PwC Economics

Estimating the cost of capital for H7 - Response to stakeholder views

A report prepared for the Civil Aviation Authority (CAA)

February 2019

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Summary

This report presents our updated WACC estimate for HAL in the 'as-is' case for the H7 price control. We review submissions from various stakeholders across the relevant methodological issues and the key components of the cost of capital, and set out our response to these submissions, with updated data and further analysis.

Further changes to the WACC to take account of the proposed capacity expansion are outside the scope of this report.

At the end of this summary we provide an updated calculation of the 'as-is' WACC for H7.

Methodological considerations (Section 2)

- In April 2018 the CAA published CAP 1658, 'Economic regulation of capacity expansion at Heathrow: policy update and consultation'. This publication included updates on the CAA's thinking in relation to the overall regulatory framework in H7 and new information regarding the timings of H7.
- In terms of timings, the CAA proposes to implement a two year interim price control to apply from January 2020. A key rationale for this is to align the regulatory and planning processes. This means that the H7 price control will come into effect at the start of 2022. This contrasts to the assumption in our December 2017 report that the H7 price control would begin in January 2020.
- The delay to the start of H7 has some methodology implications. As noted in our December 2017 report, current market based approaches reflect current market conditions, but by their nature are more sensitive to changes in the economic and market outlook. A greater gap between the review of current market evidence and the price control start date adds uncertainty to the accuracy of current market evidence based WACC estimates.
- In terms of the macroeconomic outlook, there have been no major changes since our December 2017 report[1]. GDP growth projections for the period in the run up to H7 continue to remain lower than the historical average. CPI inflation remains above the 2% target but is expected to fall next year, while RPI inflation is marginally higher than October last year. The Bank of England increased the base rate at the August 2018 meeting to 0.75% (an increase of 0.25 percentage points).
- The economic and financial market data therefore suggests a continued period of subdued economic growth and low interest rates, with gradual reversion to more normal levels. However, these normal levels are unlikely to match figures observed historically. Indeed the Bank of England has published its views on the 'equilibrium interest rate' or 'r*' and 'trend interest rate' or 'R*', towards which it expects base interest rates to trend. This trend interest rate is around zero in real terms and 2% in nominal terms.
- While current market evidence remains relevant, the time to the start of the H7 control period is now longer than when we carried the work in our December 2017 report. Absent economic and market shocks, we expect the market parameters to return towards new trend levels. Where it is the case that estimates for parameters such as total market returns estimated now are being driven in part by low current interest rates relative to estimated trend levels, if interest rates are higher when the evidence is updated, then the difference between current market evidence and trend evidence may diminish to some degree. This means we consider it valid to continue to rely on current market evidence, and it will be important to update the market parameters nearer to the start of H7.

[1] We note that there remains considerable uncertainty around Brexit and its potential impact on the macroeconomic outlook. This will need to be monitored in the run up to the H7 period.

Reponses on gearing (Section 3)

Topic 3a – Use of a notional gearing approach

- IAG recognise that HAL's actual gearing is higher than that of the notional financial structure the CAA used to inform the Q6 review. The AOC and LACC agree in principle that it is sensible to re-examine what the correct level of gearing should be for a notionally efficient company.
- As noted in our December 2017 report, we consider the need to assume a notional capital structure approach in setting allowed revenues to be an integral part of RPI-X incentive based regulation. It provides company management with the incentive to manage the actual financing of the airport. Management are best placed to manage finance risks, through the timing of finance raising, the maturity profile of debt raised, the types of finance raising instruments used (e.g. index-linked debt or more complex debt instruments) and which markets to tap (including international debt capital markets). For example, a company can seek to avoid raising finance at times of heightened debt finance costs by carefully managing cash flow.
- In our opinion, an economic regulator is not best placed to make these detailed financing assumptions and decisions, and any approach which moves the management of finance risk from companies and on to customers through the regulatory regime risks dampening longer term incentives for efficient financial management by companies. For this reason we consider the notional gearing approach used by the CAA in Q6 remains fit for purpose in H7.
- A 60% notional gearing level for HAL is consistent with our initial analysis of the cost of capital in our December 2017 report. It is also aligned with more recent regulatory precedent on notional gearing assumptions.
- Instead of changing the notional gearing approach, we recommend that the CAA and HAL consider a benefits sharing mechanism in the case where HAL is geared above the notional level, as suggested by Ofwat as part of its PR19 methodology.

Responses on the cost of debt (Section 4)

Topic 4a –HAL specific adjustments to the cost of new debt

- HAL proposed two adjustments to the cost of new debt approach. Firstly, HAL propose a Heathrow debt premium to the iBoxx index. HAL use a comparison to the water sector to estimate the scale of this adjustment. Specifically, they show that their August 2028 bond has a 30bps spread to a similar Anglian Water bond, and then, using Ofwat's water sector spread to iBoxx of -15bps, conclude that a +15bps spread is needed for Heathrow's new cost of debt assumption.
- HAL's second proposed adjustment is an alteration to the forward-looking adjustment applied. They reason that as HAL will issue mostly nominal debt, a nominal gilt forward curve is the appropriate forward-looking adjustment. Furthermore, they note that index-linked forward curves will under-predict future movements in nominal costs as they include an implicit allowance for inflation risk.
- We have reviewed the evidence put forward by HAL and we do not consider an adjustment to the iBoxx benchmark is required. A direct comparison of the yields on HAL bonds was made to the iboxx indices in our December 2017 report, and the evidence showed that HAL bonds trade very close to the iBoxx, and, that on average HAL's yields were marginally below the iBoxx index (average of A and BBB). As CEPA note, HAL's senior debt is A-rated, so a notionally financed company might be expected to outperform the index (comprised of an average of A and BBB) by a small margin on average.
- HAL's own analysis on the cost of new debt was a comparison of a single HAL bond to a single water sector bond. The 15bps discount to the iBoxx index used by Ofwat is based on sector wide trends rather than any individual issuance, and there is a lot of heterogeneity across bonds in the sector. Therefore, any

comparison which relies on a single bond is unlikely to be sufficiently robust for the basis of an adjustment.

- In relation to the use of nominal index-linked bonds to calculate a forward-looking adjustment, we still consider that the use of index-linked bonds remains appropriate. This is because HAL is not exposed to RPI inflation risk as a result of the RPI-X control. Where there is a divergence between the forward-looking uplift calculated from nominal bonds and index-linked bonds this is most likely to reflect changes in RPI inflation expectations. HAL is not exposed to these changes, provided the RPI inflation assumption is set at a reasonable central estimate.

Topic 4b – Use of a notional cost of embedded debt

- HAL suggested that their actual cost of embedded debt is incorporated in the embedded cost of debt calculation. HAL says the notional approach adopted underestimates the cost of embedded debt as: the simple average is not reflective of actual issuance; the index is not a reflection of a specific credit rating; no allowance has been made for the higher cost of issuing a proportion of debt as index-linked; and, a trailing average of 15-years has been used – which is too short-term.

- Virgin note that the notional cost of embedded debt estimate is "far higher" than HAL's actual cost of debt.

- We acknowledge that estimating the cost of actual embedded debt is complex, with HAL acknowledging in their response that the airport has, "a sophisticated debt structure involving different classes of debt and a portfolio of swaps to manage interest rate and inflation risk". However, we recommend that the CAA should continue to use a notional cost of embedded debt approach as it provides incentives for efficient financing, and allocates risks – such as timing risk and currency risk – to the company, who are best placed to manage them.

- The current market evidence suggests that the real cost of embedded debt immediately before the H7 control period could lie in the range **0.7% to 1.5%**.

Topic 4c – The averaging cost of embedded debt

- In our December 2017 report, we recommended a real cost of embedded debt of 1.8%, which was based on the 15-year trailing average of the iBoxx benchmark (average of A and BBB) towards the end of 2019. This represented the anticipated beginning of the H7 period (at the time of preparing the work).

- CEPA suggested that the cost of embedded debt should reflect the average cost of embedded debt over the price control period, not just the cost of embedded debt at the start point of the H7 price control.

- The approach suggested by CEPA takes account of the fact that the amount of embedded debt outstanding falls over the course of H7 (both using the trailing average approach, and for HAL actual financing as bonds mature). We conducted some additional analysis to reflect the falling amount of embedded debt over the course of H7. This approach assumes that as each year passes during the course of H7, the first year of the trailing average is removed from the cost of embedded debt calculation. The time period covered in the trailing average therefore shrinks during the H7 period. The cost estimates using this approach are presented in the table below (assuming that the H7 period will start in 2022).

Table 1: Estimates of the cost of embedded debt using the rolling average approach

	2022	2023	2024	2025	2026	Average
10yr trailing average	0.7%	0.6%	0.4%	0.3%	0.2%	0.4%
Years remaining on embedded debt	10	9	8	7	6	
15yr trailing average	1.5%	1.4%	1.2%	1.0%	0.8%	1.2%
Years remaining on embedded debt	15	14	13	12	11	

Source: Datastream from Refinitiv, Capital IQ, PwC analysis

- The estimates calculated using this approach for the 15-year trailing average are higher than CEPA's estimate. For the 10yr and 15yr trailing averages, we estimate an average cost of embedded debt for the revised H7 period of 0.44% and 1.17% respectively. This compares to CEPA's estimates of 0.17% and 0.80%.

- We continue to set our assumptions by reference to a 15 year trailing average calculation. This aligns with the period of HAL historic debt issuances and UK regulatory precedent.

- We acknowledge the point raised by CEPA and have updated our cost of embedded debt approach as a result. We estimate a revised average real cost of embedded debt of **1.2%** (reduced from 1.8% in our December 2017 report).

Topic 4d – Use of a specific liquidity allowance

- HAL note that PwC do not include any specific allowance for liquidity costs. They observe that these costs are incurred to establish and maintain sufficient liquidity to meeting regulatory and debt structure requirements.

- We acknowledge there are potential costs of obtaining sufficient liquidity (through undrawn facilities or holding cash); however, we expect efficient treasury functions to minimise these costs. Further, the need for liquidity facilities reduces at lower (notional) gearing levels and a strict assessment of liquidity should take account of working capital and cash management practices.

- In our December 2017 report we suggested an allowance for debt issuance costs of 10bps. Based on updated evidence on the cost of debt issuance and the cost of liquidity, we consider 10bps is sufficient to recover debt issuance costs and efficient costs of maintaining ongoing liquidity.

Responses on the cost of equity (Section 5)

Topic 5a – Sector comparisons of the cost of equity

- In their consultation responses, airline stakeholders drew upon comparisons to other regulated sectors to suggest that the initial WACC range from our December 2017 report was too high.

- We reviewed the market evidence, focusing on the 'as is' cost of equity estimate for H7. We believe this approach represents more of a 'business as usual' comparison to other regulatory periods such as PR19, RIIO-GD2 and RIIO-T2. In our December 2017 study the real post-tax cost of equity range 'as is' was 4.9% to 7.1%. A comparison of this 'as is' cost of equity to other sectors is set out in the table below.

Table 2: Change in cost of equity between determinations

Regulator (determination)	Post-tax cost of equity	Change in cost of equity from previous control
CAA (H7 'as is')	4.9% to 7.1%	-0.8% to -0.5%
Ofwat (PR19 – early view)	4.0%	-1.6%
Ofgem (RIIO T-2 – Sector methodology)	4.0%	-2.8% to -3.0%
Ofgem (RIIO GD-2 - Sector methodology)	4.0%	-2.7%
Ofcom (Openreach copper access)	4.5%	-0.3%

Source: Regulatory decisions and methodology documents.
Note: the figures presented are sourced from a mix of provisional regulatory views and reports written on behalf of regulators; they may not reflect the final decisions for the relevant determinations. The change for CAA is with reference to CAP 1140 and the change for Ofwat is for the PR19 early view compared to the PR14 final determination. The change for Ofgem is for the RIIO-1 final determinations and the December 2018 sector specific methodology consultation.

- Two themes emerge from the comparisons set out in the table above. Firstly, the initial cost of equity set out in our December 2017 report is higher than the cost of equity being initially proposed in water and energy. However, given differences in the regulatory regime, where Heathrow is exposed to some volume risk and other regulated companies are not, and the greater cyclicality of demand for travel compared to water and energy usage, some positive wedge is to be expected.

- Secondly, the magnitude of change from the preceding control is lower for H7 compared to water and energy. This second difference can be explained in part by the lower values for market parameters (Total market return (TMR) and Risk-free rate (RFR)) selected by the CAA in Q6. For example, where the CAA adopted a real total market return estimate of 6.25% in Q6, Ofwat selected a value of 6.75% at PR14 and Ofgem selected a value of 7.25% for RIIO-GD1.

- Overall, we find that when account is taken of lower starting values for market parameters in Q6, exposure to higher systematic risk in aviation and other regulatory differences, there is no clear discrepancy on an 'as is' basis between sectors.

Topic 5b – Use of long-run historical evidence

- In our December 2017 report, the estimate for TMR was based on current market evidence. A concern raised by HAL was that no weight had been placed on long-run historical returns evidence, and that this was, in their view, contrary to good regulatory practice.

- CEPA, on behalf of AOC, supported the "types of approach used" for estimating the TMR. Specifically, CEPA found the specification of the DDM applied by PwC to be appropriate, but considered analysis of market-to-asset ratios to be useful, at most, as a cross-check.

- We note that in its NIE 2014 price control determination, the CMA used historical approaches as its main sources for estimating the TMR, with forward-looking approaches used as a cross-check. They concluded that a TMR of between 5-6.5% is appropriate for UK and world markets. The more recent UKRN study recommends using long-run historic averages and proposes a range of 6-7% for real expected market returns (in CPI terms) which is broadly equivalent to 5.0-6.0% in RPI terms.

- We recognise the need to trade off two issues in assessing a total market returns assumption. While the long-run historic average of returns may be the best estimate of the long run market return, it may deviate from short run returns for a control period in ways that could distort investment incentives and/or undermine confidence in the decision-maker's objective use of the available evidence. Estimates of prospective market returns based on contemporary evidence, notably DDM, can address this weakness.

- However, it may be difficult for a regulator to frame its methodology and the judgements involved in a way that reassures negatively affected parties that it will accord similar weight to contemporary evidence in future when this evidence may support a decision which benefits these parties.
- In our view, to determine an appropriate TMR estimate the CAA should consider all forms of evidence that are helpful – both historical and contemporaneous forward-looking market evidence. We recommend that more current market evidence should receive priority where evidence suggests that expected returns may diverge from long-run values for an extended period of time. Given that expected returns are likely to be lower than the long-run values over the H7 regulatory period, we consider that more current market evidence should be the primary measurement approach, with historical estimates used as a cross-check. We note that the recent UKRN study suggests the difference between historical approaches and forward-looking approaches may not be as great as previously thought.

Topic 5c – Estimating historical returns

Source of historical returns

- NERA, on behalf of HAL, critiqued PwC's December 2017 historical TMR estimate by calculating a historical TMR estimate of their own using Dimson, Marsh and Staunton (DMS) data. Using long-run historical returns they derived a TMR of 6.5-7.1%. Other stakeholders identified different sources of historical equity returns data that produced higher estimates of UK equity returns.
- Since our 2017 report, there have been two major contributions to the literature on long-run historical equity returns – the Jorda et al. (2017) long-run historical equity returns dataset and the UKRN study which focuses on historical equity returns. In both studies, the authors obtain long-run real equity return estimates by using a historical CPI index. Since HAL's indexation of regulatory values is on an RPI indexation basis, the real returns calculated by Jorda et al. and UKRN need to be adjusted for any differences between CPI and RPI.

Use of arithmetic or geometric averaging to estimate TMR

- The existing body of TMR literature uses a mixture of both arithmetic and geometric averaging approaches to calculate average returns using historical returns data. We reviewed this literature and we found strengths and weaknesses to both approaches. The arithmetic average produces an unbiased estimator when the returns under consideration are independent of each other, but it can overstate the level of risk when there is a degree of predictability in returns across years. On the other hand, the geometric average better accounts for returns that exhibit serial correlation, and it is less impacted by large positive/negative deviations in returns. However, the geometric average can underestimate the level of risk associated with equity returns over time.
- The UKRN report calculates the expected TMR using the geometric mean of returns plus a volatility adjustment of 1 to 2 per cent to calculate the expected return. In contrast, NERA argue for using methods developed by Blume and JKM for estimating unbiased estimators of TMR for long investment horizons.
- To examine whether the different length holding periods impacted returns, we undertook some econometric analysis. We find that as the investment holding period increases, the predictability of returns also increases. This suggests equity return variance decreases as holding period increases, even when we control for autocorrelation.
- Our findings are in line with MMW (2003) and Robertson and Wright (2002), who also find evidence of the predictability of returns at longer horizons. In relation to the guidance from the UKRN study that regulators: "add an adjustment of 1 to 2 percentage points, depending on the extent to which regulators wish to take account of serial correlation of returns", our analysis suggests any adjustment should be at the bottom end of this range, and may indeed be lower.

Long-run evidence on inflation

- The UKRN report has used new long-run CPI measures to estimate CPI deflated real returns. This is a departure from earlier analysis of long-run returns in the UK, which has typically used RPI as the basis of calculating real returns.
- NERA find that CPI in the BoE Millennium database does not represent a reliable measure of CPI inflation and therefore should not be used as a basis for estimating the historical real TMR. They find that RPI is the most reliable measure of UK historical inflation going back to 1900.
- We agree that it is desirable to use the most consistent and credible historical inflation data to interpret the history of market returns and implement appropriate allowances for the cost of capital. We note that the UKRN authors' use of the Bank of England's composite consumer price inflation series will ensure that close links are maintained with experts and academics from statistical and financial backgrounds (such as the Bank of England or the Office of National Statistics), with a view to understanding and applying the most appropriate long-term consumer price inflation series.
- In both the UKRN and Jorda studies, the authors obtain real equity return values by using a historical CPI index produced by the Bank of England. This index draws on a range of data sources to produce a representative series that captures annual inflation from 1662 through to 2016.
- As we are interested in estimating investors' (unobservable) real return expectations from historical data, there is no definitive measure of inflation to use. Ofcom considered this issue in its 2018 BCMR consultation[2]. It concluded:

  > *"The ONS has recently established that RPI is a flawed and upwardly biased measure of inflation. Hence, assuming investors target real returns, it seems plausible that expected returns would be shaped by an expectation that nominal returns would compensate investors for CPI (currently the headline measure of inflation) rather than RPI inflation. As such, using historical evidence on real returns as a guide for forward-looking real (CPI-deflated) returns is reasonable in our view."*

- This is consistent with the observation that RPI differences opened up from the 1970s, and the Bank of England CPI inflation measure provides a long-term estimate of to guide investor inflation expectations and real returns.
- Like UKRN, Ofgem and Ofcom we therefore consider the deflation of nominal returns by the Bank of England CPI series provides a suitable estimate of ex-post real returns as the basis for estimating forward-looking real returns for use with CPI inflation. Use of any different inflation series in setting forward-looking price controls therefore requires additional adjustment.

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[2] Ofcom (2018), 'Business connectivity market review, publication updated on 19 December 2018', Annexes 1-22, Page 213

Overall evidence on expected returns from historical data

- In Table 3, we summarise the expected returns provided across different studies using historical data.

Table 3: Historical Real TMR Estimates

Real TMR Component	PwC H7 WACC Report (2017)	UKRN Study (2018)	Jorda et al (2017)
Averaging Method	Arithmetic (20 year holding period)	Geometric	Arithmetic
Real historic TMR	6.3%-7.0%[3]	5%	7.2%
Indexation	RPI	CPI	CPI
Adjustments			
Change in RPI formula effect	-0.3%	n/a	n/a
CPI to RPI inflation effect	n/a	-1.0%	-1.0%
RPI-adjusted Real TMR	6.0%-6.7%	4.0%	6.2%
Adjustment for serial correlation		+ 1% to +2%	n/a
Adjustment for outperformance	-0.4%		
Real expected TMR	5.6%-6.3%	5%-6%	n/a

Source: PwC December 2017 report, Jorda et al (2017), UKRN (2018)

- Comparing the UKRN real TMR range to that of our December 2017 report, we observe that these estimates are very similar. Indeed, the bottom end of the UKRN range is lower than our December 2017 estimates. This gives us confidence that our previously reported historical return estimates are consistent with a wider evidence base which incorporates the latest research. The Jorda study also provides consistent figures for the RPI-adjusted real TMR (but does not extend to providing a comparable expected TMR).

Topic 5d – UK centricity of the TMR analysis

- HAL find that the initial analysis is too UK centric. They raise two key points in relation to the UK focus of the analysis. Firstly, for the DDM analysis NERA state that DDM estimates are understating expected returns due to "implausibly low assumptions around dividend growth." They highlight that a consistent dividend forecast would be one which draws upon both UK and foreign earnings.

- Secondly, with respect to the low returns environment, the NERA highlights that: "it is global interest rates, and particularly US rates that are relevant to globally diversified investors". NERA go on to set out that, "realised equity returns for other major markets, namely the US and Germany, have clearly increased in recent periods with the decline in global interest rates, directly contradicting PwC's thesis that investors' expected returns are lower when interest rates are lower." On the basis of this, NERA conclude that there is no meaningful evidence that the cost of equity is low when interest rates are low.

- There is a case in principle for focussing on UK rather than global data. This relates to the ultimate purpose of cost of capital estimates in a regulatory context: UK regulators require cost of capital

[3] Source: Barclays and DMS. Since our December 2017 report, there is now an additional year of DMS data available. However, geometric real equity returns for the UK market from the DMS data remains 5.5% i.e. it is unchanged from the 2017 edition.

assumptions which are sufficient to enable UK regulated companies to finance their activities. This typically requires use of UK input parameters to cost of capital estimates. Hence, global return estimates are best suited to cross-check purposes.

- It is also important to account for appropriate inflation adjustments when considering determinations relating to European airports. HAL argues that these demonstrate a TMR of 6.3%-7.4%, yet these estimates are likely to be based on CPI inflation. For example, Ireland's CAR appear to use CPI inflation to calculate a real TMR of 6.50% in its 2014 determination for Dublin Airport's 2015-2019 charges. And the French government provide a nominal risk-free rate for Charles de Gaulle Airport, with the real TMR of 7.31% provided by HAL appearing to use CPI inflation adjustment.
- Evidence from the UK suggests that RPI inflation tends to be higher than CPI inflation. Consequently, a 1 percentage point deduction is needed to make a CPI-based TMR comparable to our RPI-based calculations. For the above cases, this yields lower real TMRs of 5.50% and 6.31% respectively.
- In summary, UK regulators require cost of capital assumptions which are sufficient to enable UK regulated companies to finance their activities. We therefore use UK input parameters to cost of capital estimates. Once the comparator (European) TMR estimates have been adjusted to ensure that they are being compared with our initial WACC range on a like-for-like basis, they are broadly comparable. Hence, the European regulatory benchmark cross-checks do not invalidate our initial WACC range.

Topic 5e – Comparisons to Bank of England DDM analysis

- CEPA's analysis on behalf of AOC considers that the "specification of model used is appropriate" when reviewing the approach to DDM.
- NERA's review of the TMR approach proposes that the PwC DDM estimates are 'fundamentally biased' due to errors that are made in the assumptions for short-term and long-term dividend growth. On short-term dividend growth, NERA state that UK GDP forecast growth is lower than independent analyst forecasts of dividends. On long-term dividend growth, NERA note that FTSE companies derive 70% of their earnings from outside of the UK and that the global economy has a higher forecast GDP growth than the UK.
- NERA highlight that independent DDM estimates from the Bank of England are higher than the PwC TMR range and that the Bank of England approach uses a weighted average of GDP growth rates for different regions from which FTSE all share companies derive their earnings.
- The Bank of England DDM model has been created to help it in "monitoring of equity price moves in support of its policy objectives". It is interested in whether risk premia are rising, or whether analysts are cutting their forecasts of earnings and dividends, and this is instructive for both managing monetary policy and financial stability. It is less concerned with the absolute level of the equity return predicted in its model. For the regulatory purpose of setting the level of equity returns the potential for analyst optimism is more problematic. For this reason using analyst forecasts of dividend growth is not suited to a regulator's purposes.
- The UKRN report also agrees with the assessment above, noting that: "The Bank of England's most recent application for example… uses the model as an accounting procedure to explain shifts in the stock market after the event, not to predict returns."
- With regards to using GDP growth assumptions in the DDM, regulators require cost of capital assumptions which are sufficient to enable UK regulated companies to finance their UK activities. If we were to use global growth assumptions, or a blend of UK and global growth, then we would produce a cost of equity for UK listed firms with their global activities. Where there is higher global growth, this would produce a higher opportunity cost of equity compared to using UK growth assumptions. We would then need to consider how the global/UK blended TMR could then be deconstructed into a UK figure and

a non-UK figure. In our view this approach seems unnecessary and a better estimate of the cost of equity for financing UK activities can be obtained by using UK GDP growth assumptions.

- We therefore consider our DDM approach remains valid.

Topic 5f – Overall TMR assumption

- To assess whether an adjustment is required to the real TMR range of 5.1% to 5.6% (in RPI terms), which we proposed in our December 2017 report, we first consider the latest output from the PwC DDM model alongside the estimates from other providers. Over the last year there has been an increase in the implied total market return outputs from the PwC DDM model, particularly driven by an increase in the share buyback yield which is unlikely to persist. At the upper end of the DDM model estimates, there has been an increase from 8.7% to 9.4% (in nominal terms), while the lower end has increased from 8.4% to 8.5%. This is equivalent to 5.3% to 6.2% in real RPI terms.

- However, other DDM models have produced lower TMR estimates, for instance Ofgem suggest a DDM range of 7.5 – 8.5%, which is consistent with the top end of our previous DDM range. Likewise, the Europe Economics estimates are broadly consistent with our previous range, although we note that they were produced in March 2017. So on this basis there is little evidence to increase the top end of our TMR range.

- The bottom end of our range was informed by a range of market evidence (including MAR analysis and investor surveys), as is now more supported by other DDM models produced for UK regulators. While there is now some DDM evidence to support a lower TMR estimate, this would then be inconsistent with our other market evidence, so again we do not consider it necessary to reduce the lower end of the TMR range. Based on the above, we view that the range proposed in our December 2017 paper of 5.1 – 5.6% in real RPI terms remains appropriate and supported by the majority of forward looking analysis.

- There are then two helpful sense-checks:

    i) Firstly, our range is close to Ofgem's overall TMR assumption of 6.25% to 6.75% in CPIH terms from its December 2018 consultation[4]. When converted into RPI terms, using the 1% wedge between RPI and CPI for simplicity, we estimate a TMR range of approximately 5.25% to 5.75%.

    ii) Secondly, our range is also at the bottom of the range of historical ex-post analysis estimates from the UKRN study. While we maintain a preference for the forward-looking market evidence, we would expect the two sources to converge as monetary and economic conditions normalise, which is an appropriate assumption as the H7 control extends well into the next decade. On this basis, a small difference between our forward-looking market evidence and ex-post historical estimates is reasonable.

Topic 5g – Use of a negative risk-free rate

- HAL and Virgin both indicated drawbacks with the application of a negative real risk-free rate – suggesting that a risk-free rate of 0% could be more suitable.

- Using market-based risk-free rates is supported by the UKRN paper. The paper's authors explain that they feel that fundamental objections to a negative real risk-free rate are not theoretically justified. They set out several reasons why the risk-free rate could be negative in principle, including that there is no economic principle that rules out a negative risk-free rate and negative risk-free rates rarely result in the cost of risky capital being negative.

- We continue to recommend that cost of capital inputs should be aligned to market evidence. The current yield on a 10-year gilt is -1.8% and the market expectation is that this will increase to between -1.6% and -

[4] Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Page 31

1.5% over the H7 period. Taking account of this, and factoring in a degree of uncertainty, we recommend a range for the real risk-free rate of **-1.5% to -1%** for the H7 period.

Topic 5h – The approach to measure beta

- Virgin find that the use of a European index had 'overestimated' calculations of beta. While CEPA used local indices to estimate the asset betas of AdP and Fraport.
- We acknowledge the range of different approaches put forward by stakeholders. In our December 2017 report we considered a range of estimation methods and then took them all into account to determine a range. We continue this approach.
- NERA advocate using company accounts to determine 'cash and near cash equivalents' for the beta calculation because this takes into account additional cash holdings not included by Bloomberg. We compared the 'cash and short-term investments measure' that we used in our analysis with the 'cash and cash equivalents' measure report in Fraport's company accounts. We found that the cash measure we used in our analysis produced marginally higher betas. We continue to recommend using the 'cash and short-term investments' measure because it includes liquid investments that are readily convertible to cash.

Topic 5i - The relative beta risk of airports

- HAL consider that relative risk analysis shows they are more, or at least as risky, as comparator airports. Virgin suggest that a more relevant comparator could be AENA.
- We acknowledge that AENA is a relevant comparator; however, AENA only listed in 2015 which prevents us from conducting the full historical beta analysis (see Appendix B for full explanation).
- We conducted some additional analysis on the risks faced by the comparator group and HAL, which is summarised in Table 4. The additional risk analysis that we have conducted indicates that CDG is closer to HAL in terms of overall systematic risk exposure. Frankfurt appears to have similar systematic risk exposure too, however, the findings are less conclusive given greater divergences in PAX volatility and regulation.

