as sensitivity of passenger growth to GDP. PwC's conclusions are incorrect and based on selective evidence. First, PwC considers peak-to-trough change in passenger numbers associated with the 2008 financial crisis, showing HAL experienced lower reduction in passenger numbers than CDG in absolute and relative terms, suggesting HAL is lower risk. PwC's analysis is based on the impact of a single economic shock (2008 financial crisis) over a limited period of two years from which it draws general conclusions about relative risk. However, PwC's conclusions are not robust to the choice of an alternative time period. For example, as we show in Table 3.5, using PwC's own metric of peak-to-trough passenger numbers, we show that looking at the impact of the Eurozone debt crisis (2012-2013) as well as the financial and Eurozone crisis together (2008-2013), HAL has been more negatively affected than CDG in absolute and relative terms.[64] On the basis of PwC's own metric but taking into account a wider set of time period, HAL faces greater risk.

64 We note our results are not sensitive to the inclusion of months associated with the volcanic ash disruption in 2010.

Table 3.5
Peak-to-trough passenger numbers during Eurozone crisis and Financial and Eurozone and crisis show HAL higher risk than CDG

	Impact of Financial crisis (PwC) 2008-2009		Impact of Eurozone crisis 2010-2013		Impact of Financial crisis and Eurozone crisis 2008-2013	
	HAL	**CDG**	**HAL**	**CDG**	**HAL**	**CDG**
Peak Passengers (m)	68.0 (Feb-08)	61.2 (Oct-08)	72.3 (Dec-13)	62.1 (Dec-13)	72.3 (Dec-13)	62.1 (Dec-13)
Trough Passengers (m)	65.7 (Jun-09)	57.9 (Dec-09)	64.8 (May-10)	57.1 (Apr-10)	64.8 (May-10)	57.1 (Apr-10)
Difference (m)	-2.3	-3.3	-7.5	-5.0	-7.5	-5.0
Difference (%)	-3.4%	-5.3%	-10.4%	-8.0%	-10.4%	-8.0%
Conclusion	**HAL lower risk than CDG**		**HAL higher risk than CDG**		**HAL higher risk than CDG**	

Source: Airport traffic statistics from ADP(http://www.parisaeroport.fr/en/group/finance/investor-relations/traffic), and Heathrow(https://www.heathrow.com/company/investor-centre/results-and-performance/traffic-statistics), Note: Figures represent rolling 12-month sums of total passengers.

Second, PwC considers the relationship between economic growth and passenger growth for HAL and CDG by estimating a single-factor regression of passenger growth and GDP growth. PwC concludes that the slope coefficient for HAL is lower than CDG, concluding HAL has lower systematic risk. However, PwC's regression analysis is simplistic and fails to include most of the relevant explanatory variables for forecasting demand, resulting in limited explanatory power (R^2 around 20 per cent for HAL). For example, the UK DfT forecasting models include factors such as foreign GDP, imports and exports, fuel costs, non-fuel costs, air passenger duty or carbon prices.[65] The omission of relevant explanatory variables renders PwC's estimated coefficient of sensitivity of passenger growth to changes in GDP biased and misleading. As a consequence, PwC's regression analysis is not reliable for assessing systematic risk for HAL.

Considering the difficulty in estimating the systematic element of overall demand risk, an alternative approach for assessing relative risk at HAL and CDG is to look at measures of absolute risk (as measured e.g. by standard deviation of passenger growth). We calculate standard deviations of year-on-year passenger growth at the two airports over the period 2003 to 2017 (the longest available period).[66] We find that the standard deviations for HAL and

[65] Airports Commission (February 2013), Discussion Paper 01: Aviation Demand Forecasting, p28; Department for Transport (January 2013), UK Aviation Forecasts.

[66] The use of year-on-year growth rate addresses seasonality in monthly passenger volume data and presents the passenger growth rate on a comparable basis. We note that our metric of year-on-year passenger growth is consistent with PwC's approach for assessing demand volatility in its Q6 report for the CAA. (PwC (October 2013), Estinmating the cost of capital for designated airports, A report prepared for the Civil Aviation Authority (CAA), Appendix 8, p119-120.