Table 4: Summary of CAA relative risk assessment for HAL, CDG, Frankfurt

	HAL	**CDG**	**Frankfurt**
Regulatory Regime	• Set timescales and strong regulatory oversight • Greater within-period exposure to demand risk	• Regular determinations • Some sharing of demand risks • Limited opportunities for regulatory re-sets	• Greater airport power to request charge increases and secure new determinations • Limited sharing of demand risks
PAX Volatility	• Lowest PAX volatility, particularly with respect to the Financial Crisis	• Higher PAX volatility, but not with respect to the Eurozone Crisis	• Highest PAX volatility • High elasticity of PAX demand to macroeconomic conditions
Revenue Volatility	• Low revenue volatility, especially when 2009 change in allowed yield per PAX is excluded	• Low revenue volatility, especially when 2011 accounting change is excluded	• Slightly higher revenue volatility

Source: PwC analysis

- Based on this analysis, we conclude that CDG and Frankfurt are the most appropriate comparators for HAL. For the H7 'as is' case we continue to recommend a beta range of **0.42 – 0.52**.

Topic 5j - Debt beta estimate

- In response to comments from stakeholders on the debt beta estimate for H7 we conducted some additional analysis to determine an appropriate debt beta. We considered recent regulatory precedents of the debt beta used for estimating an appropriate re-geared equity beta and found a range from 0 to 0.15, with 0.1 the most frequent estimate more recently.
- We then conducted empirical analysis to estimate a debt beta using market data. We considered the A and BBB 10-year+ iBoxx non-financial indices (which are also used in the cost of debt calculation) and found that between 2006 and 2018 the debt beta for the average of the two iBoxx indices has ranged from -0.09 to 0.26. We also estimated a debt beta based on HAL's own bonds. We found that the estimate follows a broadly consistent profile to the iBoxx index, with the average debt beta between January 2014 and October 2018 ranging between -0.06 and 0.18.
- The iBoxx and HAL debt beta estimates follow a broadly consistent profile, and they have both shown a marked upward trend over the past 18 months. As with much other market data, we are cautious about using short-term movements (particularly as the upward trend is now reversing). However, these market movements do mean that our initial estimate of 0.05 does need to be updated.
- We consider that a figure of 0.1 better reflects the upward movement in market data and aligns better to other recent regulatory determinations which are also targeting an investment grade rating on corporate debt. As a result, we have updated our debt beta assumption from 0.05 to **0.10**.

Responses on tax (Section 6)

Topic 6a – The tax rate in H7

- In our December 2017 report, we used a 17% tax rate in the WACC calculation. This was based on the statutory corporate tax across the H7 period as per the government's current proposals. NERA, on behalf of HAL, also used a 17% tax rate in their cost of equity calculations.
- Given the size of the third runway capex scheme in H7, an approach that applies an effective tax may be preferred by the CAA. This approach would take account of the projected notional tax payments over the course of the price control period, considering capital allowances as well as other tax credits. However, to calculate an effective tax rate, more information is required from the H7 financial model.
- For the purpose of this update, we continue to recommend using a tax rate of **17%**.

Update to December 2017 initial WACC estimate

- In Table 5 below, we compare the initial WACC range for the 'as is' case produced in the December 2017 consultation with the revised WACC range estimated in February 2019 (using October 2018 as the cut off point for market data). An important point to note is that the H7 price control has been delayed by two years and will now start in 2022. The changes to the WACC range include:
  - The risk-free rate in the 'low' case has reduced from **-1.4% to -1.5%**, reflecting the lower yield on gilts.
  - The cost of embedded debt in both the 'low' and 'high' case has reduced from **1.8% to 1.2%**, accounting for the fact that the amount of embedded debt outstanding falls over the course of H7, and reflecting the revised H7 control period dates.
  - Based on the current market evidence, the RPI assumption has increased from **2.8% to 3.0%**. However, we continue to suggest that the CAA monitor and revisit this assumption in the run up to the H7 control period.
  - Based on the current market evidence we have increased the debt beta assumption from **0.05 to 0.10**.
- The changes to the risk-free rate, the cost of embedded debt and the debt betas reduce the real vanilla WACC range for H7 'as is' from **3.0% - 3.9% to 2.5% - 3.4%.**

Table 5: Initial WACC range for the 'as is' case from the December 2017 and February 2019 (based on data from the end of October 2018) consultations

	Dec 17: H7 'as is'		Feb 19: H7 'as is'	
	Low	High	Low	High
Gearing	60%	60%	60%	60%
Risk-free rate	-1.4%	-1.0%	-1.5%	-1.0%
Total market return	5.1%	5.6%	5.1%	5.6%
Asset Beta	0.42	0.52	0.42	0.52
Debt beta	0.05	0.05	0.10	0.10
Equity beta	0.98	1.23	0.90	1.15
Cost of equity (post-tax)	**4.9%**	**7.1%**	**4.4%**	**6.6%**
Cost of embedded debt	1.8%	1.8%	1.2%	1.2%
Cost of new debt	0.15%	0.65%	0.15%	0.65%
Weighting on new debt	12.5%	12.5%	12.5%	12.5%
Issuance costs	0.10%	0.10%	0.10%	0.10%
Real Cost of debt (pre-tax)	**1.7%**	**1.8%**	**1.2%**	**1.2%**
Vanilla WACC	**3.0%**	**3.9%**	**2.5%**	**3.4%**

Source: PwC analysis

1. Introduction

1.1 In December 2017 the Civil Aviation Authority (CAA) published a policy update and consultation on the economic regulation of capacity expansion at Heathrow (CAP 1610). As part of that consultation the CAA published a technical appendix on “Estimating the cost of capital for H7” produced by PwC. In that appendix we set out an initial view on the cost of capital for Heathrow Airport Limited (HAL) in H7, taking account of the airport ‘as is’ and we also considered the balance of risk and return associated with capacity expansion.

1.2 That CAA consultation has now closed and the CAA has received responses from stakeholders.

1.3 In this document we set out our responses to the issues raised by stakeholders on the cost of capital for the ‘as-is’ case.

1.4 We have also updated market data for the period to the end of October 2018.

Recap of December 2017 findings

1.5 In the report “Estimating the cost of capital for H7”, we estimated an initial Weighted Average Cost of Capital (WACC) range for HAL, ‘as is’, of 3.0% to 3.9% (real, RPI)[5].

1.6 The addition of a capacity expansion to the ‘as is’ case led to two key changes to this range. Firstly, the weighting on new debt was significantly increased – resulting in a downward adjustment to the WACC. Secondly, there was an uplift to the WACC associated with the construction risks in H7. Combining these changes, the H7 vanilla WACC estimate - with capacity expansion - is 2.8% to 4.6% (real, RPI).

1.7 Below we recap the three main building blocks used to calculate this WACC range.

Cost of equity

1.8 The cost of equity range of 4.9% to 7.1% was informed by current market evidence: the TMR range of 5.1% to 5.6% drew upon dividend discount modelling, market valuation evidence and investor survey evidence. The risk-free rate range drew upon the forward-looking view embedded in today’s market prices; and, the asset beta analysis suggested the range applied in Q6 remained suitable.

Cost of debt

1.9 The cost of debt focused on notional estimates based on market indices. The cost of embedded debt drew on a 15-year trailing average of investment grade yields, and the cost of new debt used a market-based forward-looking to uplift current market rates.

WACC uplift

1.10 The uplift, to compensate HAL for additional construction risk, was based on a review of six case studies. These covered other cost of capital adjustments that were made to capture additional risks in the construction phase of a project.

WACC for HAL in H7 including construction of new runway

1.11 The table below sets out the WACC ranges from the December 2017 appendix.

[5] We express the cost of capital figure in real terms. We also specify the inflation index it should be used with, namely RPI. Where not specified in this report, the inflation index to be used is RPI.

Table 6: Initial WACC range from December 2017 consultation

	H7 'as is'		H7 with capacity expansion	
	Low	High	Low	High
Gearing	60%	60%	60%	60%
Risk-free rate	-1.4%	-1.0%	-1.4%	-1.0%
Total market return	5.1%	5.6%	5.1%	5.6%
Asset beta	0.42	0.52	0.42	0.52
Equity beta	0.98	1.23	0.98	1.23
Real cost of equity (post-tax)	**4.9%**	**7.1%**	**4.9%**	**7.1%**
Cost of embedded debt	1.8%	1.8%	1.8%	1.8%
Cost of new debt	0.15%	0.65%	0.15%	0.65%
Weighting on new debt	12.5%	12.5%	60.0%	60.0%
Issuance costs	0.10%	0.10%	0.10%	0.10%
Real cost of debt (pre-tax)	**1.7%**	**1.8%**	**0.9%**	**1.2%**
WACC uplift			+0.25%	+1.0%
Vanilla WACC	**3.0%**	**3.9%**	**2.8%**	**4.6%**

Source: PwC (2017) 'Estimating the cost of capital for H7'

Scope and structure of this report

1.12 This document is structured by the key issues we have identified in stakeholder responses with regards to the H7 'as-is' case. Specifically, the document is divided into five sections:

- Section 2: Methodological considerations – this section discusses developments to the H7 price control signalled by the CAA and expectations about the macroeconomic environment for H7. The section concludes with implications of these developments for the WACC.
- Section 3: Responses on gearing - this section discusses stakeholder comments on gearing and outlines our responses.
- Section 4: Responses on the cost of debt – this section discusses stakeholder comments on the cost of debt and outlines our responses.
- Section 5: Responses on the cost of equity – this section discusses stakeholder comments on the cost of equity and outlines our responses.
- Section 6: Responses on tax – this section discusses stakeholder comments on tax and outlines our responses.

1.13 In Sections three to six, we structure our discussion of each issue into three parts. Firstly, we provide an issue overview, secondly, we provide a response, and, lastly, where relevant, we provide parameter estimates based upon updated data.

1.14 Further changes to the WACC to take account of the proposed capacity expansion are outside the scope of this report. They will be addressed separately by the CAA.

2. Methodological considerations

2.1 In our December 2017 report, we noted the importance of the wider methodological considerations associated the approach to setting the WACC. A key consideration we emphasised was the trade-off between long-run historical approaches and current market approaches for estimating several parameters including the risk-free rate and total market returns.

2.2 In this section we update our view on the trade-off between these approaches. In particular, we update for the new information provided by the CAA in CAP 1658 on the H7 control, and we update for developments to the UK macroeconomic environment.

Updates to H7

2.3 In April 2018 the CAA published CAP 1658, 'Economic regulation of capacity expansion at Heathrow: policy update and consultation'. This publication included updates on the CAA's thinking in relation to the overall regulatory framework in H7 and new information regarding the timings of H7.

2.4 In terms of timings, the CAA proposes to implement a two year interim price control to apply from January 2020. A key rationale for this is to align the regulatory and planning processes in relation to capacity expansion. This means that the main H7 price control will come into effect at the start of 2022. This contrasts to the assumption in our December 2017 report that the H7 price control would begin in January 2020.

2.5 The delay to the start of H7 has some methodology implications. As noted in our December 2017 report, current market based approaches reflect current market conditions, but by their nature are more sensitive to changes in the economic and market outlook. A greater gap between the review of current market evidence and the price control start date adds uncertainty to the accuracy of current market evidence based WACC estimates.

Macroeconomic developments

GDP

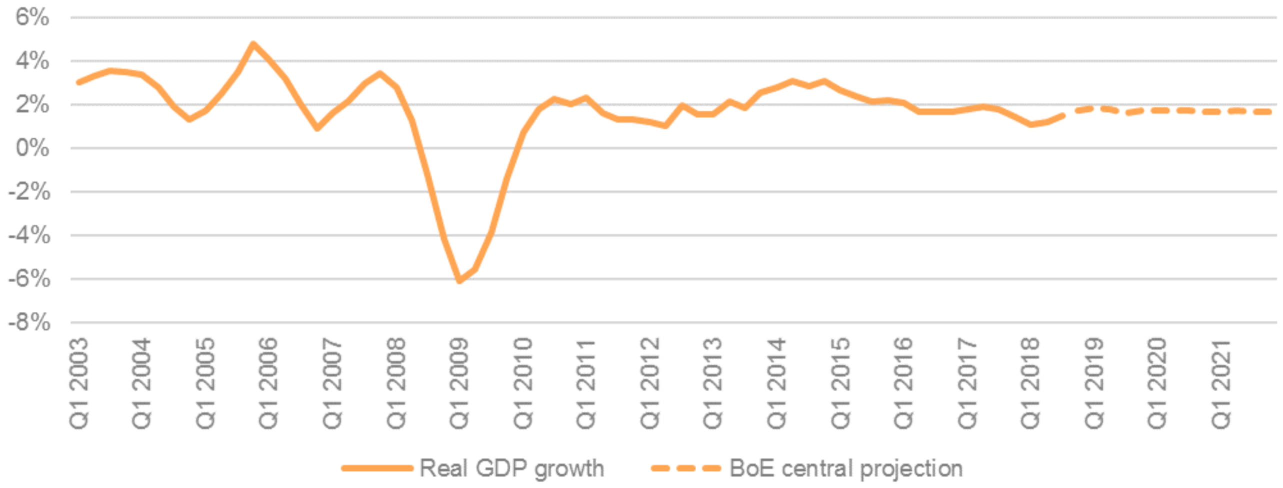
2.6 Figure 1 below shows UK GDP growth since 2003 and forecasted real GDP growth in the run up to the new H7 price control period. Following the 2008-09 financial crisis, GDP growth over the period 2010 to 2016 averaged 2.0%. To date, over the Q6 price control period it has averaged 2.0%.

2.7 In the run up to the new H7 price control period, UK real GDP growth is forecast to be marginally lower, with the Bank of England central forecast averaging 1.7% up to Q4 2021. This projection is based on a smooth transition to the UK's eventual trading relationship with the EU. Clearly, the growth outlook will depend on the nature of the UK's withdrawal from the EU.

2.8 The GDP growth forecast of 1.7%[6] for the 2018-21 period is below its historical average from 1980-2007 of 2.8% growth per annum and long-term post-war average of around 2.5%.

[6] We note that there remains considerable uncertainty around Brexit and its potential impact on the macroeconomic outlook. This will need to be monitored in the run up to the H7 period.

Figure 1: UK GDP growth



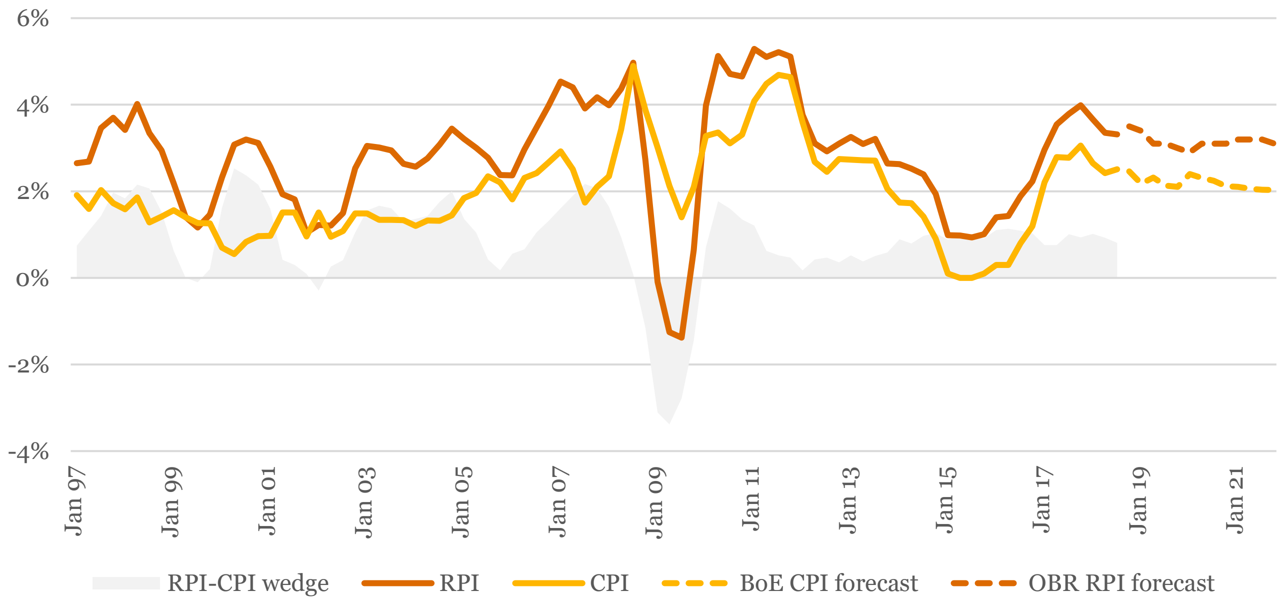
Source: Datastream from Refinitiv, Bank of England (November 2018 Inflation Report), PwC analysis

Inflation

2.9 Figure 2 below shows year-on-year growth rates of CPI and RPI. CPI and RPI inflation were 2.5% and 3.5% (in October 2018), respectively, with the wedge between the RPI and CPI 1 percentage point. This recent estimate of the RPI-CPI wedge is slightly higher than long-term averages – which are driven by a combination of formulae and coverage effects – for example over the period since 1997, the average of the difference between the RPI and CPI has been around 0.8%.

2.10 In its November inflation report, the Bank of England projected that CPI will remain above the target rate in the short term (CPI is estimated to be around 2.5% for the whole of 2018). The fall in sterling since the EU referendum is one contributing factor as this has led to higher import prices. CPI inflation is expected to trend back towards the target level of 2% in 2019.

Figure 2: UK inflation



Source: Bank of England, OBR, PwC analysis

2.11 Table 7 below shows independent forecasts for 2018 and 2019 for CPI and RPI complied by HM Treasury (as at October 2018). They suggest that CPI inflation in 2018 is expected to remain higher than the target rate of 2.0% but is expected to fall back towards the 2.0% in 2019. Likewise, RPI inflation is expected to fall from an average of 3.3% in 2018 to 3.0% in 2019.

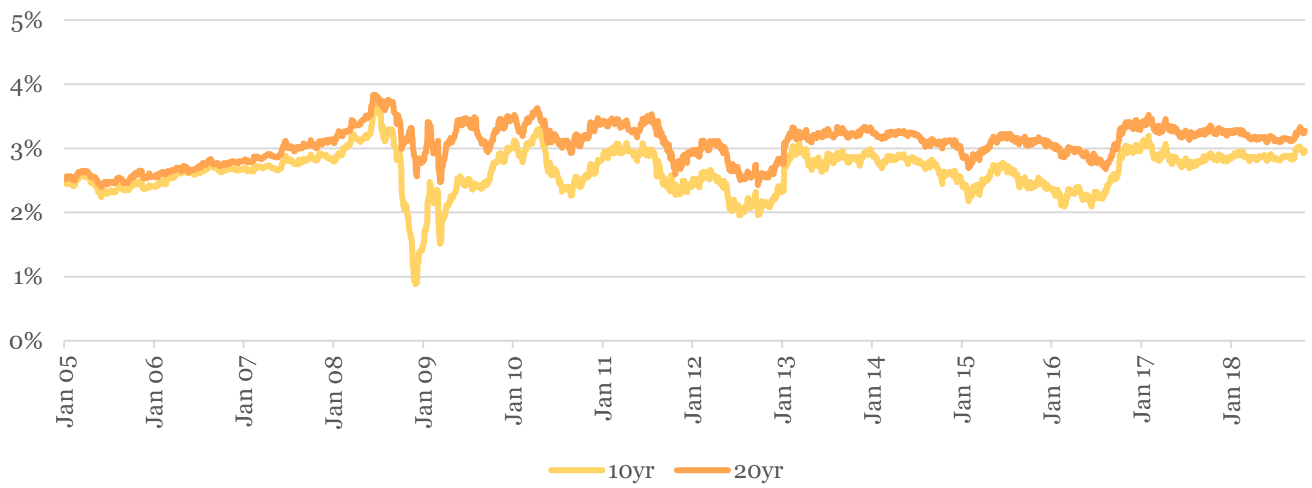
Table 7: CPI and RPI - HMT's independent forecast (October 2018)

Inflation forecasts		**October**	
Inflation for 2018 (%)	**Average**	**Low**	**High**
CPI	2.4	1.8	2.7
RPI	3.3	2.9	3.8
Inflation for 2019 (%)	**Average**	**Low**	**High**
CPI	2.0	1.5	3.5
RPI	3.0	2.6	4.2

Source: HM Treasury

2.12 Implied inflation from gilts also provides another source of RPI expectations. In Figure 3 below we present the difference in yields between conventional gilts and index-linked gilts (net of an assumed inflation risk premium of 30 basis points). Evidence from 10yr gilts suggests that RPI expectations implied by spot yields at the end of October 2018 are approximately 3.0%, while evidence from the 20yr gilts suggests an RPI figure of approximately 3.3%. RPI expectations implied by 10 yr gilts have increased by around 0.2% since our December 2017 report, while RPI expectations implied 20 yr gilts remain the same.

Figure 3: Implied inflation from UK Government gilts



Source: Bank of England

2.13 Based on the evidence above, an RPI figure of 3% is supported by independent forecasts. However, an RPI figure of 2.8% (as was used at Q6) continues to be within the range of independent forecasts. An RPI assumption in the range 2.8% to 3.0% therefore seems most relevant to the revised H7 period at this stage.

2.14 Given the market evidence outlined in this section, we have increased the forward-looking RPI assumption for the H7 period. In our December 2017 report we used an RPI assumption of 2.8% and for the purpose of the new analysis in this rport we increase this to 3.0%. This is also closely aligned to the recent regulatory publications from Ofwat (3.0%), Ofcom (2.9%) and Ofgem (3.07%)[7].

Financial market context

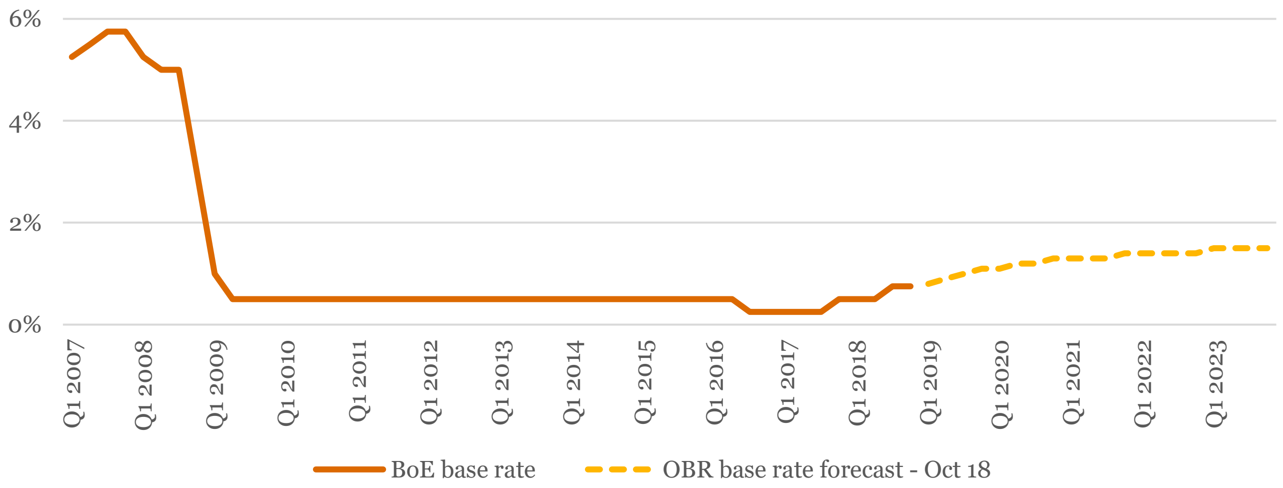
Interest rates

2.15 Figure 4 shows the Bank of England base interest rate since and the OBR base rate projection to the end of 2023. UK monetary policy has gradually tightened over the course of 2017 and 2018, with the Bank of England increasing the base rate from 0.25% to 0.5% at the November 2017 Monetary Policy Meeting (MPC) meeting, and from 0.5% to 0.75% at the August 2018 MPC meeting.

2.16 In the period before the November MPC meeting, stronger than anticipated economic activity and inflation, and increases in interest rates internationally, pushed up the market-implied path for UK interest rates. However, any future increases in the base rate are expected to be at a gradual pace and to a limited extent. The OBR base rate forecast sees the base rate reach 1.5% by the end of 2023, which still remains low in historical terms.

2.17 The market evidence indicates that the Bank of England looks set to maintain low interest rates for the foreseeable future.

Figure 4: Bank of England base rate and OBR projection

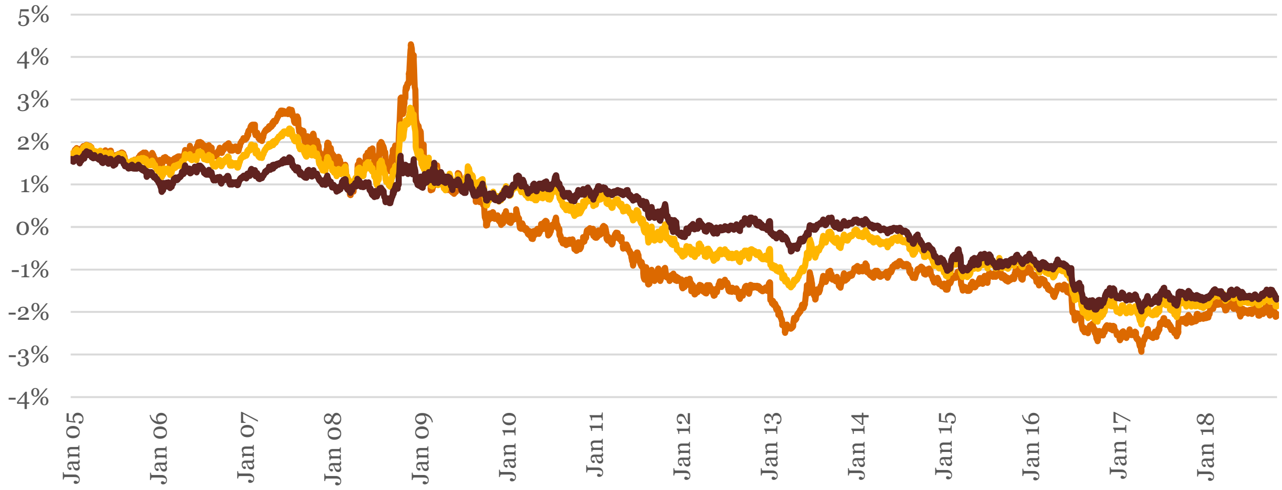


Source: Datastream from Refinitiv, Bank of England, OBR, PwC analysis

2.18 Longer-term interest rates have also decreased following a prolonged period of quantitative easing. Government bond yields remain close to historic lows and the current yield curve is relatively flat compared to recent years. This is shown in Figure 5 below, which tracks index-linked gilt yield over the period January 2000 to October 2017. The current market expectation is that the revised H7 period will be characterised by low long-term interest rates.

[7] Ofwat (2017), "Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return", Page 19, Ofcom (2018), "Business connectivity market review, publication updated on 19 December 2018", Annexes 1-22, Page 206 and Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Paragraph 5.

Figure 5: Index-linked gilts



Source: Bank of England, PwC analysis

2.19 The economic and financial market data therefore suggests a continued period of subdued economic growth and low interest rates, with gradual reversion to more normal levels. However, these normal levels are unlikely to match figures observed historically. Indeed the Bank of England has published its views on the 'equilibrium interest rate or 'r*' and 'trend interest rate' or 'R*' where it expects base interest rates to trend towards[8]. This is around zero in real terms and 2% in nominal terms.

2.20 While current market evidence remains relevant, the time to the start of the revised H7 control period is now longer than when we carried out the work in our December 2017 report. Absent economic and market shocks, we expect the market parameters to return towards new trend levels. Greater confidence can be placed on figures that are then subsequently updated closer to the final H7 decision date in late 2021. Where it is the case that current lower estimates for parameters such as the total market returns are being driven in part by lower interest rates, then, if interest rates are higher when the evidence is updated, then the difference between current market evidence and trend evidence may diminish to some degree. This means we consider it valid to continue to rely on current market evidence, and it will be important to update the market parameters nearer to the start of H7.

[8] Bank of England (2018), "Inflation Report", August 2018. Box 6

3. Responses on gearing

Topic 3a – Use of a notional gearing approach

Topic overview

International Consolidated Airlines Group SA (IAG)

3.1 IAG recognise that HAL's actual gearing is higher than that of the notional financial structure the CAA used to inform the Q6 review. They note that this will translate into higher costs for HAL in securing financing for expansion compared to being geared closer to the notional level. IAG suggest that the CAA should not make an accommodation for HAL's higher cost of debt financing due to their current levels of gearing.

AOC and LACC

3.2 The AOC and LACC agree in principle that it is sensible to re-examine what the correct level of gearing should be for a notionally efficient company. However, they note that it is up to HAL's Directors to determine their own financial arrangements and levels of gearing, and therefore the upside and the downside of such decisions reside with HAL and its shareholders.