CDG are at a similar level of 4.7 and 5.0 per cent respectively. Furthermore, if we consider passenger volatility for both Paris airports CDG and Orly, which are both part of AdP group, the standard deviation falls to 4.8 per cent This suggests that HAL and CDG/the Paris airports are exposed to similar levels of demand risk. However, as we explain in section 3.2,the regulatory regime for CDG includes provisions for demand risk-sharing and re-openers where demand deviates from the regulator's demand projection made at review, mitigating the impact of demand risk on CDG's profits and cash-flows. [67] In contrast, HAL does not benefit from any demand risk mitigants, suggesting greater risk exposure for HAL.

PwC also presents historical volatility in revenue growth, as reported in companies' accounts, as a basis of assessing relative risk. We do not consider volatility in revenue growth represents a relevant metric for assessing relative risk, as it is driven by a number of factors, e.g. changes in allowed costs, regulatory re-sets, differences in the regimes (e.g. inflation indexation of the RAB for HAL) as well as systematic demand risk (but only as one element). It is the measure of net profit/cash-flow growth (or net profit/cash-flow variation) that is relevant to measuring beta risk.

In addition, PwC's conclusion that HAL's historical revenue variability is lower compared to AdP, implying that AdP is greater risk, is flawed. PwC notes that over the whole period 2006-2014, the standard deviation of revenue growth for HAL and AdP is similar.[68] It then argues that the result for HAL is driven by the inclusion of 2009, which shows a substantial increase in revenues following the regulatory re-set, and that excluding 2009, HAL shows a lower variation in revenue growth compared to AdP, implying AdP is greater risk. However, PwC fails to observe that the alleged greater variation of AdP revenue growth compared to HAL is entirely driven by the inclusion of 2011, in which PwC presents a substantial revenue reduction of around 8 per cent for AdP.[69] Our review of AdP's financial accounts reveals that the alleged reduction in AdP revenues for 2011 is in fact driven by a change in accounting policy in this year, while on a consistent accounting basis, AdP accounts show a revenue increase in 2011 compared to 2010.[70] Using PwC's data reported in Figure 5.11, but excluding 2011 (as the PwC data reflects an accounting change and not an actual change in revenues) as well as 2009 (as argued by PwC) shows that the standard deviation of revenue growth for HAL and AdP are similar, as shown in Table 3.6 below, which does not support PwC's conclusions that AdP is greater risk compared to HAL.

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[67] The same demand risk sharing applies to Orly airport as CDG and Orly are regulated under the same contract.

[68] PwC (November 2017): Estimating the cost of capital for H7, para 5.84.

[69] PwC (November 2017): Estimating the cost of capital for H7, para 5.84 and Figure 5.11.

[70] AdP Consolidated financial statements 2011, p4, link: http://www.parisaeroport.fr/docs/default-source/groupe-fichiers/finance/relations-investisseurs/information-financi%C3%A8re/r%C3%A9sultats-et-chiffre-d'affaires/archives/2011_full_year_results_consolidated_accounts.pdf?sfvrsn=c2093ebd_2http://www.parisaeroport.fr/docs/default-source/groupe-fichiers/finance/relations-investisseurs/information-financi%C3%A8re/r%C3%A9sultats-et-chiffre-d'affaires/archives/2011_full_year_results_consolidated_accounts.pdf?sfvrsn=c2093ebd_2 and AdP Consolidated financial statements 2010, p4, link: http://www.parisaeroport.fr/docs/default-source/groupe-fichiers/finance/relations-investisseurs/information-financi%C3%A8re/r%C3%A9sultats-et-chiffre-d'affaires/archives/2010_full_year_results_consolidated_accounts.pdf?sfvrsn=1a083ebd_2

Table 3.6
Standard deviation of revenue growth: Removing 2011 (driven by accounting change) and 2009 (as argued by PwC) shows similar variation of revenue growth for AdP and HAL

Period	AdP	HAL
2006 - 2014	5.4%	7.0%
2006 - 2014, excluding 2009	5.6%	2.8%
2006 - 2014, excluding 2009 and 2011	**2.9%**	**2.9%**

Source: NERA calculations based on PwC (November 2017): Estimating the cost of capital for H7, para 5.84 and Figure 5.11

However, as explained above, we do not consider that historical revenue variability is a reliable metric for assessing relative risk, as revenue growth is affected by a number of factors unrelated to systematic risk exposure. The impact of changes in accounting policies on companies' reported revenues, as overlooked by PwC for AdP in 2011, highlights one of the many issues with this metric.

Overall, PwC's analysis provides no reason to change our view of relative risk as presented in section 3.2, namely:

- HAL is more risky than Frankfurt airport, given Frankfurt benefits from demand risk mitigation and a light-touch regulatory regime; and
- HAL is at least as risky as CDG and reasonably higher risk, given CDG and HAL experienced similar demand volatility over the period 2003 to 2017, but CDG benefits from demand risk-sharing and re-openers within period while HAL does not.

4. Gearing and tax

In this section, we discuss the gearing and tax assumption for estimating the cost of equity (pre-tax) for the H7 period.

4.1. Gearing

Heathrow's actual gearing is close to 70 and 80 per cent for junior and senior debt respectively, reflecting the airport's securitised financial structure.[71]

However, regulators typically do not take actual financial structure into account and instead set gearing based on a notional gearing assumption (as summarised in Table 4.1).

Table 4.1
GB utility regulators

Determination	Notional gearing
Ofgem GDPCR7 (2007)	62.5%
Ofgem DPCR5 (2009)	65%
Ofwat PR09 WaSCs (2009)	57.5%
Ofwat PR09 WoCs (2009)	52.5%
CC Bristol (2010)	60%
RIIO GD1 (2012)	65%
CAA Heathrow (2014)	60%
CAA Gatwick (2014)	55%
CMA NIE (2014)	45%
RIIO ED1 (2014)	65%
Ofwat PR14 (2014)	62.5%
CMA Bristol (2015)	62.5%

Source: NERA analysis of regulatory determinations

When compared to other UK regulated companies, the notional gearing assumption for Heathrow should reflect its relative risk position. As Heathrow is exposed to greater risk compared to conventional utilities such as water and energy networks, it correspondingly needs to exhibit stronger financial metrics, including gearing, to achieve a comparable credit rating. As a result, the notional gearing for Heathrow should be set at a lower level compared to conventional utilities.

71 Heathrow Finance Plc (2017), Annual report and financial statements for the year ended December 2016, p.18.

At previous reviews, the CAA set the notional gearing for Heathrow at 60 per cent. We conclude that a notional gearing of 60 per cent remains appropriate for Heathrow for the H7 period. This is lower than notional gearing of 62.5 to 65 per cent set by Ofwat and Ofgem in recent determinations, reflecting the greater risk exposure of Heathrow compared to conventional utilities.

We note that it is important for the CAA to determine notional gearing for Heathrow at a level which allows it to maintain the target credit rating used in the determination of the cost of debt element of the WACC. The notional gearing assumption should therefore be confirmed via CAA's financeability analysis.

4.2. Tax

We estimate a tax rate of 17 per cent for H7, in line with the expected corporation tax rate for the H7 period as per latest government proposals.[72]

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72 HM Revenue & Customs (March 2016), Policy Paper, Corporation Tax to 17% in 2020.

5. Cost of Equity

Table 5.1 summarises our cost of equity estimate for HAL for H7. As shown, drawing on our estimated range of the TMR of 6.5 per cent to 7.1 per cent, RfR estimate of -0.9 to 1.5 per cent, ERP calculated as the difference between the TMR and the RfR, and a range of 0.55 to 0.60 for the asset beta, we estimate a real pre-tax cost of equity of 10.5 to 11.4 per cent.

Our cost of equity estimate is higher than CAA's estimate of 7.1 to 9.5 real pre-tax at Q6. The main reason is our higher beta range of 0.55 to 0.6 (based on 0.05 debt beta) compared to CAA's point estimate of 0.5 (based on 0.1 debt beta), as well as our higher TMR range of 6.5-7.1 per cent compared to CAA's assumption of 6.25 per cent.

As we set out in this report, there are compelling reasons for CAA to increase its beta estimate from Q6, given the evidence that HAL is higher risk than Fraport, and at least as risky as CDG, contrary to CAA's conclusions at Q6, as well as increase its TMR for consistency with long-run market evidence.

Table 5.1
We estimate a real pre-tax cost of equity of 10.5 to 11.4per cent

	Low	High
Tax rate	17%	17%
Gearing	60%	60%
Total market return	6.5%	7.1%
Risk-free rate	-0.9%	1.5%
Equity risk premium	7.4%	5.6%
Asset beta	0.55	0.60
Debt beta	0.05	0.05
Equity beta	1.3	1.4
Real cost of equity (post-tax)	8.7%	9.5%
Real cost of equity (pre-tax)	**10.5%**	**11.4%**

Source: NERA analysis

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