Comments and response

Notional gearing approach

3.3 As noted in our December 2017 report, we consider the use of a notional capital structure approach in setting allowed revenues as an integral part of RPI-X incentive based regulation. It provides company management with the incentive to manage the actual financing of the airport. Management are best placed to manage finance risks, through the timing of finance raising, the maturity profile of debt raised, the types of finance raising instruments used (e.g. index-linked debt or more complex debt instruments) and which markets to tap (including international debt capital markets). For example, a company can seek to avoid raising finance at times of heightened debt finance costs by carefully managing cash flow.

3.4 In our opinion, an economic regulator is not best placed to make these detailed financing assumptions and decisions, and any approach which moves the management of finance risk from companies and on to customers through the regulatory regime risks dampening longer term incentives for efficient financial management by companies. For this reason we consider the notional gearing approach (i.e. setting a notional capital structure based upon wider benchmarks for efficient and resilient financing) used by the CAA in Q6 remains fit for purpose in H7. Alternatives, such as mirroring actual gearing levels in the regulator's own assumptions, risk dampening incentives for efficient financing.

3.5 We recognise, however, that the CAA's regulatory remit has evolved over recent years. From undertaking regular price controls for Heathrow, Gatwick and Stanstead, the economic regulation of Stanstead and Gatwick has been rolled back, so that ex-ante price controls are now only required for HAL. This means there is a potential lack of alignment between the notional capital structure assumption in the WACC and HAL's own capital structure. With such inconsistency a lack of alignment was inevitable when regulating a number of airports. However, now that the CAA is only setting price caps for HAL, it could use a notional capital approach which is more aligned to HAL's actual financing decisions.

Impact of an alternative notional capital structure on the WACC

3.6 In Appendix A (Notional capital structures for private companies) of our December 2017 report, we investigated whether an alternative notional capital structure can be specified for HAL and what impact this may have on the regulatory WACC. Specifically, we considered whether the Whole Business Securitisation financing structure, which is currently used by HAL, could be used as an alternative to the existing notional capital structure. We found that the higher level of gearing using this structure does not impact the cost of capital significantly, as the more expensive junior debt is partially offset by the lower share of (more expensive) equity finance.

3.7 While the equity return is significantly higher, on a smaller equity investment, our economic analysis suggests modest reductions to the overall cost of capital for WBS structured entities[9]. This is consistent with finance theory which suggests that movements in gearing should have limited impact on the overall cost of capital.

3.8 There remains a possibility that the actual cost of equity for higher leveraged structures is not as high as predicted in our economic models, and this has been a topic regulatory policy development in recent years.

Regulatory approach

3.9 In recent years, many of the regulated companies that have increased their gearing above the notional level have generated higher returns for equity investors, as companies profits are distributed across a smaller equity base. In response, the scrutiny placed on highly leveraged regulated companies has increased as concerns have grown that these companies could be less financially resilient in the event of an economic shock.

3.10 Ofwat considered the balance of risk and return in their 'Putting the sector back in balance' report[10], particularly with regard to financing outperformance arising from high levels of gearing. They amended the PR19 methodology so that companies are required to implement sharing mechanisms where financing outperformance relates to high levels of gearing. A number of companies have responded to this by suggesting benefit-sharing mechanisms in their PR19 business plans.

Conclusion

3.11 In our December 2017 report we considered 60% was an appropriate assumption for the notional gearing of HAL. This figure was based upon gearing analysis of benchmark companies, credit rating analysis, and regulatory benchmarks. This should provide financial headroom to manage shocks and allow for short-term deviations in capital structure, without placing undue pressure on ratings or the cost of debt. It is also aligned with recent wider regulatory precedent on notional gearing assumptions, for example Ofwat and Ofgem both currently use a 60% assumption[11].

3.12 Instead of changing the notional gearing approach, we recommend that the CAA and HAL consider a benefits sharing mechanism where HAL is geared above the notional level, as suggested by Ofwat as part of its restoring balance proposals in the PR19 methodology. This will enable customers to share in any benefits from financing outperformance associated with higher levels of gearing. Such a mechanism does not impact the risk profile of the notional company (because there would be no financing outperformance associated with higher gearing), so does not impact on the other WACC parameters in our assessment.

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[9] A more geared equity return may suit certain equity investors who don't want to commit as much investment to one entity or have a preference for a higher expected return investment with higher risk.
[10] Ofwat (2018). 'Putting the sector back in balance: Consultation on proposals for PR19 business plans.'
[11] Ofwat (2017), "Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return", Page 20 and Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Page 40.

4. Responses on the cost of debt

4.1 In this section we set out comments and responses to issues raised on the cost of debt. Each is responded to in turn below.

Topic 4a – HAL specific adjustments to the cost of new debt

Topic overview

HAL

4.2 Regarding the cost of new debt, HAL raised two issues. Firstly, HAL proposed a company specific adjustment should be made to iBoxx index yields. Secondly, HAL proposed that any adjustment for future new debt costs should be based on nominal gilts data rather than index-linked gilts data.

4.3 With regards to a company specific adjustment, HAL proposes that a premium of 15bps should be added to iBoxx index yields (with an average of the A and BBB ratings). The scale of this proposed premium is set with reference to the water sector. Specifically, HAL notes the Ofwat assumption that water companies will be able to outperform iBoxx index yields by approximately 15bps i.e. the water sector has a 15bps discount to the index. HAL then compared the traded yield on its own August 2028 bond to the traded yield on an Anglian Water January 2029 bond and found a spread of 30bps over the period 2015 to early 2018. This spread of +30bps, in tandem with the Ofwat discount of 15bps, was used to conclude that a HAL company specific premium to iBoxx index yields of +15bps is appropriate.

4.4 With regards to the adjustment for future debt costs, HAL notes that the adjustment made for forward new debt costs made in the PwC report is based on index-linked gilts. In response, HAL says that this approach is incorrect for three reasons:

i) PwC is adjusting the forward-curve inconsistently due to differences in index-linked costs and nominal costs;

ii) HAL largely issues nominal bonds, and therefore that the nominal gilt yield curve is better suited to estimating the forward new debt cost; and

iii) The index-linked forward curve is likely to under-predict future movements in nominal costs as it includes an implicit allowances for inflation risk.

AOC

4.5 CEPA reviewed the cost of new debt on behalf of the Heathrow Airline Operators Committee (AOC). CEPA raised two issues with the cost of new debt estimation. Firstly, they do not consider there to be a compelling rationale to change from the use of 10-15yr A and BBB rated iBoxx indices. Secondly, they note that if there is expected systematic outperformance against chosen indices that that this would be reflected in a downwards adjustment to the index.

Comments and response

4.6 In our December 2017 report we used a notional approach to assess the cost of debt. Where this approach is used the main consideration when selecting an efficient cost of debt index is the maturity and the credit rating. Consistent with the long-life of airport assets, we selected a long-term maturity. We therefore considered the 10Y+ iBoxx indices, which typically have average bond maturity of around 20 years, to be appropriate. Furthermore, consistent with an investment credit rating, we used a blend of A and BBB rated debt. This benchmark is used widely across other UK regulators.

4.7 In addition to the considerations set out above, we carried out a suitability check by comparing the notional cost of debt to actual company debt financing costs. The purpose of this suitability check is to look for consistent and material discrepancies which may reveal that there is a risk, to either financeability (from under-performance) or consumers (from over-performance), from the choice of index. Where a clear discrepancy does exist, further review can be conducted and, if relevant an appropriately sized adjustment can be made.

4.8 In reviewing the evidence put forward by HAL, we do not consider an adjustment to be warranted. This is for the reasons set out below:

i) A direct comparison of the yields on HAL bonds was made to the Iboxx indices in our December 2017 report, and the evidence showed that HAL bonds trade very close to the iBoxx indices, and that on average is there is a very small discount to the iBoxx index (average of A and BBB).[12] This was further supported by the yield to maturity at issue for a number of HAL bonds which were very close to the prevailing iBoxx index (again, average of A and BBB).

ii) The 15bps discount to the iBoxx index used by Ofwat is based on sector wide trends rather than any individual issuance, and there is a lot of heterogeneity across bonds in the sector. Therefore, any comparison which relies on a single bond is unlikely to be sufficiently robust for the basis of an adjustment.[13]

iii) As CEPA note, HAL is A- credit rated in relation to its senior debt, so ex-ante might be expected to outperform the index (comprised of an average of A and BBB bonds) by a small margin (HAL's senior debt is above the 60% notional debt to RAB ratio, so, on this basis, a notionally financed airport may be expected to outperform the iBoxx A/BBB index).[14]

4.9 In relation to the use of nominal or index-linked bonds to calculate a forward-looking adjustment, we still consider index-linked bonds remain appropriate. This is because HAL is not exposed to RPI inflation risk through the RPI-X control. Where there is a divergence between the forward-looking uplift calculated from nominal bonds and index-linked bonds this is most likely to reflect changes in RPI inflation expectations. HAL is not exposed to these changes, provided the RPI inflation assumption is set at a reasonable central estimate. This means index-linked bonds provide a good basis for estimating the expected future movement in real debt finance costs.

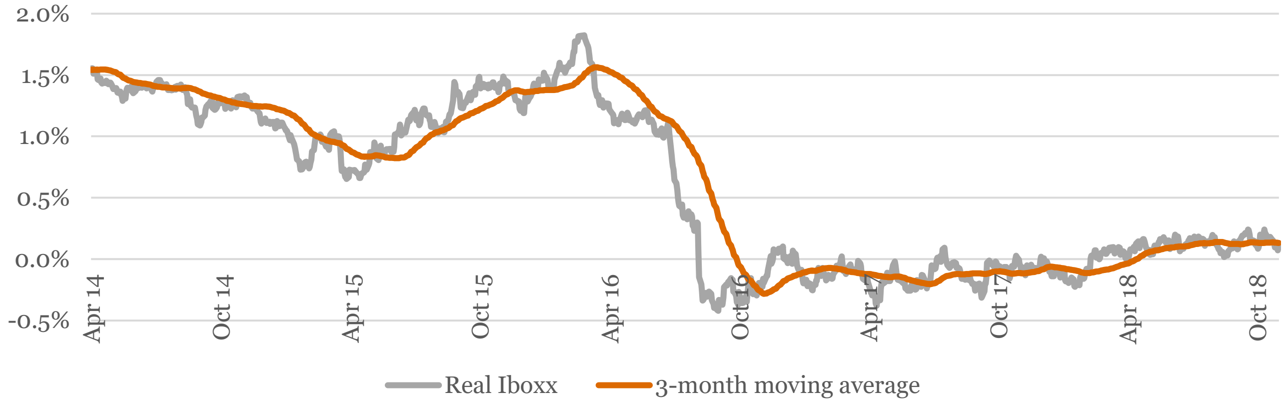
Conclusion and data update

Spot corporate bond yields

4.10 Figure 6 shows how real iBoxx yields have evolved in recent years. There have been no material changes to yields since we published our December 2017 report. Based on the 3-month moving average, which smooths out daily fluctuations, recent yields are approximately 0.1%.

[12] A separate allowance is made to the overall cost of debt for issuance costs.
[13] Furthermore, we note that the spread between the HAL and Anglian Water bonds is not consistent over time (it is lower pre-2015), and we note that where an alternative bond comparison is made e.g. to a Southern Water bond with a similar maturity, the same credit rating and the same currency, that the spread is materially lower on average than the Anglian Water bond spread.
[14] S&P and Fitch rated HAL's Class A debt at A- as at 30 October 2018. Source: https://www.heathrow.com/company/investor-centre/credit-ratings

Figure 6: Real iBoxx yields over time



Source: Bank of England, Refinitiv, PwC analysis

Forward-looking adjustment

4.11 As interest rates are likely to change over the course of the H7 period, it is appropriate to make a forward-looking adjustment to account for expectations of future interest rate changes[15]. To inform this adjustment, we review evidence from both nominal and index-linked gilts.

4.12 Table 8 below shows the forward-looking adjustment implied by forward yields around the middle of the revised H7 control period (October 2024).

Table 8: Forward-looking adjustment implied by gilts

Analysis date	Gilt type	Date	Yield	Forward-looking adj.
October 2018	Nominal	Spot (Oct 2018)	1.43%	
		Forward (Oct 2024)	2.20%	+0.77 percentage points
	Index-linked	Spot (Oct 2018)	-1.83%	
		Forward (Oct 2024)	-1.56%	+0.27 percentage points
October 2017	Nominal	Spot (Oct 2017)	1.39%	
		Forward (Oct 2022)	2.30%	+0.91 percentage points
	Index-linked	Spot (Oct 2017)	-1.76%	
		Forward (Oct 2022)	-1.37%	+0.39 percentage points

Source: PwC calculations

4.13 For the reasons above, we use index-linked bonds to assess likely movements in future debt finance costs. This is around 0.30 percentage points. Based on the current market evidence, and factoring some degree of uncertainty (25bps above and below our central projection) from forward-looking adjustments based on forward yields, we conclude that the cost of new debt during H7 could be 0.4% (i.e. spot yield of 0.1% + forward looking adjustment of 0.3%) +/-0.25%. This produces a range for the real cost of new debt of **0.15% to 0.65%**, which is unchanged from our December 2017 range.

[15] Some stakeholders have suggested that longer term bonds may have higher liquidity premiums, and therefore rising yields are not only due to rising interest rate expectations. In our analysis we only look at medium term bonds and we consider the liquidity of these bonds to be sufficient. We also note that Ofgem do not adjust for this their analysis of forward movements for RIIO-2 (although their equity indexation approach effectively mitigates the need for this).

4.14 We recognise that the CAA's cost of debt methodology for H7 has not yet been confirmed. For the purposes of this update report, we therefore consider this forward-looking market based approach an appropriate working assumption for the cost of new debt.

4.15 While there is uncertainty over the degree to which current market yields are being driven by temporary or permanent factors, evidence from the future direction of long-term interest rates supports the view that long-term equilibrium interest rates have declined. However, as there is a risk that current rates used for the purposes of our analysis are possibly being distorted by short-term market uncertainty, market movements should be monitored between now and the final determination of the H7 controls.

Topic 4b – Use of a notional cost of embedded debt

Topic overview

HAL

4.16 HAL stated that it is important the CAA reflects the actual cost of embedded debt in the WACC. HAL put forward the argument that doing otherwise would effectively assume inefficiency. HAL said that the 1.8% cost of embedded debt set out in our December 2017 report was considerably lower than the actual cost of debt, which they estimates to be between 2.5% and 3.4% (real, RPI).

AOC

4.17 CEPA in their note for AOC supported the use of a notional approach, noting the incentives this placed on Heathrow to pursue efficient financing. CEPA highlighted that the use of actual debt costs could lead to moral hazard.

Comments and response

4.18 The advantages of a notional approach to the cost of embedded debt were set out in our December 2017 report. In summary, a notional approach provides incentives for efficient financing, and allocates risks – such as timing risk and currency risk – to the company, who are best placed to manage them. The allocation of these risks to the company means that differences can exist between the notional cost of debt and the actual cost of debt. Where the notional cost of debt is below the actual cost of debt it does not automatically imply inefficiency. Differences may instead simply be a manifestation of the company bearing appropriate risk, for example around the specific timing of debt issuance.

4.19 Estimating the cost of actual embedded debt is complex, and HAL themselves in their response acknowledge that the airport has, "a sophisticated debt structure involving different classes of debt and a portfolio of swaps to manage interest rate and inflation risk." We note that HAL's own estimates of a real cost of embedded debt of 2.5% to 3.4% is based on just a sub-sample of their total debt, and may not be representative of aggregate debt costs.

4.20 To further illustrate the complexity of calculating an actual cost of embedded debt, the response from Virgin estimated a much lower figure for HAL's actual embedded cost of debt. Specifically, Virgin estimated an actual nominal cost of debt for HAL of 3.95%. This figure was sourced from HAL's published consolidated debt summary at 30th September 2017[16] and appears to include bonds of multiple currency types and multiple coupon types, as well as subordinated debt. Then, using an RPI assumption of 3.6%, Virgin converted to an actual real cost of debt for HAL of 0.34%.

4.21 As an actual cost of debt approach lacks the incentive strength of a notional approach, and is substantially more complex, we continue to recommend a notional approach to estimating embedded debt costs.

[16] Specifically for the Heathrow Airports Holdings Limited entity.

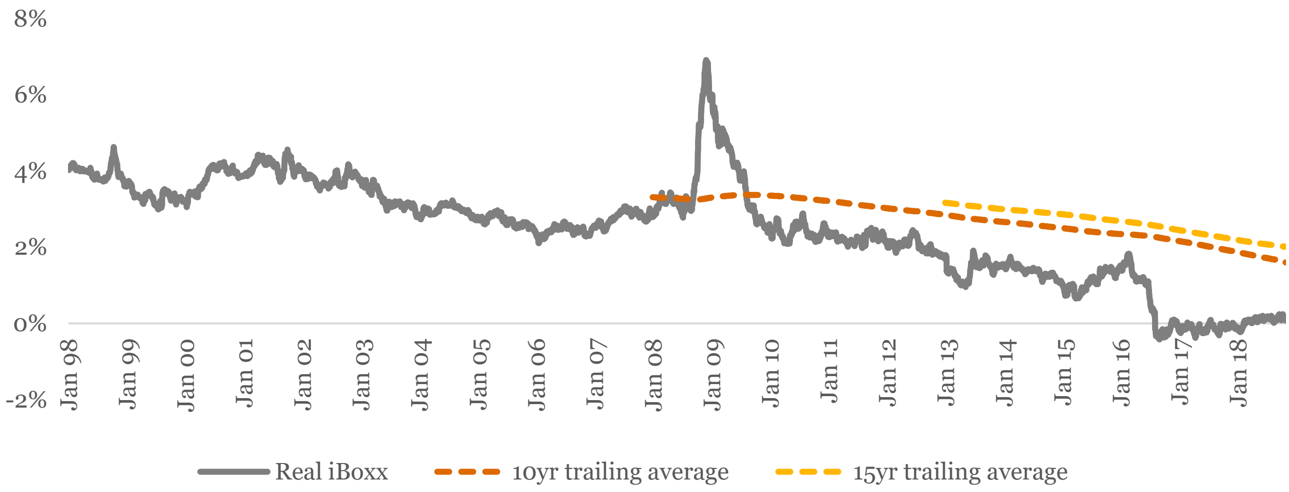
Conclusion and data update

Historic yield averages

4.22 Figure 7 below displays trends in real iBoxx since 1998 and plots the 10yr and 15yr moving averages. The current 10yr moving average is 1.6% and the 15yr moving average is 2%. This is lower than the 10 and 15yr moving averages estimated in our previous report of 1.9% and 2.2%, respectively, as a consequence of a continued period of low corporate borrowing costs.

4.23 Given that current yields are below these averages, these historic average figures are likely to continue moving downwards in the near-term. Consistent with the forward-looking adjustment implied by gilts in the previous issue, towards the end of 2021 (i.e. the period before the beginning of the revised H7 period), these figures could be approximately 0.7% and 1.5% for the 10yr and 15yr, respectively[17].

Figure 7: Real iBoxx yields and long-term moving averages



Source: Bank of England, Refinitiv, PwC analysis

4.24 The current market evidence suggests that the cost of embedded debt immediately before the H7 control period could lie in the range 0.7% to 1.5%.

Topic 4c – The averaging of embedded debt cost

Topic overview

CEPA

4.25 CEPA[18] suggested that the cost of embedded debt should reflect the average cost of embedded debt over the price control period, not just the cost of embedded debt at the start point of the H7 price control.

Comments and responses

4.26 The approach suggested by CEPA takes account of the fact that the amount of embedded debt outstanding falls over the course of H7 (both using the trailing average approach, and for HAL actual financing as bonds mature). CEPA do not provide a detailed methodology for their calculations, but

[17] These averages are rolled forward on the assumption that observed yields increase linearly from October 2018 spot yields through the yields forecast for October 2024 for the real cost of new debt. However, it should be noted that forward curves suggest a larger proportion of increases could occur in earlier time periods (rather than being linear as assumed). The large decline in the forward-looking 10-year average is caused by higher yields from 2008 dropping out of the sample as the averaging window rolls forward to 2021.

[18] CEPA (2018), 'CEPA review of CAA Economic regulation of capacity expansion at Heathrow: policy update and consultation, (CAP1610) – cost of capital issues' for the Heathrow Airline Operators Committee (AOC), February 2018

they suggest taking the mid-point of their estimated 10yr and 15yr trailing averages over 2020-2024, which gives a cost of embedded debt of 0.84% (see table below).

Table 9: CEPA's estimates of cost of embedded debt based on rolling averages of embedded debt

	2020-2024	2021-2025	2022-2026
10 year trailing average	0.39%	0.24%	0.17%
15 year trailing average	1.28%	1.02%	0.80%

Source: CEPA

4.27 We conducted some additional analysis to reflect the falling amount of embedded debt over the course of H7. This approach assumes that as each year passes during the course of H7, the first year of the trailing average is removed from the cost of embedded debt calculation[19]. The time period covered in the trailing average therefore shrinks during the H7 period. The cost estimates using this approach are presented in the table below (assuming that the H7 period will start in 2022).

Table 10: Estimates of the cost of embedded debt using the rolling average approach

	2022	2023	2024	2025	2026	Average
10yr trailing average	0.7%	0.6%	0.4%	0.3%	0.2%	0.4%
Years remaining on embedded debt	10	9	8	7	6	
15yr trailing average	1.5%	1.4%	1.2%	1.0%	0.8%	1.2%
Years remaining on embedded debt	15	14	13	12	11	

Source: Datastream from Refinitiv, Capital IQ, PwC analysis

4.28 The estimates calculated using this approach for the 15-year trailing average are higher than CEPA's estimate. For the 10yr and 15yr trailing averages, we estimate an average cost of embedded debt for the revised H7 period of 0.44% and 1.17% respectively. This compares to CEPA's estimates of 0.17% and 0.80%.

4.29 As seen in Table 4, a key assumption is the period of averaging. We have considered a range of perspectives:

i) The period over which HAL has raised its financing is a useful proxy for the averaging period. Where the two diverge this can lead to potentially undesirable mismatches.

ii) In our December 2017 report, we noted a 15-year average may better reflect the past period of HAL's issuances (because HAL has a number of bond issuances from the 2008/9 period, so a 10 year average would risk a considerable mismatch between actual financing costs and notional financing costs).

iii) CEPA use an average of both 10 year and 15 year trailing averages.

[19] As embedded debt is removed, where this financing is still required by HAL, then it forms part of the new debt financing which is covered by the new cost of debt assumption.

iv) Ofwat use a 10 year trailing average and analysis of the sector's actual embedded debt costs (based upon their actual issuance dates)[20].

v) Ofgem use a 10 year trailing average (to set debt costs for both embedded and new debt combined) for both gas transmission and electricity transmission. For electricity distribution, the averaging period is being gradually extended out to 20 years, in part to avoid a material mismatch between the notional approach and a portion of electricity distribution company debt, which was issued considerably more than 10 years ago.[21]

vi) While differences in averaging period will even out over the longer-term, a shorter averaging period will be more responsive to interest rate changes, whereas a longer averaging period will be more stable.

4.30 It is clear that UK regulators have sought to better align the period of estimates of the notional cost of embedded debt with the actual cost of embedded debt. On this basis we still use a 15 year averaging period for the calculation of embedded cost of debt. We therefore assume a real cost of embedded debt of **1.2%**.

Conclusion

4.31 We acknowledge the methodological point raised by CEPA and have updated our approach to calculating the cost of embedded debt as a result. However, we use the 15 year trailing average to calculate our estimate to be consistent with a long-term financing assumption and broadly aligned to the period over which HAL existing debt was issued. On this basis, we revise downwards our previous cost of embedded debt estimate from 1.8% to 1.2%. This downward movement is by the change in approach and the deferral of the H7 price control period.

Topic 4d – Use of a specific liquidity allowance

Topic overview

HAL

4.32 HAL[22] note that PwC do not include any specific allowance for liquidity costs. They observe that these costs are incurred to establish and maintain sufficient liquidity to meeting regulatory and debt structure requirements.

Comments and responses

4.33 HAL put forward a liquidity cost range of 4 bps to 40 bps depending on the liquidity requirement and its format. In an earlier response, HAL[23] provide more detail on how they reached this estimate. HAL observe that the cost of forward liquidity is largely dependent on the form of the liquidity and the minimum period for forward liquidity provided. They suggest that forward liquidity can be provided in two forms: cash and revolving credit facilities.

4.34 HAL find that under the 'as is' scenario, in which the RAB experiences a level of growth similar to Q6, forward liquidity costs are mainly due to debt repayments. HAL estimate that the extra allowance to recover the cost under current market conditions would increase from 4 bps and 7 bps for 12 and 24 months' forward liquidity from undrawn facilities. Alternatively, HAL estimate that the cost of liquidity is between five and six times higher when using cash reserve requirements, resulting in costs of 20 bps for 12 months and 40bps for 24 months.

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[20] Ofwat (2017), "Delivering Water 2020: Our methodology for the 2019 price review Appendix 12: Aligning risk and return" Page 76.
[21] Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Page 7
[22] HAL (2018), 'Economic regulation of capacity expansion at Heathrow: policy update and consultation (CAP 1610)'
[23] HAL (2017), 'Consultation on core elements of the regulatory framework to support expansion at Heathrow (CAP 1541)'

4.35 To guide their estimate, HAL cite the decision by the CMA to allow Bristol Water 10 – 20 bps for the cost of holding cash balances and maintaining liquidity. However, we observe that the CMA decision was based on the actual cost of embedded debt, whereas we are trying to estimate a figure based on the notional cost of embedded debt.

4.36 We acknowledge there are potential costs of obtaining sufficient liquidity (through undrawn facilities or holding cash); however we expect efficient treasury functions to minimise these costs. Further, the need for liquidity facilities reduces at lower (notional) gearing levels and a strict assessment of liquidity needs should take account of working capital and cash management practices[24],[25].

4.37 An example based on the notional cost of embedded debt is the analysis conducted by Europe Economics[26], on behalf of Ofwat, on the debt issuance and liquidity costs in the water sector. They considered all of the issuances in the 1993 – 2017 period and found that the average cost of issuance was 5 bps, while the average since 2000 is 3 bps. They combine this analysis with our estimate[27] of the issuance cost for Artesian debt of 6bps, to provide a range of 3 to 6 bps for issuance costs.

4.38 To estimate the cost of liquidity, Europe Economics analyse the cost of revolving facilities, which they assume to be a good approximation of liquidity costs. Using information sourced from water companies as well as internal Ofwat analysis, they find the cost of undrawn credit facilities to be around 35 – 45 bps, and they assume that, on average, firms have credit facilities for around 10 per cent of the value of their debt. This implies the liquidity cost is around 3.5 – 4.5 bps. Europe Economics then combine the debt issuance and liquidity cost to estimate a range of 6.5 to 10.5 bps. They take 5 bps as a conservative estimate for issuance costs and round the upper end of the liquidity costs to produce an estimate of 10 bps.

Conclusion

4.39 In our December 2017 report, we suggested an allowance for debt issuance costs of 10bps. Based on the evidence above this allowance is sufficient to recover debt issuance costs and efficient costs of maintaining ongoing liquidity.

[24] Ofwat highlight use of facilities with ultra-low short-term interest rates as one way in which companies can mitigate the cost of liquidity.
[25] For substantial capacity expansion HAL may require more extensive and expensive liquidity facilities.
[26] Europe Economics (2017), 'PR 19 – Initial assessment of the Cost of Capital'
[27] PwC (2014), 'Company specific adjustments to the WACC'

5. Responses on the cost of equity

5.1 In this section we set out comments and responses to issues raised on the cost of equity. Each topic is responded to in turn below.

Topic 5a – Sector comparisons of the cost of equity

Topic overview

5.2 In their consultation responses, airline stakeholders drew upon comparisons to other regulated sectors to suggest that the initial WACC range from our December 2017 report was overly generous.

AOC

5.3 On behalf of AOC, CEPA contrasts their own estimate of the high-end post-tax cost of equity for H7 – equivalent to 9.6%[28] – with Ofwat's PR19 final methodology post-tax cost of equity. CEPA notes that the equivalent figure for Ofwat is 4.0%, a difference of 5.6%. They use this comparison to conclude that the adjustment for risk in H7 is overly generous.

5.4 CEPA also use their conversion of the WACC adjustments to asset beta equivalents to draw comparisons to Ofgem's determinations. Specifically, the net adjustment they make to asset beta results in an "effective PwC H7 R3 beta (zero debt beta)" range of 0.43 to 0.64 range. This is compared to:

i) An asset beta of 0.38 for National Grid Electricity Transmission (NGET) in RIIO-T1;

ii) An asset beta of 0.43 for Scottish Hydro Electric Transmission Limited (SHETL) in RIIO-T1; and

iii) An asset beta of 0.45 to 0.55 for the "competition proxy".[29] Which CEPA note is assumed to be for a single project with no existing RAB.

Virgin

5.5 Virgin cite another recent regulatory reference point, contrasting the initial H7 WACC range to the NIE RP6 final determination of 3.18%.

Comments and response

5.6 We begin by noting that CEPA selected a high-end point of reference for their cost of equity comparison. This is because all the capacity expansion risk compensation – assumed to be the upper value of 100bps – is concentrated in the cost of equity, and, the value selected is from the top-end of the range. Where a lower adjustment for capacity expansion of 25bps has been used, the cost of equity range calculated using the CEPA approach would be 5.6% to 7.7%, significantly closer to the Ofwat initial PR19 figure of 4.0% than the 9.6% quoted by CEPA.

5.7 Having noted this, our analysis here focuses on the 'as is' cost of equity estimate for H7. We believe this approach represents more of a 'business as usual' comparison to other regulatory controls such as PR14, PR19, RIIO-GD1 and RIIO-ED1 and methodology guidance around RIIO-2. In our December

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[28] CEPA translated the adjustments to WACC of 25bps and 100bps (associated with capacity expansion) into asset beta equivalents of +0.04 and +0.15 respectively. Concentrating the WACC adjustment into a cost of equity equivalent impact. A further adjustment is also made debt beta. Using the higher asset beta adjustment of +0.15, they derive a real post-tax cost of equity ranging from 7.4% to 9.6%. Their point of comparison is the upper-end of this range.

[29] The competition proxy model has been recently introduced by Ofgem, and is part of a move towards using competitive benchmarks to inform regulatory allowances. In the context of a single project, using the competition proxy model to set regulatory allowances would involve estimating the outcome of a (hypothetical) efficient competitive bidding process for the financing, construction and operation of the project. In practice, it is the regulated entity that delivers the project, with the regulator using this competitive benchmark to set regulatory allowances.

2017 study the real post-tax cost of equity range 'as is' was 4.9% to 7.1%. A comparison of this 'as is' cost of equity to other regulated sectors is set out in the table below.

Table 12: Change in cost of equity between determinations

Regulator (determination)	Real post-tax cost of equity	Change in cost of equity from previous control
CAA (H7 'as is')	4.9% to 7.1%	-0.8% to -0.5%
Ofwat (PR19 - early view)	4.0%	-1.6%
Ofgem (RIIO-T2)	4.0%	-2.8% to -3.0%
Ofgem (RIIO-GD2)	4.0%	-2.7%
Ofcom (Openreach copper access)	4.5%	-0.3%

Source: Regulatory decisions and methodology documents.
Note: the figures presented are sourced from a mix of provisional regulatory views and reports written on behalf of regulators; they may not reflect the final decisions for the relevant determinations. The change for CAA is with reference to CAP 1140 and the change for Ofwat is for the PR19 early view compared to the PR14 final determination. The change for Ofgem is for the RIIO-1 final determinations and the December 2018 sector specific consultation.

5.8 Two themes emerge from the comparisons set out in the table above.

5.9 Firstly, the initial cost of equity set out in our December 2017 report is higher than the cost of equity being initially proposed in water and energy. However, given differences in the regulatory regime, where Heathrow is exposed to volume risk and other regulated companies are not, and the greater cyclicality of demand for travel compared water and energy usage, some positive wedge is to be expected.

5.10 Secondly, the magnitude of change from the preceding control is lower for H7 compared to water and energy. This second difference can be explained in part by the lower values for market parameters (Total market return (TMR) and Risk-free rate (RFR)) selected by the CAA in Q6. For example, where the CAA adopted a real total market return estimate of 6.25% in Q6, Ofwat selected a value of 6.75% at PR14 and Ofgem selected a value of 7.25% for RIIO-GD1.

Conclusion

5.11 Overall, we find that the combination of: (i) lower starting values for market parameters in Q6; and (ii) exposure to higher systematic risk in aviation and regulatory differences, properly accounted for, show that only small discrepancies exists on an 'as is' basis between sectors.[30]

Topic 5b – Use of long-run historical evidence

Topic overview

HAL

5.12 In our December 2017 report, the estimate for TMR was based on current market evidence. A concern raised by HAL was that no weight had been placed on long-run historical returns evidence, and that this was, in their view, contrary to good regulatory practice.

5.13 HAL highlighted that an approach which draws upon Dividend Growth Model (DGM) analysis, investor surveys and market transaction data was a short-term view.[31] HAL emphasise that a long-term

[30] We note the selection of TMR parameter in the most recent CAA, Ofwat, Ofgem and Ofcom publications has significantly converged, but is not totally aligned. This may be to different timing of data used to support decisions and different timing of price control periods.
[31] Dividend growth modelling (DGM) is also referred to as Dividend discount modelling (DDM).

perspective should be applied, and NERA, on behalf of HAL, emphasise the relative stability of the TMR over time supports the use of long run historical returns as a basis of estimating expected TMR.

AOC

5.14 CEPA, on behalf of AOC, supported the "types of approach used" for estimating the TMR. Specifically, CEPA found the specification of the DDM applied by PwC to be appropriate, but, considered analysis of market-to-asset ratios to be useful, at most, as a cross-check.

Comments and response

5.15 In our December 2017 report we noted the trade-offs that exist when considering the use of long-run historical approaches and current market approaches. Those trade-offs remain relevant and must be considered by the CAA when selecting a preferred approach to setting the WACC. While our report sets out evidence based on both approaches, we drew upon current[32] market approaches for estimating the initial WACC range estimate for H7. This focus on current market approaches was taken as the wider economic and market context within which investors are forming their return expectations is one of interest rates that have remained, and are set to remain, "lower for longer".

5.16 As shown by the stakeholder comments above, there is disagreement over the preferred approach, and we discuss these different views in the subsection below. Before this discussion, we first cover the views on different approaches to estimating TMR from the UK Regulators Network (UKRN) study on the cost of capital produced by Wright, Burns, Mason and Pickford.[33] We cover this paper as it provides a discussion of relevant topics, and was published after our December 2017 report was finalised.

UKRN study

5.17 Since the publication of our December 2017 document, the UKRN released a report on the cost of capital, and this report considered different approaches to estimating the "expected market return" (EMR), using to a varying degree historical and forward-looking evidence. We note that EMR is equivalent to the 'Total market return' (TMR) terminology that we used in our December 2017 report and throughout this report. Specifically, five approaches were considered:

i) Approach one: The MMW (Mason, Miles and Wright) methodology,[34] which is that, the expected real return on investments in the equities of a firm with a CAPM β of precisely one, should be assumed constant, and set in the light of realised historic real returns in a range of stock markets, over long samples;

ii) Approach two: Assume the equity risk premium (ERP) is stable;

iii) Approach three: Update the estimate of the EMR in line with econometric evidence of return predictability;

iv) Approach four: Estimate the EMR using alternative models such as the Dividend Discount Model; and

v) Approach five: Separately, the usefulness of bid premia as a source of information for setting the cost of equity was discussed.

5.18 We set out the view of the UKRN report on each of these five approaches below.

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[32] Current market approaches draw from recent market data, but also incorporate smoothing to remove short-term volatility.
[33] Wright et.al (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators: An update on Mason Miles and Wright (2003)'.
[34] Mason, Miles and Wright (MMW) refers to the authors of 2003 paper produced for the UKRN and the analysis and approaches which that paper took.

Approach one:

5.19 With regards to approach one, the UKRN study emphasises the stability of US stock returns over two centuries. The study also emphasises the lack of stability in long-term returns on cash and bonds. By implication, the authors conclude, the ex-post equity premium has been far from stable. The conclusion from the study is that historical evidence supports a stable EMR in real terms.

Approach two:

5.20 With regards to approach two, the study concludes that there is evidence that risk premia are countercyclical, and that the empirical basis for a stable ERP is weak. But, also emphasises that it, "should not be taken as a claim that the EPR moves precisely one-for-one in the opposite direction to the RFR."[35]

Approach three:

5.21 With regards to approach three, the UKRN report finds that evidence for this type of approach has strengthened. Specifically, they link declining equity return expectations among financial practitioners to the recognition that valuation indicators such as the cyclically adjusted P/E ratio appear to have some predictive power.[36] The authors of the study conclude that this evidence does undermine Approach one, and does even more so where regulators evaluate EMR at a long-term investment horizon, as this is where the predictive power of this approach is strongest. However, they question the implementability of this evidence on a quantitative basis e.g. the time period over which valuation ratios tend back to long-run values.

Approach four:

5.22 With regards to approach four, the UKRN reports notes that DDM is a widely used technique. And, that is applied carefully, it can be mutually supportive and complementary to CAPM.

5.23 The study notes that one key feature of the DDM is that, as expected growth estimates tend to update gradually, there is an inverse relationship with the stock market prices and the implied cost of equity from DDM. This feature is linked to the predictive power of DDM for subsequent returns. That is, a rise in the stock market, and an associated fall in the implied cost of equity implies a prediction of lower returns over long horizons (holding other parameters constant).

5.24 The study also comments on contribution of forecast growth in dividends. They highlight that errors in growth forecasts feed more or less one-for-one into errors in the estimated cost of equity.

5.25 The authors find DDM may provide value as a cross-check on their preferred methodology. However, they are less supportive of DDM purely as a means of estimating EMR. This is driven by uncertainty over predicting the growth rate of dividends over time and the acceptability of past outputs from a DDM methodology from a consumer perspective (as it may have led to a high cost of equity being set).

Approach five:

5.26 The UKRN report also comments upon the link between 'bid premia', which we refer to as 'market-to-asset ratios' and returns. Specifically, the study notes that observed bid premia on recent transactions imply that the return on regulatory equity expected by the buyers of a company could be around twice the true market cost of equity. It is noted that since the true expected return on regulatory equity cannot be observed, and neither can the true market cost of equity, explaining the gap is therefore challenging.

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[35] Wright et.al (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators: An update on Mason Miles and Wright (2003)', Section 4.4.2

[36] Declining return expectations were sourced from the Horizon Actuarial Services, Survey of Capital Market Assumptions, Editions 2012 to 2017.

5.27 The authors differ on the extent to which the bid premia can be attributed to (i) the regulatory allowed return being set in excess of the WACC i.e. an overestimate of the WACC by regulators, or, (ii) regulatory expected returns exceeding the regulatory allowed return due to outperformance of targets.

5.28 One view is that both have made significant contributions. Mason, Pickford and Wright, three of the authors of the study, find that, "recent bid premia imply such large differences between the Required Equity Return and the WACC that it is very hard to provide an explanation that does not rely on both factors making a material contribution." This finding is consistent with our December 2017 report.

5.29 However, the view of Burns differs from the other authors of the study. Burns finds that outperformance may have made a larger contribution to bid premia than the other authors suggest. Focusing on transaction premia for energy networks, Burns finds outperformance of costs and output targets, along with financing outperformance, could account for a RAB premium of around 40% for an optimistic investor that expects current levels of outperformance to continue (but does also note that an expectation such as this may be unrealistic). Overall, the final view of Burns is that there are challenges to using bid premia to make inferences about the cost of equity.

Conclusion

5.30 In summary, disagreement exists between the suitability of difference approaches for estimating TMR. What is clear from the discussions above is that no technique is without drawbacks, and that, where carefully applied, different techniques can be used as a cross-check on one another.

5.31 From this, our view remains that the CAA should seek to corroborate evidence from a preferred source with information – whether that is qualitative or quantitative – from other sources.

5.32 While the UKRN study recommends that realised real stock returns over long samples should be used as a basis for setting regulatory return allowances, they also note that evidence from other approaches can call into doubt the outputs from this approach.

5.33 Our view remains that current market evidence, such as DDM estimation, remains a valid approach so long as regulators are aware of the trade-offs associated with use of current market evidence, and there are appropriate cross-checks to its outputs. In particular, a useful cross-check that results from the findings by the UKRN study is one which combines long-run historical return data with information from stock market ratios (such as cyclically adjusted price to earnings ratios, or market to asset ratios).

5.34 The use of current market evidence is most helpful at points when markets are most demonstrably far from historical norms, as measured by equity valuations ratios, interest rates and other financial market indicators. This was more clearly the case following the global financial crisis and the period of ultra-low interest rates which followed. As financial market indicators gradually return to longer-term norms, then the difference between historical measures of expected equity returns and forward-looking measures should narrow. In this case, the two broad approaches should become more mutually supporting.

5.35 In section 5c below, we review in more detail the evidence base for historical returns. This review helps to frame the range for TMR that is suggested by historical data, and which, in turn, can be used to guide the cross-check set out above.

Topic 5c – Estimating historical returns

Topic overview

5.36 Having discussed the use of long-run historical approaches in Topic 5b above, this topic focuses on the estimation of a value for long-run real historical equity returns, and assessment of a suitable figure for future real expected returns, based upon historical evidence.

HAL

5.37 NERA on behalf of HAL calculated their own historical TMR estimate. Using Dimson, Marsh and Staunton (DMS) data based upon arithmetic averages of historical returns, NERA estimate a real TMR range of 6.8% to 7.1%. The lower end of this range is then revised downwards by 0.3% to account for recent changes in the RPI formula effect, producing an estimated TMR range of 6.5% to 7.1%. This is significantly higher than the 5.6%-6.3% range estimated in our December 2017 report.

5.38 Noting the differences in historical TMR estimates across appraisers, NERA argue that the PwC historical TMR range is excessively low. They state that the "adjustments to long-run historical evidence are unjustified"; focusing on the forward-looking returns adjustments in particular, they argue that "the adjustment for good fortune can only be considered as illustrative, rather than an objective adjustment based on evidence of historical good fortune".

Comments and response

5.39 In this section, we assess the latest evidence on estimates of the long-run historical TMR. Since our December 2017 report, there have been two major contributions to the literature on long-run historical equity returns. We begin by examining the findings of Jorda et al (2017)[37], who have constructed a comprehensive new historical returns dataset and used this to analyse long-run asset returns. We focus particularly on these authors' estimates of UK and global equity returns, which are reported as arithmetic CPI-adjusted averages. Our next step is to analyse a recent UKRN study which focuses on historical equity returns, specifically for UK regulatory purposes. This study reports geometric CPI-adjusted average returns.

5.40 The 2018 UKRN study finds that arithmetic averages can create spurious differences and that it is more appropriate to calculate geometric returns. The UKRN study then recommends that an adjustment is applied to geometric returns, where the recommended adjustment is +1 to + 2 percentage points depending on: "the extent to which regulators wish to take account of serial correlation of returns".

5.41 We review the relative merits of both the arithmetic and geometric averaging approaches and consider the impact of different holding period lengths and the presence of serial correlation on the selection of an appropriate estimate. We then conduct econometric analysis to indicate the size of the adjustment required to the geometric mean in the context of H7.

5.42 To relate the UKRN and Jorda findings to the RPI-indexation context relevant to H7, we then investigate the studies' approach to inflation adjustment. We analyse historical Bank of England inflation indices to review the basis of the real estimates and then adjust to calculate RPI-adjusted historical equity returns for both data sources.

5.43 Finally, we conclude by combining our analysis of these studies with our December 2017 evidence to derive an updated estimate of long-run historical TMR.

[37] Jorda et al. (2017), Rate of Return on Everything, 1870-2015.

The source of historical returns

Jorda et.al study

5.44 One recent contribution to the equity returns literature, unavailable at time we produced our initial report, has come from Jorda et al (2017), who have developed a long-run asset return dataset. This dataset extends the evidence base on long-run asset returns, in that it incorporates 16 advanced economies across a 145-year timespan (1870-2015). The comprehensiveness of the data allows for analysis of historical asset returns at both the domestic and global level.

5.45 Jorda et al use their dataset to analyse the typical returns earned across a range of assets. Specifically, they study market returns data for 16 advanced economies across four asset classes: equity, housing, bonds and bills.

5.46 When assessing trends in returns across their full historical sample, with all 16 countries included, the study finds that the risk premium between safe and risky assets has displayed considerable volatility over the long run. Notably, Jorda et al report that low-frequency and enduring swings in the risk premium have often exceeded the amplitude of business-cycle swings, which weakens the notion of a natural risk premium.

5.47 Nevertheless, the study finds that the risk premium has tended towards 4-5% during most peacetime eras. When combined with average real safe rates of 1-3%, this has resulted in average real risky rates (including housing) of 6-8% (typically corresponding to CPI deflated returns).

5.48 Another finding is that risky rates have often been more stable than safe rates, with Jorda et al reporting several instances where changes in the risk premium have been largely driven by changes in safe rates. This is true of recent years, where risk premia have widened due to safe rates falling more dramatically than risky rates[38].

5.49 The sample-wide findings of Jorda et al suggest that caution should be taken when attempting to derive a representative equity TMR from historical global equity returns. Not only do equity returns fluctuate significantly over time, but there remains considerable cross-country heterogeneity in spite of some recent convergence (which is driven partly by cross-country variation in safe rates). In forming UK-specific TMR estimates, it is therefore advisable to focus attention primarily on UK historical data.

5.50 Focusing on UK-specific data from the study, Jorda et al form a nominal equity return series using several sources[39]. The authors weight market returns by the market capitalisation of large UK companies to achieve representative nominal UK return estimates. Having obtained nominal returns, Jorda et al then use historical CPI data calculated by the Bank of England to compute real return estimates[40].

5.51 The table below captures estimates from Jorda et al of arithmetic average nominal and real UK TMR, which we decompose into capital appreciation and dividend yield components. We also report the authors' estimates of nominal and real global equity returns as a point of comparison[41].

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[38] This finding supports the assessment of total equity returns and subsequent decomposition into a risk-free rate and equity market risk premium, rather than separate estimation of a risk-free rate and equity market risk premium.

[39] As described in Section L of their Appendix, Jorda et al use a combination of sources to derive a nominal UK equity return series spanning the years 1871 to 2015. For 1871-1928, they use return data for all UK stocks listed on the London stock exchange, which is taken from Grossman (2002, 2015). For 1929-1963, they use a blue-chip equity returns index based on the largest 30 stocks listed on the London stock exchange, as reported in Barclays (2016). For 1964-2015, they use data from the FTSE all-share index.

[40] The CPI series used by Jorda et al comes from the Bank of England's millennium of macroeconomic data.

[41] As explained by Jorda et al (2017) in their paper, global return estimates draw from a range of countries, with data period coverage varying across these countries. For data availability reasons, the estimates presented here are not weighted by country GDP.

Table 13: Arithmetic average of annual nominal and CPI-deflated equity returns, full available sample

		Nominal			Real
		Capital gain	Dividend income	TMR	TMR
UK	Post-1950	*NR*	*NR*	*NR*	9.22%
	Post-1980	*NR*	*NR*	*NR*	9.34%
	Overall	6.42%	4.75%	11.25%	7.20%
Global	Overall	6.62%	4.18%	10.81%	6.60%

Source: Jorda et al (2017). "NR" implies that the listed quantity is not reported in the paper.

5.52 In the context of the RPI indexation to HAL's Regulatory Asset Base (RAB) it is worth re-iterating that Jorda et al use a CPI inflation measure to calculate real UK equity returns. Since HAL's indexation is on an RPI indexation basis, the real returns calculated by Jorda et al need to be adjusted for any differences between CPI and RPI (which we set out later in this section).

5.53 Another important consideration is that the above estimates use arithmetic rather than geometric averages. To obtain approximate geometric estimates for UK and global equity returns, we can apply adjustments based on further data reported in Jorda et al (2017). When reporting global returns (both nominal and real), Jorda and his colleagues calculate geometric averages to supplement arithmetic averages. The reported geometric average is 2.18 percentage points lower for nominal equity returns and 2.25 percentage points lower for real equity returns. Applying these wedges to nominal and real UK TMR (as an approximation) yields geometric UK TMR estimates of 9.07% (nominal) and 4.95% (real, CPI).

5.54 We discuss the distinction between the two approaches in more detail in the discussion of the UKRN report below.

UKRN study on the cost of capital

5.55 The UKRN study begins by noting that UK regulatory practice has typically followed the recommendations of Mason, Miles and Wright (MMW). This recommendation was that:

> *"the expected real return on investment in the equities of a firm with a CAPM β of precisely one, should be assumed constant, and set in light of realised historic real returns in a range of stock markets over long samples."* [42]

5.56 The 2018 UKRN study considered a number of different approaches (as discussed in Section 5b above), but concluded with the same recommendations as MMW. In light of this recommendation, the 2018 UKRN study provided an update to estimates of realised real historic equity returns. These estimates are set out in the table below. The study concludes that a figure of around 5% is supported by historical evidence.

Table 14: Summary of long-term real returns on UK and global stock markets from the 2018 UKRN study

	UK £ (DMS)	UK £ (CPI)	UK $	World $	World ex.US $	US $
1899 to 2016	5.48%	5.23%	5.07%	5.05%	4.33%	6.39%
1899 to 2000	5.88%	5.58%	5.61%	5.36%	4.63%	6.79%
2000 to 2016	2.97%	3.01%	1.78%	3.16%	2.43%	3.87%

Source: Wright et al (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators: An update on Mason, Miles and Wright (2003), Table 1, Appendix E

[42] Wright et al (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators: An update on Mason, Miles and Wright (2003), page 36.

5.57 The long-run average returns set out in the table above are geometric averages. The 2018 UKRN study finds that arithmetic averages can create spurious differences and that it is more appropriate to calculate geometric returns. The UKRN study then recommends that an adjustment is applied to geometric returns, the recommended adjustment is +1 to + 2 percentage points depending on:

> *"the extent to which regulators wish to take account of serial correlation of returns".*

5.58 The study then notes that, where regulators set returns with a longer-term investment horizon in mind, an adjustment as large as +2 percentage points becomes less appropriate.

5.59 As captured in the table above, one source of difference between long-run estimates of realised historic real equity returns is the choice of inflation measure used to deflate nominal total returns. Regarding the choice of inflation, the 2018 UKRN study notes that,

> *"As discussed in MMW (2013), Dimson Marsh and Staunton (2002) use RPI inflation from 1947 onwards and a much more narrowly defined cost of living index in earlier data, which rose less rapidly than the Bank's estimates of RPI or CPI. DMS in 2016 updated their methodology to account for the perceived problems with the RPI by using CPI from 1988 onwards."*[43]

5.60 The 2018 UKRN study then goes on to apply – in the interests of consistency – a Bank of England long-term price measure. Retaining DMS's nominal total return series, but applying this alternative deflator, the 5.23% "UK £ CPI" figure is estimated. As set out in the quotation above, the reason for a lower real return than DMS's own calculations, is that inflation is higher in the earlier part of the sample in the Bank of England inflation data.

5.61 Having reviewed the recent additional studies on historical equity returns we now focus on the key decisions regulators need to make when interpreting long-run data. These are:

i) Use of arithmetic or geometric averaging to estimate TMR;

ii) The investment horizon;

iii) Adjustment for serial correlation;

iv) Adjustment for forward-looking inflation;

Use of arithmetic or geometric averaging to estimate TMR

5.62 One of the main issues for regulators in setting the cost of equity is the use of arithmetic versus geometric averages of estimating the expected total market returns (TMR). Historical averages can be calculated using both approaches and there has been a wide-ranging debate on which method is the most appropriate to use in setting return requirements.

5.63 Arithmetic averages simply average the individual annual returns over the return period under consideration. This approach produces an unbiased estimator when the events under consideration are independent of each other (for instance, taking the average of scores on a school test, or in the case of financial markets, the average of historical equity returns if the returns are independent of all preceding years) and are constant over time. Some practitioners prefer an arithmetic average as a measure of total market returns, based on the justification that it represents an unbiased estimate[44].

5.64 Other practitioners prefer the use of a geometric average, which calculates the annual compound growth rate in returns over the time period under consideration. Their justification is based on a number of reasons. Firstly, empirical studies indicate that returns on stock are negatively correlated

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[43] Wright et al (2018), 'Estimating the cost of capital for implementation of price controls by UK Regulators: An update on Mason, Miles and Wright (2003), Appendix D

[44] Kolbe, L.A., Read J.A. and Hall, G.R. (1984) 'The cost of capital, Estimating the Rate of Return for Public Utilities'

over a long period[45]. Consequently, the arithmetic average method is more likely to overstate the forward looking required risk premium. Secondly, while asset pricing models like the Capital Asset Pricing Model (CAPM) are single period models, regulatory models are used to estimate expected equity returns over longer periods. Finally, the geometric average is not skewed by large (positive) deviations, which prevents the risk premium from being overstated.

5.65 Lastly, some practitioners suggest a blend between the two. This view is consistent with Indro and Lee (1997) who argue for a weighted average of the arithmetic and geometric premiums, with the weight on a geometric premium progressively increasing with a longer investment time horizon. Such an approach was reflected in the CMA (2014)[46] work where short-term investments were modelled based on the arithmetic average, while long-term investment returns justified the use of a geometric average. We agree that neither approach is perfect, and rather they form a starting base from which adjustments need to be made.

5.66 Ultimately, practitioners deciding on which approach to use should base their adjustments on their assumptions on:

- the investment holding period under consideration (See Appendix E for further analysis on this issue); and
- the degree to which expected returns exhibit serial correlation.

Investment holding period

5.67 To estimate TMR for H7, it is important to consider the wider regulatory context, as well as the investment-holding period and the degree to which returns exhibit serial correlation. Given that infrastructure investment is for long investment horizons and regulation is set for repeated five year time periods, we recommend that the CAA takes a longer-term perspective in assessing the inputs to the cost of capital. This view is in line with recommendation 2 of the UKRN report, which states that, *"On balance, we are in favour of choosing a fairly long horizon, for example, 10 years, in estimating the CAPM-WACC"*.

5.68 We also note that many market investors, such as pension funds, insurers and some retail investors typically have longer-term investment horizons, and are therefore unlikely to make significant changes to their equity holdings on an annual basis. Even short-term investors, such as traders, are basing their investment decisions on the valuation of investments made by long-term investors, and any arbitrage opportunity this may create. This means typical the investment holding period for an asset can't be used to infer the investment horizon used to value assets and set expected returns.

Adjustment for serial correlation

5.69 It is also important to consider the degree to which returns are "predictable"[47] in equity markets. As noted earlier, if market returns are independent of all previous periods i.e. they follow a 'random walk', then the arithmetic average is an unbiased estimator. We note that while there is an element of 'random walk' in markets, numerous academic studies find evidence of negative serial correlation, i.e. periods of good return performance are followed by periods of weak return performance and vice-versa. This biases arithmetic averages upwards. However, using the geometric approach to estimate returns in

[45] Negative autocorrelation means that good return years are more likely to be followed by poor return years, and vice versa. The evidence on negative serial correlation is widely cited, including analysis conducted by Fama and French (1988). While one year serial correlation is low, they find that five year correlations are strongly negative across all size classes. Fama, E.F. and K.R. French, 1992, The Cross-Section of Expected Returns, Journal of Finance, Vol 47, 427-466.
[46] CMA. (2014). 'Northern Ireland Electricity Limited price determination'
[47] i.e. exhibit serial correlation, so the returns in one period are influenced by the returns in prior periods. There may be other factors which can also predict returns.

markets that exhibit serial correlation generally biases return estimates downwards by underestimating the impact of return volatility, which also leads to an imprecise estimate of the average TMR.

5.70 In their 2018 report, the UKRN[48] argue that the expected TMR should be estimated using the geometric average with an upwards adjustment of 1-2 percentage points, "*rather than calculate arithmetic averages directly (which can generate spurious differences, especially when returns are affected by exchange rate fluctuations), it is more appropriate to work from geometric (compound) average returns and add an adjustment of 1 to 2 percentage points, depending on the extent to which regulators wish to take account of serial correlation of returns.*" The study also notes that an upward adjustment of 2 percentage points is weakened if regulators wish to set returns on a consistent basis for a longer horizon (for example, a 10 year period), given that long run returns have lower volatility compared to following a random walk.

5.71 The issue of whether TMR should be calculated using an arithmetic average or a geometric average was discussed in more depth in MMW (2003)[49]. The authors explain that, assuming returns are log normally distributed, the arithmetic average return exceeds the geometric average return by $(1/2) * \sigma^2$, where σ is the variance of the log of returns. They note, "*suppose that the volatility of log returns is 0.2, a rough ballpark figure for a range of equity markets, according to figures from Dimson, Marsh, and Staunton (2001a). The implied difference between the arithmetic and log (hence geometric) means will approximately equal $0.2^2/2 = 0.02$, or two percentage points.*" The UKRN report uses this figure as the upper bound estimate of the adjustment to the geometric measure of the TMR, which is equivalent to the simple arithmetic average and implicitly assumes that returns follow a random walk.

5.72 MMW also consider how longer-term time periods affect the estimate of expected return. They note that if log returns are unpredictable, then the variance of the five-year log return will simply be five times the variance of the one-year return. Whereas, if the variance of stock returns increases less than proportionally with the investment horizon, stock returns exhibit signs of negative serial correlation.

5.73 When modelling a longer time period with predictability of returns, MMW find a reduction in long-run return variances (when using a cointegrating vector autoregressive model) compared to the random walk assumption, providing evidence that stocks are less risky over longer time periods when talking account of negative serial correlation. Their findings are set out in Table 15 below.

5.74 MMW conclude that: "the implication of these figures is that if they truly capture return predictability, the gap between the arithmetic mean return and geometric return would fall to only around one percentage point over a five year horizon, and even less over a ten year horizon."

Table 15: Equity return variances at different time horizons, adapted from MMW.

	Random returns	Cointegrating vector autoregressive model[50]	Ratio
1 year	0.044	0.036	0.82
5 year	0.222	0.118	0.53
10 year	0.455	0.180	0.39

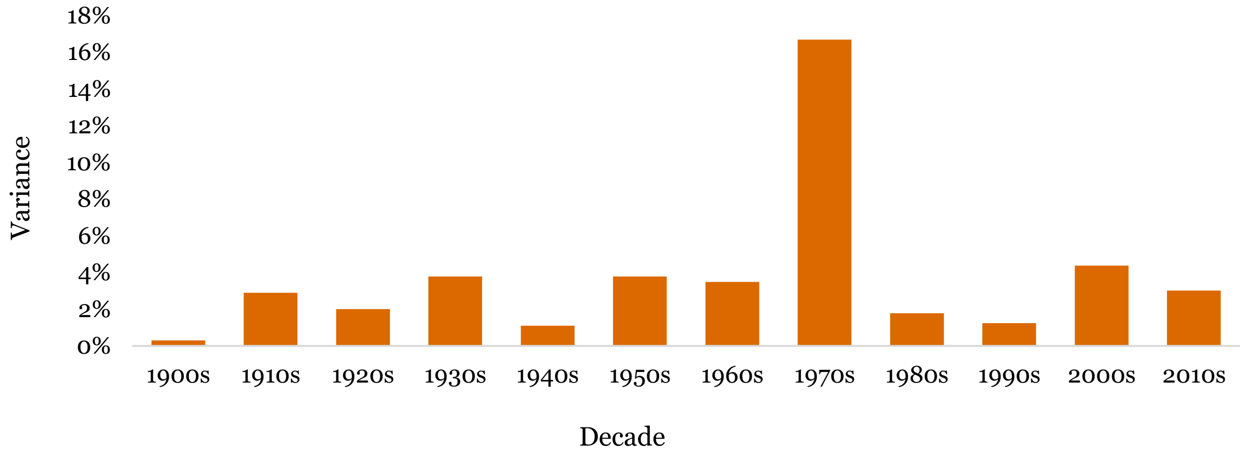
Source: MMW (2003). Based upon US equity market data.

[48] UKRN. (2018). 'Estimating the cost of capital for implementation of price controls by UK Regulators'
[49] Mason, R. Miles, D. Wright, S. (2003). 'A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the U.K.'
[50] Econometric model used to capture the evolution and the interdependencies between multiple time series. The MMW approach also incorporates Tobin's Q (ratio of market value of assets to book value of assets) as an additional variable which explains returns (and therefore reduces variances.

5.75 To guide our estimate of the adjustment to the geometric mean, it is important to consider historical volatility (measured by variance) in equity returns. In Figure 8 below, we present the variance in annual equity returns by decade. The figure highlights that since the start of the twentieth century, variance in each decade has generally been between 1.5% - 4%; however, there was a spike in volatility in the 1970s due to a significant market crash in 1973-74, which was followed by a sharp recovery in stock prices.

5.76 In the subsequent decades volatility has been lower, with average variance in the current decade at 3%. The volatility in the most recent decades (2000s and 2010s) do not stand out as markedly different to long-term averages, so views of forward-looking volatility are likely to be driven by whether the 1970s is considered to be a truly exceptional period highly unlikely to recur, or a period of volatility which could repeat itself.

Figure 8: Variance in annual real UK equity returns, by decade



Source: DMS data, PwC analysis

5.77 The variance in annual returns in Figure 8 suggests using historical variance as a guide to future return variance, but the holding period under consideration and the degree to which returns are predictable and also important determinants of future returns variance. As mentioned previously, if log returns are unpredictable, then the variance of the 5-year log return will simply be the five times variance of the one year return. However, if there is predictability of returns, this can lower long run return variances when compared with random returns.

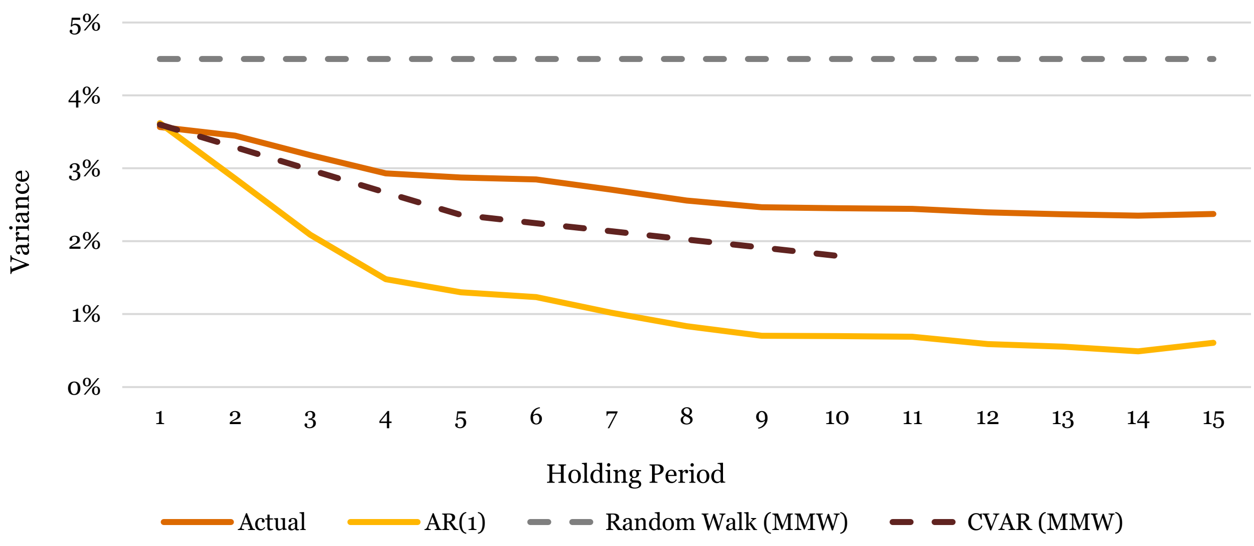
5.78 To examine this we consider the variance in equity returns for a range of models and markets. Figure 9 shows the variance of log returns for each holding period, divided by the number of years in the holding period, for each of these models. The random walk and CVAR models[51] were developed by Robertson and Wright (2002)[52] and are cited in MMW paper. They use data for the US stock market, which has been slightly more volatile over the 1900-2016 period (compared to UK data used in the DMS dataset). The estimates from the random walk model highlight that variance remains constant as holding period increases, as expected with unpredictable returns. Whereas under the CVAR model, variance declines as the length of holding period increases, indicating the presence of serial correlation in US equities market and other factors (such as Tobin's Q) which can be used to predict equity returns.

5.79 The 'Actual' line in Figure 9 below shows the variance of log returns for the UK equities market, using data up to 2017, sourced from the DMS dataset. For longer holding periods, the variance decreases, indicating the presence of serial correlation (or returns predictability). To account for the presence of serial correlation we also plot variance in UK equity returns from an autoregressive econometric model

[51] We investigated building a CVAR econometric model to replicate the Robertson and Wright (2002) analysis for the UK equities market. However, we were unable to identify a suitable Tobin's Q time series for the UK market dating back to 1900.
[52] Robertson D. and S, Wright. (2002) 'The Good News and the Bad News about Long-Run Stock Returns'

(see the red 'AR(1)' line). In the AR(1) model we regressed logged annual equity returns on 1-period lagged returns for each holding period. The AR(1) model allows us to test whether actual equity returns follow a random walk model or otherwise. Our regression results for each holding period show that the lagged equity returns are statistically significant, indicating that equity returns are indeed autocorrelated (i.e. not random walk). As the holding period increases, the predictability (as indicated by the adjusted R-squared) also increases. This suggests actual equity returns variance decreases as holding period increases, even when we control for autocorrelation. The decline in variance is even steeper for longer holding periods.

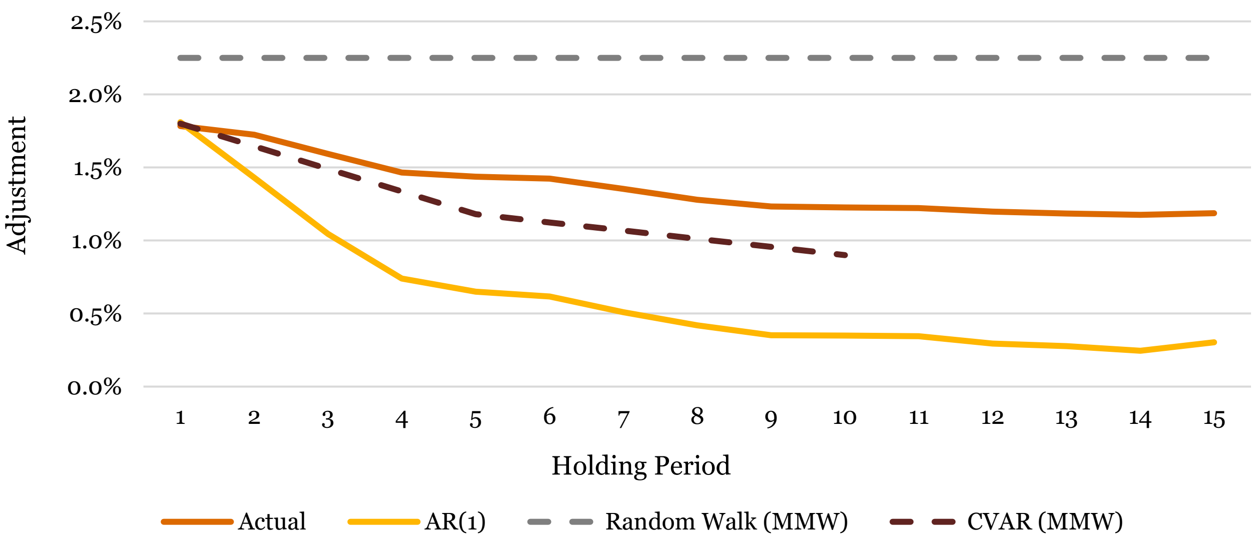
Figure 9: Variance in log equity returns by holding period under different return models



Source: MMW (2003), PwC analysis

5.80 Figure 10 examines the impact of different holding periods in terms of the adjustment which should be made to the geometric mean. In line with MMW (2003), we divide the variance by two to calculate the adjustment to make to the geometric mean. We base the adjustment on the historic variance and do not make any adjustment for higher or lower equity volatility in future.

Figure 10: Adjustment to the geometric mean



Source: MMW (2003), PwC analysis

5.81 The adjustment in the random walk model remains the same regardless of the holding period given that the variance simply increases with the number of years in the holding period. The adjustment for the 'Actual' UK equities market declines from 1.8% for a 1-year holding period to 1.2% for a 10-15 year holding period. The decline in adjustment is even greater under the AR(1) regression model, where it reaches an adjustment of c. 0.3% for a 10-15 year holding period.

5.82 Our findings are in line with MMW (2003) and Robertson and Wright (2002), who also find evidence of the predictability of returns at longer horizons. In relation to the guidance from the UKRN study that regulators: "*add an adjustment of 1 to 2 percentage points, depending on the extent to which regulators wish to take account of serial correlation of returns*", our analysis suggests any adjustment should be at the bottom end of this range, and may indeed be lower.

Long-run evidence on inflation

5.83 In both the UKRN and Jorda studies considered above, the authors obtain real equity return values by deflating using a historical CPI index produced by the Bank of England.[53] This index draws on a range of data sources to produce a representative series that captures annual inflation from 1662 through to 2016. However, this is not the only long-run inflation series produced by the Bank of England: an alternative CPI measure and an RPI measure are both available[54].

5.84 Below we compare the differences between three long-run inflation series produced by the Bank of England. We assess the relative variation between different measures of inflation. The two CPI indices considered here have much of their source data in common, with the exception of the 1750-1914 period. For that period, the "original method" index draws on ONS estimates that leverage implied consumption; meanwhile, the "preferred measure" index uses a range of historical price indices produced by academic historians. The RPI based index meanwhile relies on historian estimates from 1600-1750 and ONS estimates after that.

5.85 The table below provides summary statistics that illustrate the differences between the three inflation indices, focussing on the 1899-2013 period used by Jorda et al in their calculation of long-run UK equity returns.

Table 16: Summary Statistics for Bank of England Inflation Indices, 1899-2013

Summary Statistic	CPI Preferred (%)	CPI Original (%)	RPI (%)
Mean (arithmetic)	4.15	4.12	4.37
Mean (geometric)	3.99	3.96	4.20
Median	2.82	2.83	3.13
Standard Deviation	5.83	5.84	5.98
Maximum	25.20	25.20	25.20
Minimum	-14.00	-14.00	-14.00

Source: Bank of England, "A millennium of macroeconomic data" (version 3.1)

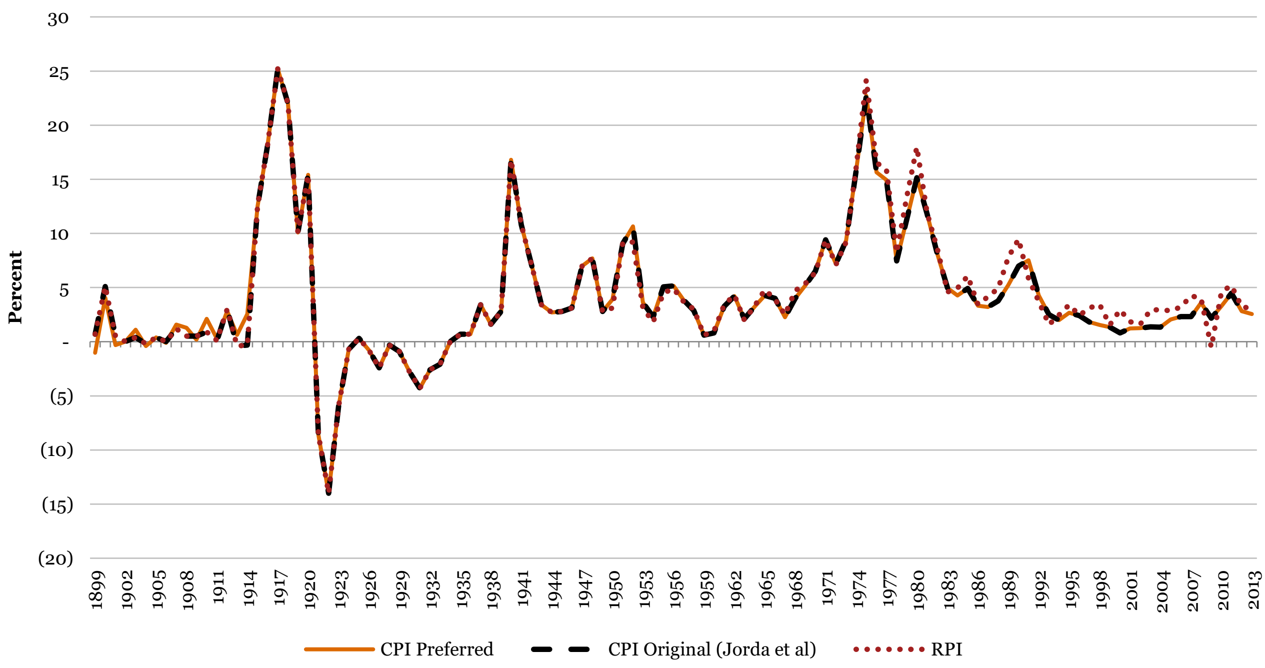
[53] Jorda et al (2017) probably use the same CPI series featured in the accompanying Jorda, Schularick and Taylor Macrohistory Database (see macrohistory.net/data). This is the Bank of England's "original method from version 1.0" CPI index, which can be accessed via the Bank of England's millennium of macroeconomic data (see https://www.bankofengland.co.uk/statistics/research-datasets).

[54] It should be noted that official UK CPI measurement only began in 1998, but has been modelled back to 1949. Prior to this date, the Bank of England's CPI inflation indices capture more general measures of the cost of living, and there are no differences between the CPI Original and RPI measures of inflation (CPI Preferred inflation is a little different pre-1949 however). It is difficult to assess whether this generalised measure of inflation is more akin to CPI or RPI, but the wedges are likely to be small, as they were over the period up to 1970.

5.86 Studying the geometric mean (which captures the effect of inflation rate compounding), we observe a relatively small difference between the two CPI measures. If "preferred" rather than "original CPI" had been used to adjust for inflation, then a similar real TMR estimate would have arisen.

We analyse the nature of the index differences in more detail in the chart below. The chart captures the movements of the three inflation series over the sample period.

Figure 11: Annual Inflation Rate, 1899-2013



Source: Bank of England, "A millennium of macroeconomic data" (version 3.1)

5.87 We observe from this chart that while the two CPI measures have tracked each other closely, a significant divergence between measured RPI and CPI inflation measures opened up from around the 1970s. It is this divergence that drives the observed differences between CPI and RPI over the 1899-2013 period. More recent estimates of the wedge between CPI and RPI are therefore much higher, as we discuss in the section below.

5.88 As we are interested in estimating investors (unobservable) real return expectations from historical data, there is no definitive measure of inflation to use. Ofcom considered this issue in its 2018 BCMR consultation[55]. It concluded:

> *"The ONS has recently established that RPI is a flawed and upwardly biased measure of inflation. Hence, assuming investors target real returns, it seems plausible that expected returns would be shaped by an expectation that nominal returns would compensate investors for CPI (currently the headline measure of inflation) rather than RPI inflation. As such, using historical evidence on real returns as a guide for forward-looking real (CPI-deflated) returns is reasonable in our view."*

[55] Ofcom, "Business connectivity market review, publication updated on 19 December 2018", Annexes 1-22, Page 213

5.89 This is consistent with the observation that RPI differences opened up from the 1970s, and the Bank of England inflation CPI measure provides a long-term estimate of to guide investor inflation expectations and real returns.

5.90 Like UKRN, Ofgem[56] and Ofcom[57] we therefore consider the deflation of nominal returns by the Bank of England CPI series provides a suitable estimate of ex-post real returns as the basis for calibrating forward-looking real returns for use with CPI inflation. Use of any different inflation series in setting forward-looking price controls therefore requires additional adjustment.

Inflation adjusted measures of equity returns

5.91 In this section, we have reviewed the latest research on historical equity returns, and we have supplemented this discussion with analysis of the long-run inflation series used to deflate historical returns. In order to compare our findings with our December 2017 estimates, Table 17 provides a summary of the equity return estimates generated across our historical returns sources. We also convert onto a consistent RPI basis and adjust for historical outperformance which is unlikely to recur. This means our estimates are still based upon historical data, but are more likely to reflect long-run expected returns.

5.92 In its December consultation, Ofgem noted[58]:

> *"The 2018 UKRN Study made a specific recommendation that: "There is a strong case for regulators choosing a measure of inflation for estimating the CAPM-WACC that is consistent with that chosen by HM Treasury and implemented by the Bank of England for inflation targeting." We sought clarification from Professor Stephen Wright, one of the UKRN Study authors, whether page 30 and page E-125, when taken together, mean that the recommendation on page E-125, of a TMR in 6-7%, is in CPI terms rather than RPI terms. Professor Wright confirmed that the recommendation on page E-125 of the 2018 UKRN Study, for a TMR of 6-7%, is in CPI terms, and therefore can be interpreted as 5-6% in RPI terms given the recent expected difference between RPI and CPI inflation of 1% (ignoring the Fisher equation for simplicity)."*

5.93 We use this approach to convert the UKRN study figure of TMR into RPI terms.

5.94 For estimates calculated using RPI inflation, we apply the 2010 difference in formula effect to adjust for changes to the estimation methodology for RPI.[59]

5.95 We then include adjustments to calculate an expected TMR figure. While our December 2017 report and the UKRN both provide an expected return estimate, Jorda et al (2017) does not - hence we have reported this as "N/A"[60]. For the UKRN report, this relates to the adjustment for forward looking serial correlation. For our December 2017 report, this was based upon adjusting for 'historical outperformance' a factor recognised by Dimson, Marsh and Staunton (2017).

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[56] Ofgem, "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Paragraph 3.81
[57] Ofcom, "Business connectivity market review, publication updated on 19 December 2018", Annexes 1-22, Page 213
[58] Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Page 91
[59] As has been well-documented, there was a structural increase in the long-run wedge between CPI and RPI in 2010, which arose from methodological changes applied to clothing prices. Since the majority of historical return observations pre-date this change, downward adjustment is required to adapt long-run estimates for regulatory RPI-indexation purposes.
[60] The difference between our historical and forward-looking estimates from December 2017 reflects a -0.4% adjustment for historical outperformance, as set out by Dimson, Marsh and Staunton (2017), which is one of our December 2017 sources. By contrast, the UKRN study contains an upward forward-looking adjustment as its authors recommend applying an uplift to geometric average returns to account for serial correlation in returns. We refer the reader to the UKRN study (Appendix E) for further explanation of the reasoning behind the real TMR estimates presented here.

Table 17: Historical Real TMR Estimates

Real TMR Component	PwC H7 WACC Report (2017)	UKRN Study (2018)	Jorda et al (2017)
Averaging Method	Arithmetic (20 year holding period)	Geometric	Arithmetic
Real historic TMR	6.3%-7.0%[61]	5%	7.2%
Indexation	RPI	CPI	CPI
Adjustments			
Change in RPI formula effect	-0.3%	n/a	n/a
CPI to RPI inflation effect	n/a	-1.0%[62]	-1.0%
RPI-adjusted Real TMR	6.0%-6.7%	4.0%	6.2%
Adjustment for serial correlation		+ 1% to +2%	n/a
Adjustment for outperformance	-0.4%		
Real expected TMR	5.6%-6.3%	5%-6%	n/a

Source: PwC December 2017 report, Jorda et al (2017), UKRN (2018)

5.96 Comparing the UKRN real TMR range to that of our December 2017 report, we observe that these estimates are very similar. Indeed, the bottom end of the UKRN range is lower than our December 2017 estimates. This gives us confidence that our previously reported historical return estimates are consistent with a wider evidence base which incorporates the latest research. The Jorda study also provides consistent figures for the RPI-adjusted real TMR (but does not extend to providing a comparable expected TMR).

Conclusion

5.97 Taking into account the new evidence available on long-run returns, we conclude that a real (RPI) TMR range informed by long-run historical evidence of approximately 5.0% to 6.0% is appropriate for H7.

5.98 In line with MMW (2003) and Robertson and Wright (2002), we find evidence of the predictability of returns at longer horizons. This points to a smaller adjustment to the geometric mean for the longer term holding period under consideration by the CAA. This suggests any point estimate should be taken from the lower end of this range.

[61] Source: Barclays and DMS. Since our December 2017 report, there is now an additional year of DMS data available. However, geometric real equity returns for the UK market from the DMS data remains 5.5% i.e. it is unchanged from the 2017 edition.
[62] This ignores the fisher effect for simplicity.

Topic 5d – UK centricity of the TMR analysis

Topic overview

5.99 HAL find that the initial analysis in our December 2017 report is too UK centric. HAL propose that DDM assumptions should be more global, arguing that dividend yields for major UK companies are influenced not only by UK GDP growth but also by global GDP growth.

HAL

5.100 NERA critique the assumptions used in our DDM model, arguing that DDM estimates are understating expected returns due to "implausibly low assumptions around dividend growth." They highlight that a consistent dividend forecast would be one which draws upon both UK and foreign earnings, referencing the fact that forecast GDP growth rates are currently higher overseas.

5.101 In relation to the current low interest rate environment, NERA for HAL argue that it is global interest rates that matter to globally diversified investors. NERA further make the case that realised equity returns across some advanced economies (such as the US and Germany) have increased in recent periods despite the decline in global interest rates, contradicting the thesis that interest rates and the TMR move in tandem. On this basis, NERA conclude that there is no meaningful evidence that the cost of equity is necessarily low when interest rates are low.

5.102 To complement the above argument, HAL argue that global long-term returns on equity are consistent with a 7.0% TMR, which is higher than the 5.1%-5.6% range set out in our December 2017 report. In support of this position, EY on behalf of HAL report a series of recent TMR determinations made by European airport regulators. They suggest these determinations imply a real TMR range of 6.32%-7.40%.

Comments and response

5.103 There is a case in principle for focussing on UK rather than global data. This relates to the ultimate purpose of cost of capital estimates in a regulatory context. UK regulators require cost of capital assumptions which are sufficient to enable UK regulated companies to finance their activities. This typically requires use of UK input parameters to cost of capital estimates. Global assumptions could be used, on a consistent basis, but then adjustments would be required convert them back into a UK cost of capital (for example, for differential real yields or forecast inflation). Our preference is to use UK based parameters, and proxies, wherever possible as it avoids the need for further adjustments.

5.104 Notwithstanding the drawbacks associated with international data set out above, where international case studies are drawn upon as a benchmark, it is important to ensure comparisons are like-for-like. In the UK context, the RPI indexation of HAL's RAB means that RPI inflation is currently used to derive the real cost of capital in CAA regulatory determinations. Consequently, it is important to account for any systematic differences between RPI inflation and the international deflators used to calculate real TMRs.

5.105 Our review of the international case studies presented by HAL suggests that CPI deflators have been used to derive real TMR estimates. This is in line with international convention, since almost all advanced economies use CPI-based measures of inflation. As discussed further below, the use of RPI measures is almost non-existent outside of the UK. There is therefore a need to adjust for any systematic differences between international deflators and UK RPI. A substantial UK literature on this topic finds evidence of a persistent 1.0% wedge between CPI and RPI measures, which partly reflects statistical differences in the composition of these indices (see Topic 5c for full discussion). By applying an appropriate adjustment for systematic inflation differences, having accounted for international index composition, we can ensure that international TMR estimates are fully relevant in a RPI-indexation context.

5.106 In a paper prepared for HAL, EY reference several recent TMR determinations from the European aviation sector. These determinations all date from 2014-2016 and apply to Western European cities, although they cover a variety of regulatory periods (from one year to six years). Given that all of these estimates use CPI deflators, an RPI adjustment should be applied in all cases to ensure comparability. We illustrate this adjustment below using an example from the EY report.

5.107 One determination EY use as a reference point is Charles de Gaulle, which is also one of the comparator airports used for beta analysis. Specifically, EY review the Economic Regulation Agreement published by the French government in January 2015, which set airports charges for Charles de Gaulle Airport (CDG) over the 2016-2020 period. This agreement includes the following nominal TMR parameters, which are used to calculate a nominal WACC estimate.

Table 18: Nominal TMR for Charles De Gaulle Airport (2015)

Nominal Risk-Free Rate	Equity Risk Premium	Nominal TMR
2.68%	6.00%	8.68%

Source: Aéroports de Paris (2015) "2016-2020 Economic Regulation Agreement: Public consultation document", p.72

5.108 To convert these figures to real terms, EY adjust this data for inflation to calculate a real TMR estimate for CDG. As their report makes clear, this inflation adjustment uses regulators' stated expected rate of inflation wherever possible. In the CDG case, the Economic Regulation Agreement includes the following inflation assumption:

> "*This proposal is established on the assumption of an average annual increase of 1.3% in the consumer price index*"[63].

5.109 By applying this assumption to the nominal CDG TMR values, EY calculate a real TMR value for this determination which comprises the following real parameter values.

Table 19: Real TMR for Charles de Gaulle Airport (2015)

Real Risk-Free Rate	Equity Risk Premium	Real TMR
1.31%	6.00%	7.31%

Source: EY (2018) "Setting the Cost of Equity for Capacity Expansion at Heathrow Airport: A Review of Evidence on the Total Market Return for Infrastructure in Other Countries", p.5

5.110 Comparing the published CDG inflation assumptions (which date from January 2015) to IMF World Economic Outlook projections from October 2014, we observe that the 1.3% CPI inflation rate assumed for CDG broadly aligns with macroeconomic forecasters' expectations for French CPI at the time[64].

Table 20: IMF WEO Projections for French CPI (October 2014)

Year	2016	2017	2018	2019
Forecast CPI	1.00%	1.13%	1.23%	1.32%

Source: IMF World Economic Outlook, October 2014

5.111 The real TMR adopted, and reported by EY, therefore appears to be a reasonable reflection of the CPI-adjusted TMR that CDG could expect to face over 2016-2020. However, these CPI-adjusted estimates cannot be applied to a RPI-indexation context without appropriate adjustment for the differences between RPI and CPI.

[63] Aeroports de Paris (2015), "2016-2020 Economic Regulation Agreement: Public consultation document", p.18
[64] The October 2014 World Economic Outlook only provides CPI projections up to 2019.

5.112 There is a substantial UK literature on the differences between RPI and CPI inflation measures, and there are a number of factors which together cause these differences (See topic 5c for full discussion). Overall, the OBR conclude that the total CPI-RPI wedge is around 1.0% in the long run[65].

5.113 Given only minor differences in the composition of UK and French CPI measures, a 1.0% wedge is a reasonable approximation for the long-run difference between a CPI and RPI deflator. The differences between these two series are underlined by the fact that French CPI is based on the Jevons formula, whereas UK RPI does not use the Jevons formula at all (see Appendix A for further explanation). By applying a 1.0% wedge to the 2015 CDG determination, we can therefore express the real TMR estimates reported by EY in UK RPI terms, as shown in the table below.

Table 21: RPI-adjusted Real TMR for Charles De Gaulle Airport (2015)

Real Risk-Free Rate (RPI)	Equity Risk Premium	Real TMR (RPI)
0.31%	6.00%	6.31%

Source: PwC analysis

5.114 Applying the CPI-RPI wedge, producing a more like-for-like comparison reduces the real TMR from this case study to 6.31%.

5.115 As set out above, there is good reason to believe that the need for CPI-RPI wedge adjustment applies not only to CDG but to all of the European airport determinations referenced by EY. This follows from the fact that use of RPI indexation is almost non-existent outside of the UK, with European countries being required to report a CPI measure that adheres to EU regulations. These regulations effectively prohibit the use of the Carli formula in consumer price indices, eliminating RPI as an acceptable measure of consumer price inflation (see Appendix A) . Consequently, to ensure that real TMR estimates are relevant as benchmarks for the UK context, adjustments for the CPI-RPI wedge are required across all of the international case studies presented.

5.116 Returning to the set of airport determinations reported by EY, we apply a 1.0% wedge to the CPI-deflated real TMR estimates, since the CPI measures used across European countries are similarly constructed. This adjustment reduces the real TMR range from 6.3%-7.4% to an RPI-deflated range of 5.3%-6.4%, which overlaps with the 5.1%-5.6% real TMR range set out in our December 2017 report.

Conclusion

5.117 In summary, UK regulators require cost of capital assumptions which are sufficient to enable UK regulated companies to finance their activities. We therefore use UK input parameters to cost of capital estimates.

5.118 Once the comparator TMR estimates have been adjusted to ensure that they are being compared with our initial WACC range on a like-for-like basis, they are broadly comparable. Hence, the European regulatory benchmark cross-checks do not invalidate our initial WACC range.

Topic 5e – Comparisons to Bank of England DDM analysis

Topic overview

HAL

5.119 NERA raised objections to the DDM approach used to measure TMR in our December 2017 report, highlighting that TMR estimates generated from our model were lower than those of the Bank of

[65] ONS (2015), 'Revised assumption for the long-run wedge between RPI and CPI inflation', Economic and Fiscal outlook - March 2015. Also consistent with our current view of the wedge set out in Section 2.

England, which uses a separate DDM model. In their response, NERA argue that our lower TMR estimates are flawed and this results from two factors:

i) Firstly, whereas our model draws on UK GDP growth forecasts in forming dividend growth assumptions, other models, and in particular the Bank of England DDM model, uses weighted global GDP growth forecasts for its long-run growth assumption. NERA find that focussing on UK GDP growth alone ignores the role that foreign economic developments play in determining FTSE companies' dividend growth. NERA support this argument by noting that FTSE companies derive 70% of their earnings from outside of the UK.

ii) Secondly, NERA note that the Bank of England DDM model uses analyst dividend growth forecasts for its short-run growth assumption, they highlight that short-run forecasts of UK GDP growth are lower than independent analyst forecasts of dividend growth.

AOC

5.120 CEPA's response on behalf of the AOC also makes reference to our DDM model, noting that "the specification of model used (with five years of short-term data, before reverting to a GDP-growth based long-term dividend forecast) is appropriate"[66]. To justify this assertion, CEPA highlight that Ofwat's PR19 methodology documentation sets out the case for using GDP growth forecasts to inform dividend growth estimates, demonstrating why analyst dividend growth forecasts are a less reliable benchmark[67].

Comments and response

UK versus global inputs

5.121 With regards to the use of UK versus global growth assumption in the DDM, we acknowledge that many FTSE All share listed companies derive a substantial portion of their earnings from outside the UK, where GDP growth rates may be higher than the in the UK. Use of global growth rates, or a blend of global and UK growth rates in our DDM model would be expected to produce higher TMR estimates.

5.122 However, as discussed in Section 5d above, regulators require cost of capital assumptions which are sufficient to enable UK regulated companies to finance their activities.. If we were to use global growth assumptions, or a blend of UK and global growth, then we would produce a cost of equity for UK listed firms with their global activities. Where there is higher global growth, this would produce a higher opportunity cost of equity compared to using UK growth assumptions. We would then need to consider how the global/UK blended TMR could then be deconstructed into a UK figure and a non-UK figure. In our view this approach seems unnecessary and a better estimate of the cost of equity for financing UK activities can be obtained by using UK GDP growth assumptions.

5.123 Furthermore, to ensure cost of capital parameters are consistent, greater use of global evidence for the setting of TMR would also require a global approach to estimating beta. Such an approach may involve estimating betas against an index such as the MSCI world index. Betas calculated with respect to global indices typically exhibit much larger confidence intervals, and for utility stocks produce lower beta estimates than the equivalent estimate from a local stock index.[68] So, as well as introducing additional uncertainty, it is unclear whether such an approach provides a definitively different answer.

Use of analyst forecasts

5.124 With regards to the use of analyst dividend growth forecasts or GDP growth as a proxy for dividend growth, it is important to consider the different purposes of DDM models. The Bank of England DDM

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[66] CEPA (2018), 'CEPA review of 'CAA Economic regulation of capacity expansion at Heathrow: policy update and consultation, (CAP1610) – cost of capital issues'
[67] Ofwat (2017), PR19 Final Methodology, Appendix 12: Aligning risk and return
[68] We find that the asset beta of UK water companies regressed against the MSCI World Index (proxy for global market index) is 7 basis points lower than when it is regressed against the FTSE All share index

model has been created to help it understand and "monitoring of equity price moves in support of its policy objectives"[69]. The Bank of England is interested whether risk premia are rising, or whether analysts are cutting their forecasts of earnings and dividends and this is instructive for both managing monetary policy and financial stability. For the Bank of England's purposes, its approach is designed to incorporate analyst views into its model as it wants to pick up movements in analyst return expectations. It is less concerned with the absolute level of the equity return predicted in its model.

5.125 We note that recent observations from the 2018 UKRN study support our views about the contrasting purposes of different DDM models. In reference to the Bank of England's DDM model, the UKRN authors observe that "The Bank of England's most recent application for example… uses the model as an accounting procedure to explain shifts in the stock market after the event, not to predict returns". Furthermore, the UKRN authors reference a recent Bank of England article on its revised DDM model to demonstrate that the Bank places less emphasis on the precise level of equity returns:

> *"As the ERP cannot be observed, any estimate of it is necessarily subject to uncertainty. Part of the uncertainty associated with model-based estimates of the ERP reflects uncertainty about the measurement of the model's inputs. For example, investors' true dividend expectations cannot be observed, so any proxy for these used in a DDM, whether derived from analyst surveys or GDP forecasts, is necessarily only an approximation. The inherent uncertainty about the true value of the ERP is reflected in the wide dispersion of ERP estimates in the literature. Given the uncertainty associated with measuring the ERP, the Bank's analysis tends to focus less on the precise level of the ERP and more on changes in the ERP over time or on the level of the ERP relative to historic averages"*[70].

5.126 In contrast to the Bank of England, UK regulators are interested in the absolute level of the equity return predicted by a DDM model. Regulators are therefore more concerned with the suitability of analyst forecasts as a proxy for dividend growth. It is therefore more problematic for regulatory purposes, analyst forecasts have been found to be both biased and inefficient.[71] Furthermore, regulators do not require a model which picks up high frequency variations in analyst return expectations, as they are typically concerned with setting longer-term parameters that are suitable for an entire price control. For these reasons using analyst forecasts of dividend growth are not suited to a regulator's purposes.

Data update

5.127 The Bank of England DDM is not suited to a regulator's purpose. We therefore continue to use our DDM model as one basis for estimating the TMR. We acknowledge that ours is only one such model, and as we set out in our December 2017 report, the model outputs are sensitive to input assumptions. We therefore review other DDM models which have been created for UK regulatory purposes.

5.128 In Table 22 below, we show the outputs from the PwC, Europe Economics and CEPA DDM models, all provided for UK regulators. In our updated figure, we have increased our RPI inflation assumption from 2.8% to 3.0% to reflect current market expectations of RPI inflation.

5.129 We can see that the estimates produced are comparable when using models of similar structure, with the minor differences as a result of the different estimation dates.

[69] Bank of England (2017), 'An improved model for understanding equity prices'
[70] Bank of England (2017), 'An improved model for understanding equity prices'. See Quarterly Bulletin 2017 Q2, p.92
[71] Work done in the Bank in the past found that IBES aggregate forecasts of earnings and dividend growth in both the United Kingdom and the United States for the first, second and third year (fixed-event forecasts) are biased (non-zero average error) and inefficient (errors correlated with past information). In particular, analyst based forecasts are excessively optimistic during economic downturns and too pessimistic in recoveries. Harris (1999) found also that analysts' long-run earnings forecasts for US companies are biased and inefficient.

Table 22: PwC, Europe Economics and CEPA DDM results

Model and estimation date	Model features	TMR range, nominal	TMR range (Real, RPI)
PwC multi-stage GDP-based DDM (Oct 17)	• Based on FTSE All-Share index • Nominal terms model • UK GDP growth assumptions • RPI assumption of 2.8%	8.4 – 8.7%	5.4 – 5.7%
PwC multi-stage GDP-based DDM (Oct 18)	• As above but using updated market data and an updated RPI assumption of 3.0%	8.5 – 9.4%	5.3 – 6.2%
Europe Economics multi-stage GDP-based DDM (Mar 2017)	• Based on FTSE All-Share index • CPI-real model • UK GDP growth assumptions	8.0 – 9.0%	4.9 – 5.9%
Europe Economics update for Ofcom (March 2018)	• As above	8.13 – 9.07%	5.0 – 5.9%
Europe Economics multi-stage GDP-based DDM (Mar 2017)	• Same as above but with GDP growth forecasts deflated using expected inflation, rather than the outturn.	8.3 – 8.9%	5.1 – 5.8%
Europe Economics update for Ofcom (March 2018)	• As above	8.52 – 9.50%	5.4 – 6.3%
Europe Economics multi-stage historic dividend growth-based DDM (Mar 2017)	• Based on FTSE All-Share index • CPI-real model • Dividend growth assumption provided by outturn dividend yields and growth from the FTSE All-Share	7.3 – 8.3%	4.2 – 5.1%
Europe Economics update for Ofcom (March 2018)	• As above	8.70 – 9.28%	5.5 – 6.1%
CEPA multi-stage GDP-based DDM (Jul 18)	• Based on FTSE All-Share index • Nominal terms model • UK GDP growth assumptions • Including share buybacks	7.85 - 8.45%	4.85 – 5.45%
CEPA update for Ofgem (Dec 18).	• Nominal terms model • UK GDP growth (sensitivities include international growth and UK historic dividend growth)	8.0%	4.8%[72]
Ofgem DDM range	• Based upon CEPA December update and sensitivity analysis	7.5% to 8.5%	4.3% - 5.3%[73]

Source: Ofwat[74], Europe Economics, CEPA[75], PwC

[72] Calculated using Ofgem's 3.07% RPI assumption in its RIIO-2 Sector Specific Methodology Annex: Finance, published in December 2018.
[73] Calculated using Ofgem's 3.07% RPI assumption in its RIIO-2 Sector Specific Methodology Annex: Finance, published in December 2018.
[74] Ofwat (2017), 'Delivering Water 2020: Our methodology for the 2019 price review, Appendix 12'
[75] CEPA (2018), 'Review of cost of capital ranges for new assets for Ofgem's networks division'

5.130 We observe that the lower estimate from our DDM model in October 2018 falls within the range of other DDM models which have been created for UK regulatory purposes[76]. We note, however, that our updated upper estimate lies towards the top of the range presented in the Table 22. This was based upon our spot estimate from October 2018 and was driven by a substantial increase in share buyback yield. In our view this elevated yield associated with buybacks is unlikely to persist, and over time total returns will revert to a lower level. As mentioned previously in this report, this is one of the reasons why we refrain from placing too much weight on data from a single point in time, and instead prefer to use some smoothing of market data to avoid short-term volatility.

Topic 5f – Overall TMR assumption

Topic overview

5.131 During the consultation process we have received a number of comments on our overall TMR assumption, in particular around the range proposed in our December 2017 report of 8.0% to 8.6% in nominal terms, or 5.1 – 5.6% in RPI terms. To produce this range, we focused on three sources of ex-ante evidence: dividend discount modelling, market valuation evidence, and investor survey evidence. The top end of the range was based the outputs of PwC's DDM model, while the bottom end of the range was based on our work for Ofwat on publicly listed water company RCV premia, and investor survey evidence, which suggested a TMR closer to 8.0% in nominal terms.

5.132 In the section below we discuss the latest developments on TMR and how this affects the range that we proposed in our December 2017 report.

Comments and response

5.133 To assess whether an adjustment is required to the range we proposed previously, we first consider the latest output from the PwC DDM model alongside the estimates from other providers. Over the last year there has been an increase in the implied total market return outputs from the PwC DDM model, particularly over the 2nd half of 2018 as equity markets have been increasingly volatile due to uncertainty around the Brexit process and reduced equity valuations. At the upper end of the DDM model estimates, there has been an increase from 8.7% to 9.4% (in nominal terms), while the lower end has increased from 8.4% to 8.5%.

5.134 On the other hand, when we consider a wider range of evidence (See table 22 above) we can see that other DDM models have produced lower TMR estimates, for instance Ofgem suggest a DDM range of 7.5 – 8.5%, which is consistent with the top end of our previous DDM range. Likewise, the Europe Economics estimates are broadly consistent with our previous range, although we note that they were produced in March 2017. So on this basis there is little evidence to increase the top end of our TMR range.

5.135 The bottom end of our range was informed by a range of market evidence, as is now more supported by other DDM models. While there is now some DDM evidence to support a lower TMR estimate, this would then be inconsistent with our other market evidence, so again we do not consider it necessary to reduce the lower end of the TMR range[77]. Based on the above, we view that the range proposed in our December 2017 paper of 5.1 – 5.6% in real RPI terms remains appropriate and supported by the majority of forward looking analysis.

5.136 There are then two helpful sense-checks[78].

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[76] The lower end of our updated DDM analysis is based upon a five year trailing average (to reduce the impact of short-term volatility.

[77] We also do not consider it helpful to present an overly wide range, which could encompass all the DDM evidence, but would then range from 4.2% to 6.2%.

[78] As an additional sense-check, Ofgem have also found world returns in US$ as comparable to UK returns.

i) Firstly, our range is close to Ofgem's overall TMR assumption of 6.25% to 6.75% in CPIH terms from its December 2018 consultation[79]. When converted into RPI terms, using the 1% wedge between RPI and CPI for simplicity, we estimate a TMR range of 5.25% to 5.75%.

ii) Secondly, our range is also at the bottom of the range of historical ex-post analysis estimates from the UKRN study. While we maintain a preference for the forward-looking market evidence, we would expect the two sources to converge as monetary and economic conditions normalise, which is an appropriate assumption as the H7 control extends well into the next decade. On this basis, a small difference between our forward-looking market evidence and ex-post historical estimates is reasonable.

Topic 5g – Use of a negative risk-free rate

Topic overview

5.137 HAL and Virgin both indicated drawbacks with the application of a negative real risk-free rate – suggesting that a risk-free rate of 0% could be more suitable.

HAL

5.138 NERA on behalf of HAL estimate a real RFR range of -0.9% to 1.5%, the lower end of the range being based on market evidence. However, HAL note that current market estimates are "heavily distorted" by short-term market effects. Also, they note that a real RFR below zero "seems unlikely to be aligned with consumers' long-term preference for deferred consumption." They conclude that a real RFR below zero should be used with caution.

Virgin

5.139 Virgin agreed that the real RFR should be lower than the 0.5% adopted for Q6. Virgin draw upon forecasts produced by the OBR and the FCAs time-series modelling of index-linked gilts to form a real RFR range from -1% to 0%. Virgin conclude a RFR of close to 0% may be preferable given regulatory precedent.

AOC

5.140 CEPA on behalf of the AOC emphasised caution in 'aiming up' of market evidence when estimating the real RFR – given that future expectations should be priced into yields.

Comments and response

5.141 In this section, we set out the theoretical and empirical justifications for a negative real risk-free rate. We begin by referencing arguments made by Wright et al (2018) for the UKRN, which explain why negative real risk-free rates are compatible with economic theory. We then turn to an empirical assessment of current and future UK gilt yields, drawing on a number of sources to demonstrate that there is empirical evidence supporting use of a negative risk-free rates over H7.

Theoretical evidence

5.142 We note that several respondents advise caution in using negative real risk-free rates on the grounds that this is against regulatory precedent and incompatible with economic theory regarding deferred consumption. While it is true to say that UK regulators have not set negative risk-free rates until very recently, we do not regard this as a valid justification for setting non-negative risk free rates in H7. Moreover, as we go on to explain below, the argument that negative risk-free rates are incompatible with economic theory does not hold.

[79] Ofgem (2018), "Consultation - RIIO-2 Sector Specific Methodology Annex: Finance", Page 31

5.143 In their 2018 study for the UKRN, Wright et al consider several potential justifications that regulators could use for avoiding negative risk-free rates, explaining why these justifications are not persuasive in their view. Among the theoretical justifications considered by the study are the following arguments:

i) The market for risk-free debt is distorted by various institutional features, which have led to yields on gilts being artificially depressed;

ii) A negative risk-free rate is unsustainable in the long run; and

iii) Negative risk free rates are incompatible with standard economic theories of intertemporal optimisation.

5.144 In response, the UKRN study provides a series of rebuttals to these points:

i) The UKRN authors argue that regardless of whether this point is true, the market price for risk-free debt is nevertheless of importance to regulators. This is because the drivers of the risk-free rate are ultimately unimportant: what matters is the rate itself, because this has implications for the prices of substitutes (other low-risk investments) in the market. From a financeability perspective for regulated entities, the market price is therefore sufficient.

ii) The UKRN study highlights that there is no economic principle that rules out a negative risk-free rate, meaning that rates can feasibly be negative for lengthy periods. It is further pointed out that risk-free rates have indeed been negative in the past.[80]

iii) Having referenced the equilibrium condition of a standard intertemporal optimisation model, the UKRN authors identify multiple cases in which a negative risk-free rate is plausible. If either (a) future consumption growth is expected to be negative or (b) individuals experience and are averse to uncertainty about future consumption or (c) there are financial market frictions which depress the risk-free return, then a negative real risk-free rate is plausible.[81] Given that conditions (b) and (c) are both feasibly met in the current risk-free investment market, we find that there is no theoretical impediment to a negative real risk-free rate being set for HAL in H7.

Empirical evidence

5.145 Having outlined the theoretical case for negative real risk-free rates, we now examine the empirical evidence. Our December 2017 report considered yields on UK gilts as a proxy for the risk-free rate (RFR), taking nominal gilts as a proxy for the nominal RFR and index-linked gilts as a proxy for the real RFR. To understand the current market environment, we analysed movements in the spot market for index-linked yields. Our analysis demonstrated clear evidence of a fall in real yields over recent years, with yields on 10-year RPI index-linked gilts falling below -2.0% during 2017. The historically low yields seen today reflect investors' expectations that interest rates will remain low for an extended period.

5.146 To complement our assessment of current gilt yields, we have also taken note of forward-looking evidence to understand how the risk-free rate might change over the H7 period. Our December 2017 report computed implied forward gilt yields at future dates. Having applied this approach with index-linked gilts, we found that the market expectations signalled a gradual rise in yields over the next decade, with yields on longer-maturity gilts rising to around -1.4% towards the centre of the H7 period.[82] Nonetheless, we note that these forward-looking estimates remained within negative territory.

5.147 In their consultation response, Virgin provided their own forward-looking analysis using an alternative methodology. Virgin argue that forward yields of currently trading bonds are not a reliable indicator of future yields. Instead, Virgin consider forecasts of future yields from a range of sources. Specifically,

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80 Wright et al (2010), "Estimating the cost of capital for implementation of price controls by UK Regulators", pg. 35
81 For further explanation of these points, we refer the reader to Wright et al (2010), p. 35
82 The H7 period in our December 2017 report was assumed to start in 2020.

they reference a 2017 analysis by the Financial Conduct Authority (FCA), which offers a medium-long term forecast for 10-year index-linked gilts. These projections suggest that real yields will rise slowly from current levels to around -0.4% by 2024, reaching -0.25% by 2032.[83]

5.148 Taking the empirical evidence together, there is a strong case for a negative real risk-free rate assumption over H7, regardless of the timing and methodology behind the evidence used. In general, expectations of a prolonged period of low interest rates have resulted in historically low UK gilt yields which look set to persist throughout the H7 period. Despite UK regulators having not set negative risk-free rates until recently[84], we judge that a non-negative risk-free rate would be inappropriate given current market evidence. The only adjustments required to our December 2017 assumption are an update to reflect recent market movements, and an adjustment for the newly proposed H7 timings, which we set out below.

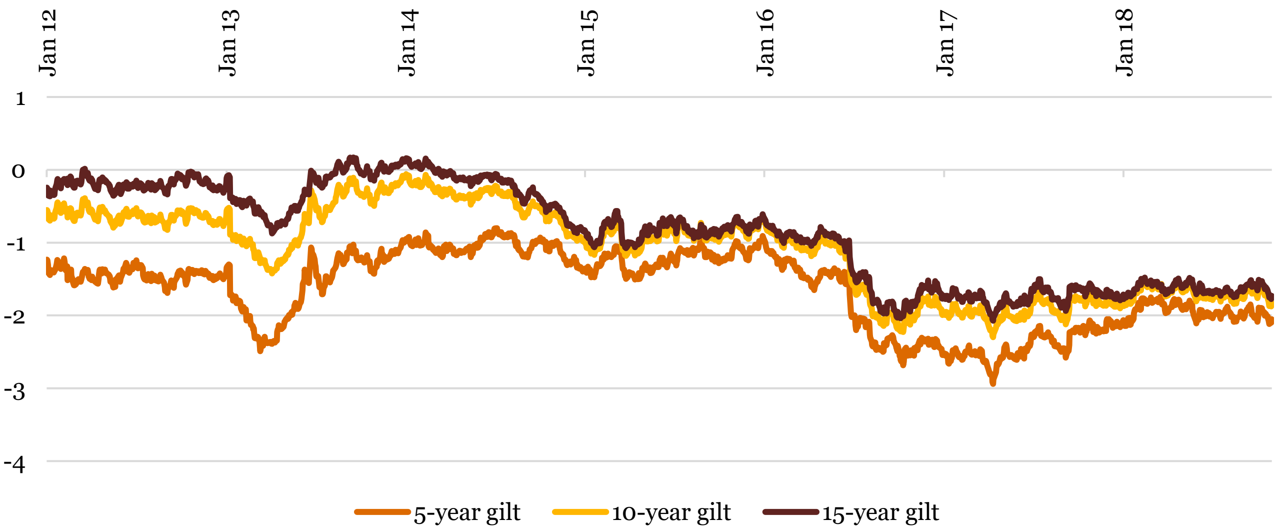
Conclusion and data update

5.149 We continue to recommend that cost of capital inputs should be aligned to market evidence. To ensure that our recommendations reflect current market conditions, we have undertaken a review of the current market data as of the end of October 2018.

Spot market evidence

5.150 The yields on index-linked gilts have declined markedly since early 2014. Yields continued to decline in 2016 as expectations that interest rates would remain low prolonged. Over 2017 and 2018, yields on 10 and 15-year gilts were relatively stable, whereas yields on 5-year gilts increased.

Figure 12: Index-linked gilt yields (real terms)



Source: Bank of England

Forward-looking evidence

5.151 From a forward-looking perspective, the spread between long-term gilts and short-term gilts is a proxy for understanding expectations of future interest rate changes. In Figure 13 we plot the spread between 10-year gilts and 2-year gilts and the spread between 20-year gilts and 2-year gilts. The larger the spread between the two, the steeper the anticipated path for future interest rate rises. As shown, expectations for future rate rises have softened since the start of 2014.

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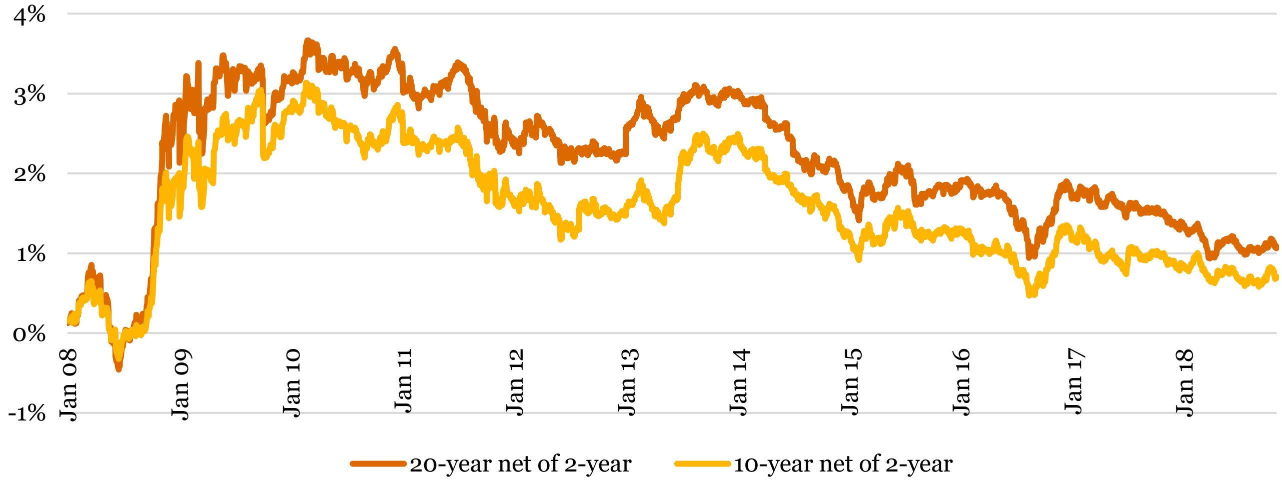
[83] See Virgin Atlantic Airways response to the CAA's consultation on Economic regulation of capacity expansion at Heathrow: policy update and consultation (CAP 1610), p.8

[84] Ofcom (2018) used a figure of -1.25% in its BCMR consultation and Ofwat (2017) used a figure of -0.88% in its final PR19 methodology.

Figure 13: Yield curve proxy for rate change expectations

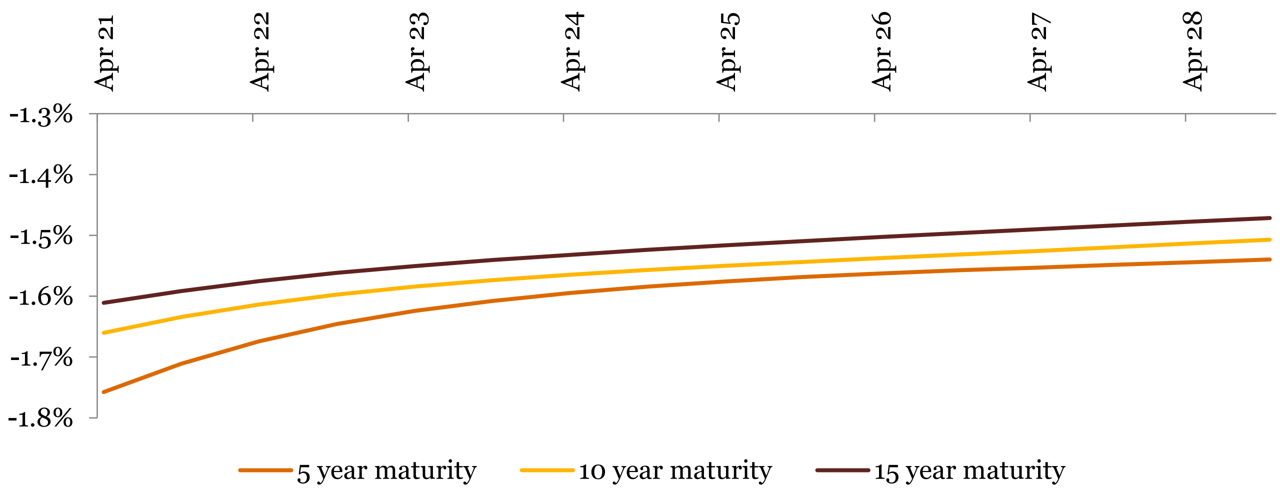


Source: Datastream from Refinitiv

5.152 Spot market data can also be used to produce implied forward-gilt yields; that is, the implied yield on a gilt of a given maturity at some future date. Figure 14 sets out the implied forward gilt yields from index-linked gilt yields (using spot from the end of October 2018). This evidence shows that markets anticipate that yields on index-linked gilts will be marginally higher than recent market values. Yields on the 10-year gilt (as of the end of October 2018) are currently -1.8% and they are expected to increase to -1.6% by 2022 and up to -1.5% by the end of 2027 (i.e. end of the revised H7 regulatory period).

5.153 Future yields are now expected to be lower than those implied by the market in October 2017 (i.e. PwC's 2017 report). Yields are expected to gradually increase, with the 10-year gilt reaching -1.5% in 2028. Whereas the previous expectation was that gilts of all maturities (i.e. 5, 10, 15 year) would flatten out at -1.4% over the H7 period.

Figure 14: Implied index-linked forward gilt yields (end of October 2018)



Source: Bank of England, PwC analysis

5.154 The spot market evidence is broadly aligned with the evidence presented in PwC's December 2017 report, albeit the yield on 5-year gilts has increased slightly since the middle of 2017. The spread between the 10-year gilts and 2-year gilts and the spread between 20-year gilts and 2-year gilts has reduced, indicating that the expectations of future interest rate rises have softened. This is also reflected in market implied forward yields, which have also reduced over the H7 period.

5.155 To conclude, current market evidence suggests that the adjustment to the spot rate should be smaller than the 0.4% suggested by the data in PwC's December 2017 report. The current yield on a 10-year gilt is -1.8% and the market expectation is that this will increase to between -1.6% and -1.5% over the H7 period. Taking account of this, and factoring in a degree of uncertainty, we recommend a range of **-1.5% to -1%** for real risk free rate the H7 period.

Topic 5h – The approach to measuring beta

Topic overview

5.156 Stakeholders put forward a range of different approaches to measure beta risk of the airports.

Virgin

5.157 Virgin note that the use of a European index (rather than a local index) as a method to produce comparative betas had 'overestimated' beta.

HAL

5.158 HAL note that NERA's estimates of asset beta are higher than PwC's as:

i) NERA has used more up to date data; and

ii) NERA has used net debt from annual reports.

Comments and response

5.159 There are a range of approaches that can be taken to estimate betas, each have their advantages and disadvantages. Instead of relying on one approach, we consider different approaches to inform our views.

Use of European or local market indices

5.160 For the purpose of calculating betas for comparable airport activities, there is a choice to be made between using a local (or economy specific) index and a regional index. For example, the returns to Fraport could be assessed against a Germany specific market index, or a European wide index.

5.161 In our December 2017 report, we presented betas for AdP and Fraport based on both local and regional indices and use this to sense check the indicative asset beta range assumed for H7. No single approach was relied upon, rather a balanced view was taken across a range of estimators.

5.162 Using daily data the outputs for ADP are more recently close to 0.5, while for Fraport the outputs more recently are between 0.3 and 0.4. Using monthly data the recent outputs for ADP are broadly between 0.4 and 0.5, while for Fraport they are closer to a 0.45 to 0.55 range.

5.163 This compares to the Q6 beta range of 0.42 to 0.52 used for HAL for Q6, which we used to indicate a range for H7 on the basis that there has been no fundamental changes to HAL's drivers of systematic risk.

5.164 Table 23 below shows the asset betas calculated in our December 2017 report for AdP and Fraport and their respective descriptive statistics[85]. We note that when betas are estimated using local indices this produces marginally lower beta estimates for both AdP and Fraport (up to 0.05 lower in the case of 2-year daily betas and up to 0.08 lower in the case of 5-year monthly betas).

5.165 We can use descriptive statistics to test the statistical quality of the different estimates. There are only small differences between local and European indices for the 2-year daily beta estimates. For the 5-year monthly betas, the standard errors are slightly higher when betas are estimated using the European

[85] These asset betas are calculated using a debt beta of 0.05 as per our December 2017 report.

index, indicating that the data are more dispersed. The R-squared estimates vary according to which airport is considered: AdP has a higher R-squared using the European index whereas Fraport has a higher R-squared using the local index.

Table 23: Asset betas for AdP and Fraport and descriptive statistics (2 year averages of spot rates)

		AdP	Fraport
2-year daily betas	Local index		
	Asset beta	0.47	0.32
	Standard error	0.03	0.04
	R-squared	0.40	0.24
	European index		
	Asset beta	0.51	0.37
	Standard error	0.04	0.05
	R-squared	0.39	0.25
5-year monthly betas	Local index		
	Asset beta	0.40	0.45
	Standard error	0.12	0.13
	R-squared	0.27	0.39
	European index		
	Asset beta	0.50	0.58
	Standard error	0.13	0.18
	R-squared	0.30	0.35

Source: Capital IQ, Datastream from Refinitiv, PwC analysis

5.166 We note that there is a degree of judgment involved in deciding whether to use local or European indices to calculate airport betas. It may be reasonable to consider, for example, that an investor in European airport equities will diversify their portfolio across the European market. Airports, by their nature are exposed to regional (and global) demand risks.

5.167 However, we do not rely on one single approach to estimate comparator betas for the purposes of H7.

Source of net debt data used to delever equity betas

5.168 In our December 2017 report, we used Capital IQ to source a measure of net debt. NERA advocate using company accounts to determine cash and near cash equivalents because this takes into account additional cash holdings not included by Capital IQ/Bloomberg. NERA find that the use of company accounts and Capital IQ/Bloomberg produces broadly the same estimates for AdP, but Fraport's beta is 0.02 higher sourcing data from financial accounts directly.

5.169 The Capital IQ database provides a 'Cash and Cash Equivalents' measure, which represents funds in the form of cash, readily convertible deposits, securities and other instruments having maturities of less than 3 months at the time of purchase. It includes short term, highly liquid investments that are readily convertible into known amounts of cash and are near their maturity as well as cash on hand consisting of coins, currency, deposited checks, money orders and drafts, and deposits in banks. This value is taken directly from the company financial accounts.

5.170 In our beta analysis we use the broader 'cash and short-term investments' measure from Capital IQ in the net debt calculation. This consists of: Cash And Equivalents (as outlined above) + Short Term Investments + Trading Asset Securities.

5.171 While we do not know the exact cash measurement used by NERA in their calculation, the value of 'cash' used in our analysis is broader than just 'cash and cash equivalent' as it includes short term investments and trading asset securities. In the Table 24 below, we present the values from both measurements.

5.172 The table also includes Cash and cash equivalents excluding time deposits and restricted cash, as presented in Fraport's financial statements. We include this for reference because NERA's statement suggests that they believe we may have used a value that does not include additional cash holdings (such as restricted cash and 3 month+ deposits).

Table 24: Comparison in the cash measurement approaches between Capital IQ and Fraport company accounts, €m

	2017 Q2	2017 Q1	2016 Q4	2016 Q3	2016 Q2	2016 Q1
Cash and cash equivalents (excl. time deposits and restricted cash)	Not available	461.0	Not available	Not available	Not available	448.8
Financial statement 'cash and cash equivalents'	1,163.9	736	481.2	423.7	423.7	406
'Cash and short-term investments' measure used by PwC	1,163.9	888	481.2	423.7	423.7	619.3
Difference between statements and Capital IQ	0	-152	0	0	0	-213.3

Source: Capital IQ, Fraport company accounts, PwC analysis

5.173 As evidenced in Table 24 above, the 'Cash and short-term investments' measure we used reports a higher cash value, which we then use in the net debt calculation. This serves to reduce the gearing ratio, which in turn increases the beta estimate for Fraport (compared to using a more narrowly defined measure of cash).

Table 25: Comparator airport 2-year daily asset beta outputs (Fraport), Capital IQ net debt vs. Annual report net debt (2 year averages of spot rates)

		Local index	European index
2-year daily betas	'Cash and short-term investments' measure used by PwC	0.32	0.37
	Financial statement 'cash and cash equivalents'	0.32	0.36

Source: Datastream from Refinitiv, Capital IQ, PwC analysis

5.174 We also note that, Fraport's measure of 'cash and cash equivalents' in the consolidated statement of financial position includes 'restricted cash' (Restricted cash can include items like amounts pledged as collateral to insurance companies) and 'time deposits with a remaining term of more than 3 months'. Under IFRS reporting standards these short-term assets are not typically recorded as cash equivalent because they are not convertible within 3 months.

5.175 In summary, by using the cash and short-term investments measure from the Capital IQ database in our beta calculations, we produce marginally higher betas than those produced by using 'cash and cash equivalents' from Fraport's financial statements.

Beta estimation approach (OLS/GARCH) and timeframe of estimation

5.176 While beta estimates are typically calculated using OLS regression techniques, there have been a number of suggestions by regulation stakeholders that more complex calculation techniques can lead to more robust beta estimates. In particular, the UKRN report recommended that betas could be estimated using GARCH statistical models.

5.177 NERA reviewed UKRN's use of GARCH techniques to estimate betas instead of the more established OLS approach. They find that using more typical time periods of 1-5 years, and using daily data, GARCH techniques derive almost identical beta estimates as those based on OLS techniques. However, they note that GARCH models are complex and subjectivity in model choice increases regulatory risk. They find that long beta estimation time-periods ignore changes in risks over time, and relying on low frequency data leads to less precise beta estimates.

Conclusion

5.178 There are a range of approaches that can be taken to estimate betas, each have their advantages and disadvantages. Instead of relying on one single approach, we take a view across a range of measurement approaches and use both local and European indices.

5.179 In our estimate of net debt, we use the 'cash and short-term investments' measure from the Capital IQ database, which produces betas that are marginally higher than those produced using 'cash and cash equivalents' measure from Fraport's financial statements as suggested by NERA.

Topic 5i – The relative beta risk of airports

Topic overview

5.180 HAL consider that relative risk analysis shows they are more, or at least as risky, as comparator airports.

Virgin

5.181 Virgin highlight that a more relevant comparator could be AENA.

HAL

5.182 HAL also highlight that NERA's relative risk analysis of HAL, CDG and Frankfurt Airport found that HAL is higher risk than Frankfurt due to different regulatory arrangements, and that HAL is at least as risky as CDG – and perhaps more risky due to CDG benefitting from additional demand risk sharing and less return at risk from incentives. NERA also draw on evidence from the Eurozone crisis to make the case that overall PAX volatility is at least as high for CDG as for HAL.

AOC

5.183 In CEPA's analysis of beta they state that they agree that "the two comparators [CDG and Frankfurt Airport] face higher (systematic) risk than Heathrow".

Comments and response

5.184 In this section, we first consider the different regulatory regimes of HAL, Frankfurt and Charles De Gaulle.

5.185 In response to Virgin's suggestion, we considered using AENA in the comparator analysis. However, the AENA group only listed in 2015, which means that there is not enough market data to conduct the full range of beta analysis for AENA (see Appendix B for full explanation). The analysis that we were able to conduct shows that AENA faces a similar level of systematic risk as Fraport and ADP, in particular, their respective equity betas have all been close over the last year. Hence, this has not changed our views on the appropriate asset beta to use for regulated airports.

5.186 In comparing the relative risks faced by investors at HAL and comparator airports, NERA on behalf of HAL argue that relative risk is strongly influenced by the regulatory regimes that different airports face.

5.187 NERA use this argument to critique the argument that HAL is exposed to lower demand risk than two key comparator airports, Charles de Gaulle (CDG) and Frankfurt. NERA argue that considering PAX movements in isolation ignores the role of broader regulatory differences in determining the risks faced by these airports. More specifically, NERA suggest that both CDG and Frankfurt have greater protection than HAL from the downside revenue risks posed by falling passenger traffic. In their view, the ability of these airports to share downside risks and request regulatory re-determinations allows them to minimise variance in their revenues, providing greater stability to investors.

5.188 In response to this argument, while HAL is subject to a relatively fixed price-cap regime, there is still some flexibility in this regime which serves to reduce the uncertainty faced by investors. The length of HAL price controls is not always fixed, as highlighted by the CAA's recent decision to extend the current Q6 price control by two years in light of decisions around future capacity expansion. Decisions of these kind signal to investors that major changes can result in altered determinations.

5.189 However, we recognise that there are further dimensions to the discussion of regulatory regimes, and therefore we discuss this issue in more detail below.

Regulatory regime differences across comparator airports

5.190 In this section, we review the regulatory regimes of CDG and Frankfurt. We consider the regulatory powers available to these airports. In the next section, we provide further analysis of PAX traffic volatility which complements these regulatory considerations in order to achieve a comprehensive assessment of the relative revenue volatility faced by the three airports.

Frankfurt Airport

5.191 Frankfurt is subject to a relatively flexible regulatory regime, in which the airport has the power to propose its own tariffs at intervals of its choosing. Frankfurt's tariff proposals are subject to a statutory consultation process and appropriate revision before being sent to the approving authority, which is the Hesse Ministry of Economics, Energy, Transportation and State Development (HMWEVL). The approving authority then has the power to approve or reject new tariff proposals.

5.192 NERA argue that these regulatory powers allow Frankfurt 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[86]". We review recent regulatory decisions involving Frankfurt airport below.

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[86] NERA (2018), 'Cost of Equity for Heathrow in H7', p.33

Table 26: Recent Regulatory Decisions affecting Frankfurt Airport

Decision Date	Implementation Period	Details
1st December 2009	2010-2011	Agreement reached on substantial airport charges increases to be implemented over 2010-2011, comprising: • 4% increase on 1st July 2010 • 3% increase on 1st October 2010 • 3% increase on 1st April 2011 • 2.5% increase on 1st October 2011
19th February 2010	2012-2015	Agreement reached on airport charges increases to be implemented over 2012-2015, comprising: • 2.9% annual increase from 2012 to 2015 • Fraport AG to reimburse airlines one third of any additional revenues should passenger figures develop faster than expected.
29th October 2015	2016	Fraport AG retracted an application (originally filed on 1st July 2015) to increase airport charges by 1.9% in 2016. This resulted from differing views between Fraport AG and the HMWEVL regarding calculation of cost elements.
1st December 2016	2017	Agreement reached on a 1.9% increase in airport charges to be implemented in 2017.
5th July 2017	2018	Fraport AG announced its intention not to make a new application for airport charges covering 2018, resulting in a continuation of 2017 charges.

Source: Fraport AG Ad hoc releases and Newsroom archives

5.193 Reviewing tariff re-set proposals made by Frankfurt Airport over the last decade, we observe that Frankfurt's requests for tariff rises have tended to receive regulatory approval. Furthermore, the timing and nature of these proposals is consistent with an objective of offsetting declines in PAX by raising tariff charges to maintain revenue stability. This is illustrated by the action taken by Frankfurt airport between December 2009 and February 2010, when PAX numbers fell to lower levels in the wake of the financial crisis. During these months, Frankfurt was able to agree with HMWEVL a series of tariff rises that would cover the 2010-2015 period.

5.194 However, there are a number of caveats to these regulatory powers which restrict Frankfurt's ability to minimise revenue volatility:

i) Firstly, German law obliges Frankfurt to allow six months for consultation on tariff proposals before new charges can be approved, and proposals must be filed with the regulator five months before new charges can be approved. Only in extraordinary circumstances can these timescales be shortened.

ii) Secondly, tariff proposals are not always successful in gaining approval. This was the case in October 2015, when Fraport AG retracted an application to increase airport charges because "the HMWEVL and Fraport AG have differing views regarding the calculation of essential cost elements - including capital costs."[87] This example highlights that the HMWEVL must be clearly persuaded of the need for a rise in tariffs before any proposals are approved. Even in cases where tariff rises are ultimately approved, there may be objections raised by either the approving authority or other

[87] See https://www.fraport.com/content/fraport/en/misc/binaer/fraport-group/investors/ad-hoc-releases/ad-hoc-release--airport-charges-2016/jcr:content.file/airport-charges-2016.pdf

stakeholders (including airline representatives) which cause Frankfurt airport to revise their proposals. For instance, during the most recent tariff revision in 2016, the HMWEVL notified Frankfurt airport that its initial application was unlikely to be approved. This caused the airport to make milder auxiliary requests, which were ultimately approved.

iii) Thirdly, Frankfurt's ability to request tariff rises still leaves revenue risk, since realised passenger demand may fall below projections. When Frankfurt agreed a new schedule of charges in early 2010 to cover the 2012-2015 period, the resulting agreement left Frankfurt exposed to the downside risk that PAX numbers would fail to grow in the aftermath of the financial crisis.[88] In addition, this agreement created risk asymmetry for Frankfurt by decreeing that airlines would be reimbursed one third of any additional revenue if PAX numbers developed faster than expected.

5.195 Whilst Frankfurt has the ability to request tariff rises whenever it chooses, this doesn't necessarily reduce its investors' risk exposure. This is because investors face considerable uncertainty about the timing of Frankfurt's tariff applications and the regulator's verdict on whether they should approve each application. Under the fixed-term price cap regime faced by HAL, airport performance may deviate from expectations within each regulatory period, which exposes investors to downside risk. Nevertheless, the fixed-term nature of this regime creates a high degree of certainty around future determinations. This trade-off between forecast risk and re-set risk therefore needs to be considered.

5.196 Aside from the cited restrictions on Frankfurt's regulatory powers, there are further regulatory risk factors that must also be considered when comparing relative risk between Frankfurt and HAL. Frankfurt and the vast majority of other airports operated by Fraport are subject to a dual till regulatory regime. Airports operating under a dual till or adjusted till system are more exposed to beta risk through their retail and commercial operations because this is not taken into consideration when setting aeronautical charges. However, we note that this does depend on the exact nature of the regulatory regime around the second till, and for global operators such as Fraport, this will vary depending on the jurisdiction.

5.197 In contrast, HAL operate under a single till system, which means that aeronautical and commercial activities are both considered when setting aeronautical charges. Any movements in commercial revenues are deducted from the allowance for aeronautical revenues. Charges are then reset in the next regulatory period, which means that they are exposed to less risk from the commercial side of the business over the long run.

5.198 Having reviewed the regulatory regime in place at Frankfurt Airport and the recent determinations this has yielded, Frankfurt airport has some power to moderate fluctuations in its revenues by requesting tariff rises more frequently than HAL in the UK. However, the dual till regimes at the majority of Fraport's airports counter this effect meaning that any net effect of regulatory regime differences is likely to be small.

Charles de Gaulle Airport

5.199 CDG is regulated through a price-cap regime with five-year determination periods, which is similar to the HAL regime. However, there are some differences between the regulation of CDG and HAL. For example, CDG has risk sharing arrangements, which state that outside of a buffer zone demand risk is shared 50% on the upside and 20% on the downside – although only within the latter years of any given determination period. This risk sharing is not allowed to exceed +0.2% or -0.5% of the annual price cap.

5.200 To illustrate how this works, consider a case where the central PAX projection for 2018 is 99,063,000 but realised PAX traffic is 102,000,000 (which is outside of the buffer zone, whose upper limit would be

[88] See https://www.fraport.com/en/our-company/media/newsroom/archive/2010/airport_charges_atfrafraportandairlinesreachagreement.html

100,402,000). In this case, CDG would need to adjust fee rates such that 50% of the difference between the upper buffer zone limit and realised PAX is reimbursed. This would equate to the following corrective factor, which would then be applied to realised fee income to generate a reimbursement:[89]

$$\frac{0.5(102{,}000{,}000 - 100{,}402{,}000)}{99{,}063{,}000} = 0.81\%$$

5.201 Additionally, should PAX deviate significantly from the central demand projection (around 2 percentage points either way in the most recent determination) for three consecutive years, then the parties to the Economic Regulation Agreement (CDG and the French state) have the option to request a regulatory re-set. Should CDG request a re-set without the agreement of the French state, the airport advisory commission decides whether such a re-set is necessary.

5.202 Over recent years, CDG determinations have occurred at regular five-year intervals, with Economic Regulation Agreements being signed in 2005, 2010 and 2015. This implies that the demand projections made in these Agreements have been reasonably accurate, avoiding the need for either CDG or the French state to request a regulatory re-set. There may however have been some sharing of demand risk during this time.

5.203 CDG operates under an adjusted till system which takes certain commercial activities into account when setting aeronautical charges.

5.204 In many important respects – such as the regular five-year intervals between determinations and the adjusted till regulatory system – the CDG regime is similar to that of HAL.

PAX Volatility

5.205 Having reviewed the regulatory regimes at Frankfurt and CDG, this section reviews evidence on relative volatility in PAX traffic. By combining PAX fluctuations with an understanding of the regulatory regime faced by each airport, an indication of total revenue risk can be gained.

5.206 In response to our December 2017 report, which analysed peak-to-trough PAX movements during the 2008-2009 financial crisis, NERA argue that our findings are not robust to the use of alternative time periods. Their response additionally considers the 2010-2013 Eurozone crisis and combines the two periods into a single 2008-2013 timespan. For completeness, we therefore report the peak-to-trough changes in PAX traffic for all three airports across all three periods considered by NERA. Table 27 captures these changes.

Table 27: Passenger Flows for HAL, CDG and Frankfurt Airports (2008-2013)

	Financial Crisis			**Eurozone Crisis**			**Both Crises**		
	2008-2009			2010-2013			2008-2013		
	HAL	CDG	FRA	HAL	CDG	FRA	HAL	CDG	FRA
Peak PAX (m)	68.0	61.2	54.8	72.3	62.1	58.0	72.3	62.1	58.0
Trough PAX (m)	65.7	57.9	50.9	64.8	57.1	50.6	64.8	57.1	50.6
Difference (m)	-2.3	-3.3	-3.9	-7.5	-5.0	-7.4	-7.5	-5.0	-7.4
Difference (%)	-3.4%	-5.3%	-7.1%	-10.4%	-8.0%	-12.7%	-10.4%	-8.0%	-12.7%
Conclusion	HAL experiences lowest risk			CDG experiences lowest risk			CDG experiences lowest risk		

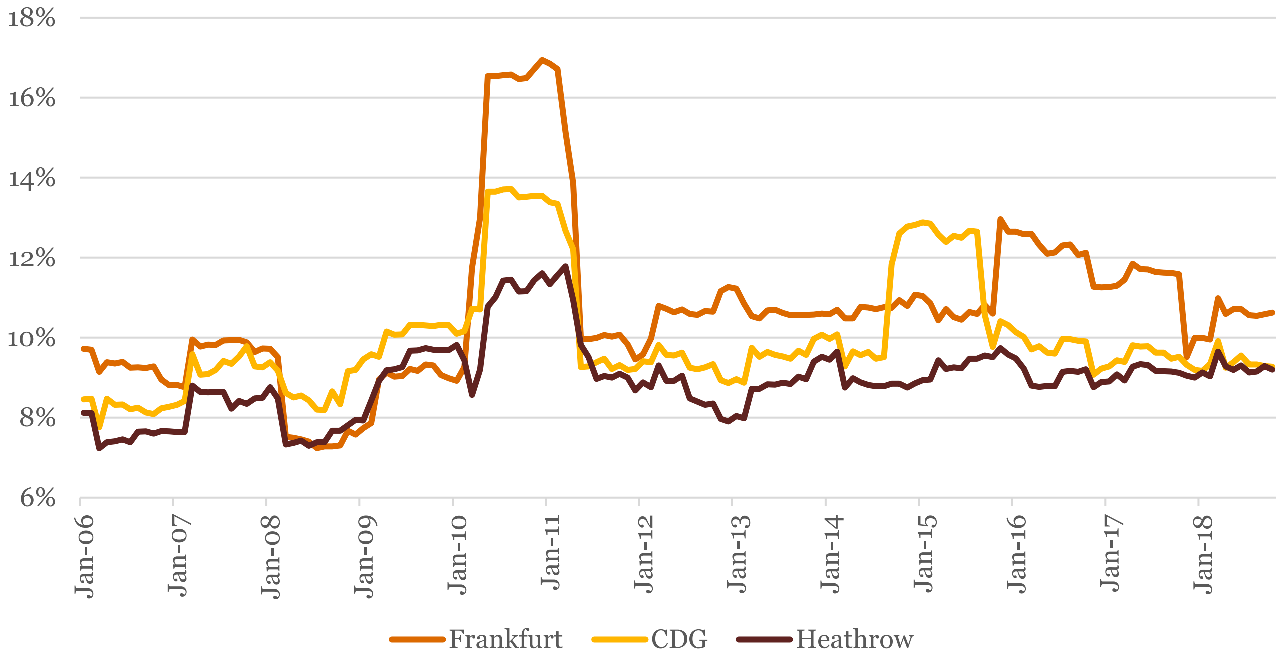
Source: Airport historical passenger traffic statistics

[89] It should be noted that this example assumes that the stated reimbursement does not equate to more than a -0.5% change in the annual price schedule. If this were the case, then the reimbursement would be capped at this level.

5.207 Notably, we observe that Frankfurt airport experienced the largest changes in passenger flows during this period. This is particularly true of the financial crisis, during which the percentage change in Frankfurt's PAX traffic was over twice as large as the change in HAL's PAX traffic. This finding suggests that the moderating influence of Frankfurt's regulatory regime on its outturn revenues may be offset by high underlying volatility in its PAX.

5.208 However, there is a case for looking beyond peak-to-trough analysis and consider more dynamic approaches to understanding PAX volatility. Specifically, we analyse the standard deviation of PAX growth across the three comparator airports, using rolling 12-month PAX growth samples. Figure 15 below captures movements in this metric between January 2006 and October 2018.

Figure 15: Standard Deviation of PAX Growth for HAL, CDG and Frankfurt Airports (2006-2018)



Source: Airport historical passenger traffic statistics

5.209 Reviewing Figure 15, we observe that HAL typically experiences lower standard deviation of PAX growth than Frankfurt and CDG. We find that Frankfurt's high PAX volatility during the financial crisis is consistent with our peak-to-trough findings. And, Figure 15 demonstrates that CDG is consistently more exposed to PAX fluctuations than HAL, with a particularly large difference emerging during 2014-2015.

5.210 Overall, it therefore appears that HAL experiences the lowest PAX volatility of the three comparator airports, with demand showing relative stability in recent years. This finding implies that the effects of regulatory flexibility on overall demand risk may be offset by underlying PAX volatility, resulting in broadly similar levels of revenue volatility across the three airports. In the following section, to investigate this, we review revenue data in more detail.

Revenue Volatility

5.211 As shown in the preceding sections, HAL and its comparators differ in terms of regulatory regime and underlying PAX volatility. This section ties these discussions together by analysing the relative volatility of airports' outturn revenues over recent years. We consider revenue volatility across each of HAL, CDG and Frankfurt over the 2006-2014 period[90], making appropriate exclusions for regulatory and accounting changes where appropriate.

5.212 Table 28 captures the standard deviation in revenue growth across the three airports. We consider three time periods: the entire 2006-2014 period, the entire period excluding 2009 to reflect a step-change in HAL's allowed yield per PAX, and the entire period excluding 2009 and 2011 to additionally reflect a change in accounting policies that affected CDG.

Table 28: Standard Deviation of Revenue Growth across HAL, CDG and Frankfurt Airports

Period	HAL	CDG	Frankfurt
2006-2014	7.0%	5.4%	6.3%
2006-2014, excluding 2009	2.8%	5.6%	4.1%
2006-2014, excluding 2009 and 2011	2.9%	2.9%	3.7%

Source: Datastream from Refinitiv, Heathrow regulatory accounts, PwC analysis

5.213 These estimates show that when appropriate exclusions are made, HAL appears to experience very similar revenue volatility to CDG and lower revenue volatility than Frankfurt. This finding is at odds with NERA's conclusion that HAL faces higher revenue risk than its comparators. The discovery that revenue volatility is broadly similar across all three airports aligns with the observation that differences in regulatory regime are broadly offset by differences underlying PAX volatility. While HAL's regulatory regime provides more exposure to demand risk, its relatively low PAX volatility reduces the impact that this has on revenues. Frankfurt airport represents the opposite case, experiencing high PAX volatility which is offset by its more flexible regulatory framework.

Summary

5.214 Overall, our review of relative risk faced by HAL and its two close comparator airports (CDG and Frankfurt) suggests that the systematic risk exposure of these airports is broadly similar. Table 29 summarises our findings.

Table 29: Comparison of Relative Risk Factors faced by HAL, CDG and Frankfurt Airports

	HAL	CDG	Frankfurt
Regulatory Regime	• Set timescales and strong regulatory oversight • Greater within-period exposure to demand risk • Single till regime	• Regular determinations • Some sharing of demand risks • Limited opportunities for regulatory re-sets • Adjusted till regime	• Greater airport power to request charge increases and secure new determinations • Limited sharing of demand risks • Dual till regime
PAX Volatility	• Lowest PAX volatility, particularly with respect to the Financial Crisis	• Higher PAX volatility, but not with respect to the Eurozone Crisis	• Highest PAX volatility • High elasticity of PAX demand
Revenue Volatility	• Low revenue volatility, especially when 2009 change in allowed yield per PAX is excluded	• Low revenue volatility, especially when 2011 accounting change is excluded	• Slightly higher revenue volatility

Source: PwC analysis

[90] We were not able to use the years after 2014 in this analysis because from this year onwards HAL changed their reporting year, from March - March to the calendar year. This means that the subsequent years are not comparable on a like-for-like basis.

5.215 Based on all the evidence set out in the table above, we find that CDG and Frankfurt are both appropriate beta comparators for HAL. It is not clear that any one airport is demonstrably more risky than another because of offsetting risk factors. We find that CDG is closer to HAL in terms of overall systematic risk exposure, meanwhile Frankfurt appears to have broadly similar systematic risk exposure as well, but, the findings are less conclusive given greater divergences in PAX volatility and regulation.

5.216 In addition, we note that while we are estimating betas for Fraport and AdP, their betas do not necessarily reflect the systematic risk faced by just Frankfurt and CDG. As part of their operations Fraport and AdP operate a range of international airports; Fraport is involved in operating c.30 airports globally while AdP operates c.25 globally. The broad range of risks faced by an international airport operator suggests that if it were possible to isolate the operations of just Frankfurt and Charles De Gaulle then they would likely face lower systematic risks than the overall group with the wide range of activities in different markets. Since capacity constrained hub-airports in mature markets are likely to have lower betas than unconstrained airports, this means it is likely Fraport and AdP's global operations are likely to increase their group betas.

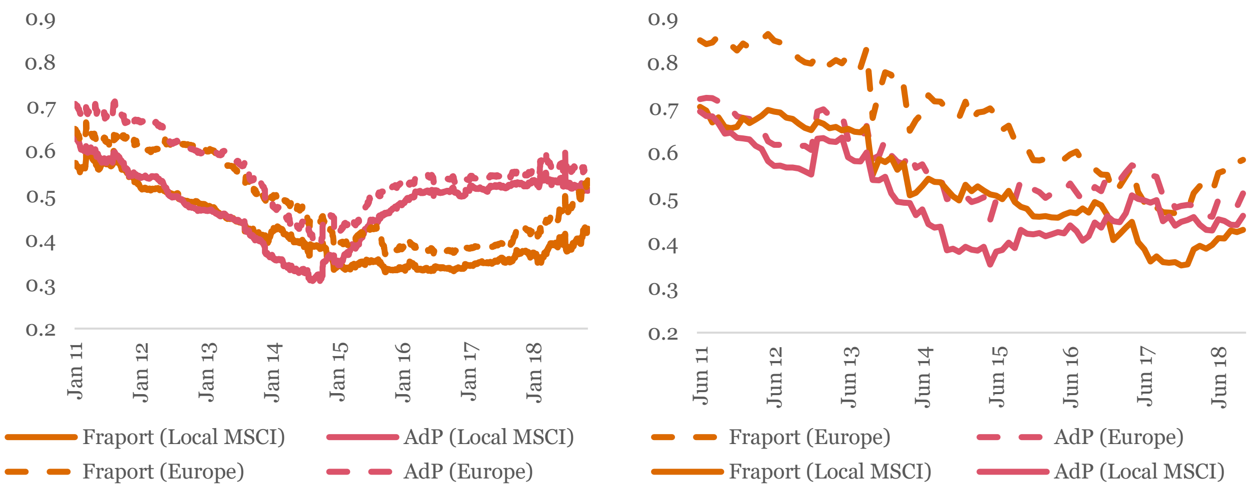
Conclusion and data update

5.217 In our December 2017 report, no single approach was relied upon to calculate betas; instead a balanced view was taken across a range of estimators, using both local and European indices

5.218 The additional relative risk analysis that we have conducted indicates that CDG is closer to HAL in terms of overall systematic risk exposure. Frankfurt appears to have similar systematic risk exposure too, however, the findings are less conclusive given greater divergences in PAX volatility and regulation.

5.219 Given that AdP and Fraport are the two most appropriate comparators for Heathrow, we have updated our beta analysis to see whether there been any material change in the measured systematic risk faced by either business. As shown in Figure 16 below, Fraport's asset beta increased slightly during the first half of 2018, while AdP's remained relatively constant. This indicates that level of systematic risk faced by each comparator has not changed significantly since our December 2017 report.

Figure 16: Comparator airport asset beta outputs (Fraport and AdP), LHS – 2 year daily, 5 year monthly



Source: Datastream from Refinitiv, Capital IQ, PwC analysis

5.220 Table 30 compares the asset betas estimated for AdP and Fraport in our December 2017 report[91] with the betas estimated using the latest market data. The change in asset beta across each time period varies depending on the estimation approach. For instance, the asset beta using the 2-year daily

[91] Updated with the revised debt beta of 0.1.

approach increases for Fraport and AdP. However, when we consider the 5-year monthly approach, Fraport's asset beta declines by 0.07 while AdP's does not change.

5.221 The updated betas indicate that there has not been any major changes in systematic risks faced by AdP or Fraport. In addition, there have been no substantial changes in how each entity operates, hence we would not expect there to be any change in systematic risk.

Table 30: Comparison of assets betas for AdP and Fraport

Estimation period	Company	2-year daily	5-year monthly	2-year daily	5-year monthly
		Local index	Local index	European index	European index
End of October 2018	Fraport	0.37	0.40	0.42	0.52
	AdP	0.52	0.46	0.55	0.51
End of March 2017 (for Dec 17 report)	Fraport	0.34	0.47	0.39	0.60
	AdP	0.48	0.42	0.52	0.51
Difference between periods	Fraport	0.03	-0.07	0.03	-0.08
	AdP	0.04	0.04	0.03	0.00

Source: Datastream from Refinitiv, Capital IQ, PwC analysis

5.222 When taking an average across all of the different estimation approaches, we obtain an asset beta estimate of 0.43 for Fraport and 0.51 for AdP as at October 2018. This supports our proposed range of 0.42 – 0.52.

5.223 Based on our summary of the risk factors in Table 29, it is not clear that any one airport is demonstrably more risky than another because of offsetting risk factors. However, in our view HAL's beta is towards the lower end of the proposed beta range given that capacity constrained hub-airports, such as Heathrow, are likely to have lower betas than unconstrained airports. In addition, the global nature of AdP and Fraport's activities means they may be more exposed to systematic risk than Heathrow.

5.224 In summary, for the HAL 'as-is' case, there is insufficient evidence to change the Q6 beta range of **0.42 to 0.52**. This range set out in our December 2017 report also benefitted from comparison to other UK regulatory determinations. These suggested that a figure below 0.42 is hard to justify when compared with other UK regulated sectors which don't face as much demand risk.

Topic 5j – Debt beta estimate

Topic overview

5.225 Throughout the consultation period, we have received questions from various stakeholders on how we reached the debt beta estimate of 0.05 which was used in our de-levering calculations in the December 2017 report. Stakeholders also questioned whether it remained appropriate given developments in financial markets over the last year.

5.226 We note that the previous estimate was based on more recent regulatory determinations, such as those published by the CC/CMA, which have typically used lower values for the debt beta. In the 2015 Bristol Water appeal, the CMA assumed a debt beta of zero and in the 2014 NIE appeal used a debt beta of

0.05. This lower value for the debt beta was also consistent with the empirical estimations that we had conducted.

Comments and response

5.227 In light of the responses from stakeholders, we have conducted some additional analysis to determine whether or not the 0.05 debt beta estimate remains relevant for the H7 period.

5.228 In Table 31 below we set out recent regulatory precedents of the debt beta used for estimating an appropriate re-geared equity beta.

Table 31: Regulatory precedent on debt beta

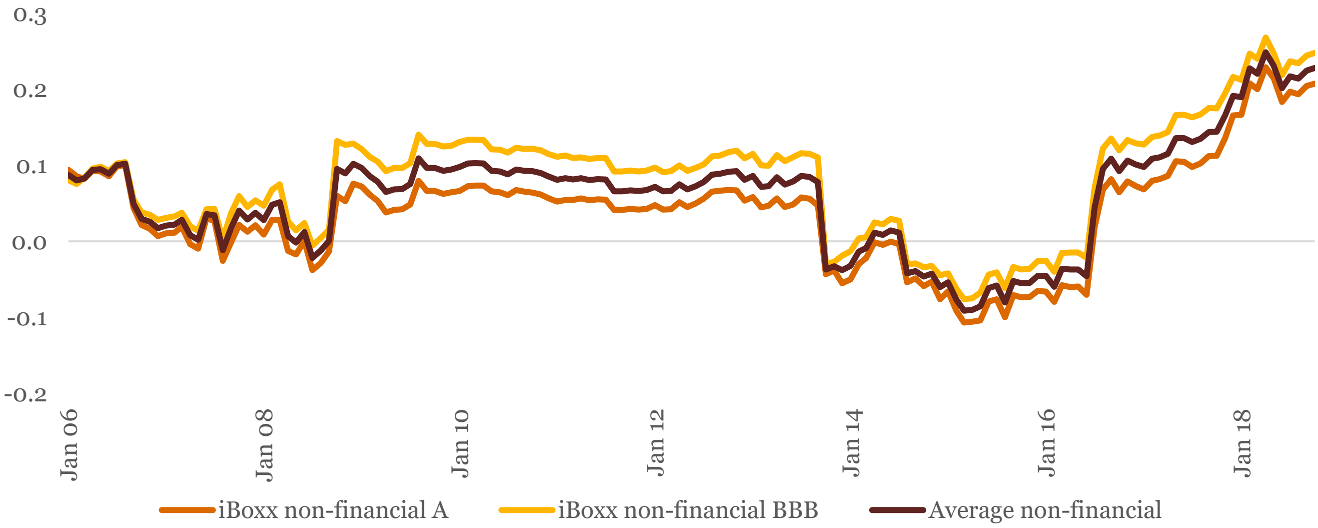
Determination	Debt beta	Rationale
Ofgem RIIO-2 sector specific methodology consultation (2018)	0.15 – 0.10	Ofgem noted there is regulatory precedent and academic support for debt betas in the range of 0.05 to 0.22, but used a narrower range for its consultation estimates.
Ofcom BCMR (2018)	0.10	Based upon a range of sources, but Ofcom noted that its advisor NERA suggested it was at the upper end of recent UK regulatory determinations.
Ofwat Delivering Water 2020 (2017)	0.10	As noted by Ofwat, this is a cautious estimate as there have been no defaults in the water sector since privatisation.
CMA Bristol Water (2015)	0.0	As noted in CC10, PR14 and NIE the debt beta has very little impact on the overall cost of capital if Bristol Water's gearing level is similar to the comparators used to estimate the asset beta.
Ofwat PR14	0.0	Little justification provided
Ofgem RIIO-ED1 (2014)	0.10	Ofgem based its asset beta range for ED1 upon the CC's asset beta range calculated for NIE. This ranged from 0.35 to 0.40. Removing the 0.02 NI-GB regulatory differential, ED1 employed an asset beta range of 0.33 to 0.38. Although the CC's asset beta range was based on observed equity betas which were de-levered using a debt beta of 0.05; Ofgem re-levered its asset beta range to an equity beta range using a debt beta assumption of 0.10 and a gearing of 65%. In doing so, Ofgem's analysis noted the relationship between gearing and debt beta highlighted by the CC's NIE work.
CAA Q6 (2014)	0.10	The CAA used a debt beta of 0.10, this was justified by placing more weight on historical academic studies of asset beta. Empirical estimates reviewed tended to produce lower results.
CC NIE (2014)	0.05	Debt beta is lower than in recent CC cases such as Bristol Water (2010), reflecting the relatively low level of gearing. (The debt beta is assumed to increase with gearing. However, debt beta assumption makes little difference to estimated cost of capital as long as the gearing assumption in the WACC is not too different from the gearing of the companies for which the equity beta was estimated).
CC Bristol Water (2010)	0.0 – 0.10	In its analysis, the Competition Commission (CC) made an assumption about Bristol Water's debt beta of 0.0 to 0.1. They noted that the results, i.e. the impact on the cost of capital, do not tend to be sensitive to the level of debt beta. Due to this they did not carry out any detailed work to assess the level of Bristol Water's debt beta.

Source: Regulatory determinations

5.229 To determine an appropriate debt beta to use in estimating the cost of capital for H7, we have conducted empirical analysis to estimate a debt beta using market data. To estimate the debt beta, we regress the returns on bonds, or more specifically bond indices, against the returns of a broad market index. The bond indices we use are the A and BBB 10-year+ iBoxx non-financial indices, which are also used in the cost of debt calculation. This is regressed against the returns on the UK MSCI index (MSCI indices are also used in the equity beta calculations).

5.230 The figure below shows the output of this analysis. Between 2006 and 2018 the debt beta for the average of the two iBoxx indices has ranged from -0.09 to 0.26. We observe that over the last two years the debt beta has been above 0.10.

Figure 17: iBoxx non-financial debt betas



Source: Datastream from Refinitiv, PwC analysis

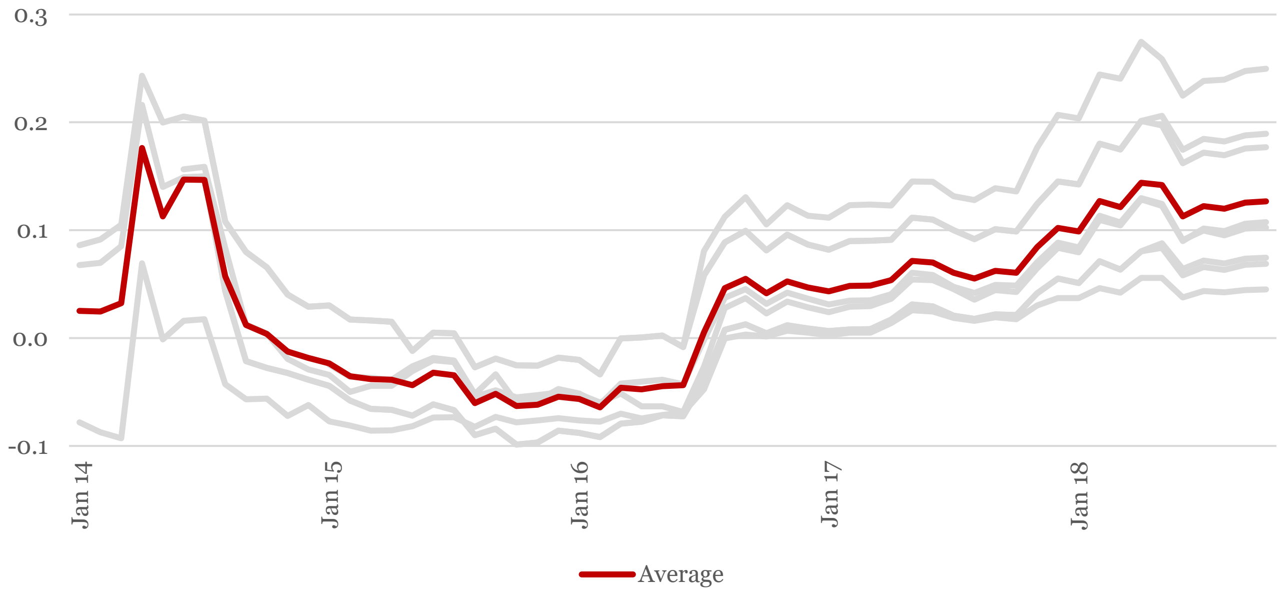
5.231 We also considered debt betas calculated using bond return data for individual bonds issued by HAL[92]. In order reduce any effects that may result from specific features of HAL's bonds, we considered bonds with the following characteristics:

- Nominal bonds, i.e. not index-linked
- Fixed coupon
- GBP denominated
- Non-convertible

5.232 The figure below shows the debt beta estimated from HAL's bonds. The grey lines represent the debt betas for individual bonds while the dark red line is the average debt beta across all of HAL's bonds. This shows that the average debt beta ranges between -0.06 and 0.18 and has been at, or above, 0.10 across 2018.

[92] For this calculation we used price return as opposed to total returns because the total returns data was not available for all of HAL's bond issuances. The list of bonds used is provided in Appendix E.

Figure 18: Debt beta based on HAL's bonds



Source: Datastream from Refinitiv, PwC analysis

5.233 The iBoxx and HAL debt beta estimates follow a broadly consistent profile, and they have both shown a marked upward trend over the past 18 months. As with much other market data, we are cautious about using short-term movements (particularly as the upward trend is now reversing). However, these market movements do mean that our initial estimate of 0.05 does need to be updated.

Conclusion

5.234 We consider that a figure of 0.10 better reflects the upward movement in market data and aligns better to other recent regulatory determinations which are also targeting an investment grade rating on corporate debt. As a result, we have updated our debt beta assumption from 0.05 to 0.10.

6. Responses on tax

Topic 6a – The tax rate in H7

Topic overview

6.1 NERA[93], on behalf of HAL, used a 17% tax rate for H7, which is the expected corporate tax rate as per the government's current plans for UK statutory corporation tax. This is in line with the 17% tax rate we have used in our analysis.

Comments and response

6.2 In Q6, the tax rate applied was the expected average statutory corporation tax rate, which was 20.2%. The equivalent figure based on the latest information for H7 would be 17%. This incorporates the UK Government's signalled reductions in the headline rate of corporation tax from the current figure of 19% to 17% from 2020.

6.3 Given the size of the third runway capex scheme in H7, an approach that applies an effective tax may be preferred by the CAA. This approach would take account of the projected notional tax payments over the course of the price control period, considering capital allowances as well as other tax credits. It would then assesses an effective tax rate for the price control period to estimate the required pre-tax WACC (still based upon a notional capital structure). In order to inform the calculation of the effective tax rate, data from the H7 financial model could be applied.

Conclusion

6.4 We continue to illustrate H7 WACC using a tax rate of 17% for the H7 period.

6.5 The CAA could consider using an effective tax rate for the runway expansion case. However, further information from the H7 financial model is required before an effective tax rate can be calculated.

[93] NERA (2018), 'Cost of equity for Heathrow in H7'.

Appendix A – Comparison of CPI and RPI inflation indices

Inflation Formula Composition

UK RPI and CPI are formed from combinations of different averaging techniques which are used to aggregate price inflation across a range of items within product categories. These techniques are known as elementary aggregate formulae, and there are three key formulae to consider.

The Carli formula is an arithmetic averaging formula which takes the rate of change in each individual price point before computing the arithmetic average of those changes. Formulaically, the resulting price index can be expressed as:

$$I_{t,0} = \frac{1}{n}\sum_{i=1}^{n}\frac{p_{i,t}}{p_{i,0}}$$

where n is the number of price quotes and $p_{i,t}$ is the price of item i at time t. It can be shown that the Carli formula injects spurious inflation when there is no overall price change between periods, inducing an upward bias known as chain drift.

The Dutot formula is also arithmetic, but it is constructed by taking the arithmetic average of prices in each period and then calculating the rate of change. This can be expressed as:

$$I_{t,0} = \frac{\sum_{i=1}^{n}\frac{p_{i,t}}{n}}{\sum_{i=1}^{n}\frac{p_{i,0}}{n}}$$

By contrast, the Jevons formula is founded on the geometric mean (which is calculated by multiplying a series of n numbers together and taking the n^{th} root of the product). The formula can be calculated by either taking the geometric mean of the rate of change of prices or by computing the ratio of the geometric mean of prices (both calculation methods yield the same result). If the first method is used for instance, this leads to the formula:

$$I_{t,0} = \sqrt[n]{\prod_{i=1}^{n}\frac{p_{i,t}}{p_{i,0}}}$$

In the UK, the RPI is calculated using a mixture of the Carli formula (27%) and Dutot formula (29%) alongside other formulae[94]. The UK CPI by contrast is calculated using a mixture of the Dutot formula (5%) and Jevons formula (63%) alongside other formulae. This difference in composition is one of the main causes of the UK CPI-RPI wedge, however, there are other factors involved e.g. coverage.

[94] P. Levell (2015), 'Is the Carli index flawed?: assessing the case for the new retail price index RPIJ', *Journal of the Royal Statistical Society Series A (Statistics in Society)*, 178(2): 303-336.

Appendix B – AENA beta

Comparator assessment

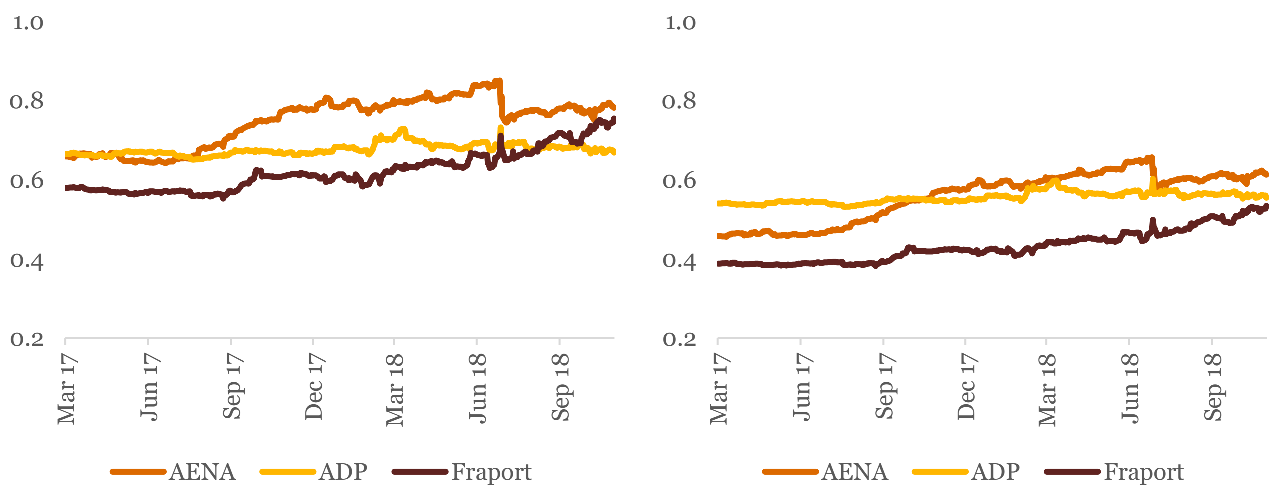
In our December 2017 report, we compared Heathrow's exposure to systematic risk to that of Fraport and ADP. All stakeholders agreed these are the best two listed comparators for beta estimation purposes. Virgin also suggested that a relevant comparator to add to the list is AENA[95].

When compared to HAL, AENA has a considerably more diversified range of operations. AENA operates, maintains and manages and administers airport infrastructures and heliports in Spain and internationally. It manages 46 airports and 2 heliports in Spain including the largest airport in Spain: Madrid Barajas airport. AENA also participates in the management of 16 airports in different countries in Europe and America through its subsidiary Aena Internacional, including the London-based Luton (of which it owns 51% of the share capital). In terms of passenger numbers, AENA is the largest airport operator worldwide with more than 265 million passengers in 2017. It also has a larger market capitalization than Fraport and AdP.

On this basis we find that AENA is potential comparator to HAL, although its globally diverse operations mean selecting an index for beta calculations is not obvious. We undertook beta analysis to calculate the level of systematic risk faced by AENA. Figure B1 below shows that AENA faces a similar level of systematic risk as Fraport and ADP; in particular, their respective equity betas have all been close over the last year. On an asset beta basis, AENA appears to be closer to ADP due to Fraport's higher level of gearing.

However, we were unable to undertake the full range of historical beta analysis (i.e. 2-year daily betas and 5-year monthly betas) because AENA only listed on the BME stock exchange in February 2015. This means that we cannot use AENA as a full comparator for HAL because we do not have enough historical evidence from which to conduct the required range of beta analysis.

Figure B1: 2-year daily equity (LHS) and asset (RHS) betas, European index



Source: Datastream from Refinitiv, Capital IQ, PwC analysis

95 Virgin (2018), Virgin Atlantic Airways response to the CAA's consultation on Economic regulation of capacity expansion at Heathrow: policy update and consultation (CAP 1610)

Appendix C – The weighting on new debt

HAL noted that the 60% weighting on the cost of new debt applied in our December 2017 report was a reasonable estimate for the end of period proportion of new debt, but, that it was not appropriate for the H7 period as a whole. HAL suggested that the proportion of new debt used in the calculation should have been 30% on average over the period. HAL suggested that this average approach would be consistent with the approach taken to the 'as is' cost of new debt.

Comments and response

The weighting on new debt for HAL 'as is' in our December 2017 report was estimated to be 12.5% on average for H7. This was consistent with steady re-financing, a tenor of debt of approximately 20 years and a price control length of 5 years.

For the capacity expansion case, the weighting on new debt in our December 2017 report was assumed to be 60%. As stakeholder comments highlight, this is an upper estimate of the weighting of new debt in H7. An upper estimate such as this would be consistent with the bulk of new debt being issued early in the H7 period. Where debt is issued on a more gradual basis per annum across the H7 period, then the average weighting on new debt – relative to embedded debt – across the period will be lower.

A key input into the estimation of the weighting on new debt is the total capacity expansion scheme cost, and the profile of finance raising for the expansion. Financing also needs to be raised significantly prior to expenditure, which brings forward the point of finance raising. As noted by the CAA in April 2018, there is still "considerable uncertainties that relate to HAL's current cost estimates".[96] For the purposes of this document we continue to illustrate the weighting on new debt using a scheme cost of £17.6bn (2014 prices), but note that the final scheme cost is likely to be different from this figure.

Using a more gradual profile of new debt issuance over the H7 period for the new issuance of capacity expansion related debt, we estimate a new debt weighting of 46%. This is shown in the table below.

Table C1: Proportion of new debt in H7

Item	Description	Value
A	Scheme cost (2014 prices) (£bn)	17.6
B	Assumed illustrative 'as is' RAB (2014 prices) (£bn)	14.5
C	Notional gearing (%)	60%
D = A*C	New scheme related debt (2014 prices) (£bn)	10.6
E = B*C	Notional existing debt stock at opening (2014 prices) (£bn)	8.7
F	Average 'as is' new debt (%)	12.5%
G = F*E	Average 'as is' new debt (2014 prices) (£bn)	1.1
H = D/2	Average new scheme related debt (2014 prices) (£bn)	5.3
I = G+H	Average total new debt (2014 prices) (£bn)	6.4
J = E-G	Average embedded debt (2014 prices) (£bn)	7.6
K = I/(I+J)	**Average new debt weighting (%)**	**46%**

Source: PwC analysis

[96] CAA (2018), CAP 1658, Economic regulation of capacity expansion at Heathrow', para 16.

For the purposes of the expansion case WACC, we recommend using a figure of 46% for the weighting on new debt. Updating the new debt weighting from 60% to 46% changes the overall cost of debt range for the capacity expansion case by approximately +23bps at the lower end of the range and +16bps at the upper end of the range. This translates into a vanilla WACC impact of approximately +14bps at the lower end of the range, and +10bps at the upper end of the range.

Based on the above evidence, we provisionally update the new debt weighting for the capacity expansion case from 60% to 46%. We note, however, that this will require updating as more up to date evidence on costs is produced. For instance, if HAL decide to front-load debt issuance then the gradual approach outlined above will not be appropriate.

Appendix D – TMR averaging approaches

The table below outlines TMR estimates using a range of averaging approaches, inflation measures and holding periods. The averaging approaches used include:

- The 'simple approach', which calculates the arithmetic average for successive time periods. Consequently, there are limited observations for longer holding periods;
- The 'overlapping approach', which is the same as the simple approach except that it allows for overlapping time periods, which greatly increases the number of observations; and
- The geometric approach, which calculates the annual compound growth rate in returns over the time period under consideration.

The inflation series used include the DMS measure of inflation, using CPI post 1988 and RPI post 1988, as well as the Bank of England preferred CPI measure.

The table highlights that when a longer holding period is considered the market returns are generally lower than under a shorter holding period (for example, when comparing a 10-year holding period with a 1-year holding period)[97]. Equity returns using the DMS measure of inflation with RPI post 1988 are slightly lower than the equity returns using the DMS measure of inflation with CPI post 1988. Equity returns using the Bank of England preferred CPI measure of inflation are even lower, with a geometric average of 5.2% compared to geometric averages of 5.5% and 5.3% for the respective DMS inflation series.

Regardless of holding period under consideration, there is a gap between the geometric average and the simple/overlapping averaging approaches. As noted in Section 5 of this report, the expected TMR lies in between the arithmetic and geometric average.

[97] Although we note that a 20-year holding period under the 'simple' approach appears to be an exception to this trend. This is likely because there is a limited number of observations in comparison to the shorter holding periods, and hence the average is more likely to be distorted by any large deviation.

Table D.1: UK equities real returns, DMS dataset (1900 – 2016)

	Simple	Overlapping	Geometric
CPI post 1988			
1-year	7.3%	7.3%	
2-year	7.7%	7.2%	
5-year	7.4%	7.0%	
10-year	6.8%	6.9%	
20-year	7.9%	7.0%	
1900-2016			5.5%
RPI post 1988			
1-year	7.1%	7.1%	
2-year	7.5%	7.0%	
5-year	7.2%	6.8%	
10-year	6.7%	6.8%	
20-year	7.8%	6.8%	
1900-2016			5.3%
Nominal DMS and BoE CPI preferred			
1-year	7.0%	7.0%	
2-year	7.3%	6.9%	
5-year	7.2%	6.7%	
10-year	6.5%	6.6%	
20-year	7.5%	6.8%	
1900-2016			5.2%

Source: DMS, Bank of England, PwC analysis

Appendix E – Bonds used in debt beta analysis

Table E1: HAL bonds used in debt beta analysis

Issuer	Coupon	Issue date	Maturity date
Heathrow Funding Limited	9.2	18-Aug-2008	29-Mar-2021
Heathrow Funding Limited	5.225	18-Aug-2008	15-Feb-2023
Heathrow Funding Limited	5.225	18-Aug-2008	15-Feb-2023
Heathrow Funding Limited	6.75	03-Dec-2009	03-Dec-2026
Heathrow Funding Limited	7.075	18-Aug-2008	04-Aug-2028
Heathrow Funding Limited	6.45	18-Aug-2008	10-Dec-2031
Heathrow Funding Limited	6.45	18-Aug-2008	10-Dec-2031
Heathrow Funding Limited	5.875	13-May-2011	13-May-2041
Heathrow Funding Limited	4.625	31-Oct-2013	31-Oct-2046
Heathrow Funding Limited	2.75	09-Aug-2016	09-Aug-2049

Source: Refinitiv from Thomson Reuters