Europe Economics

Components of the Cost of Capital for NERL

December 2018

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1 Summary

This report, commissioned by the Civil Aviation Authority (CAA) from Europe Economics, considers the asset beta, gearing and cost of debt to be applied to NATS En Route plc (NERL) at RP3, along with certain methodological issues regarding beta estimation, gearing and cost of debt indexation.

1.1 Context

Recent years have seen some changes to regulation in the aviation sector, including changes to tilling arrangements at certain airports and proposals to change the European risk sharing mechanism for air traffic services revenues. These has also been some additional emerging potentially systematic risk associated with "no deal Brexit" scenarios. We believe that these factors, in combination, should have been expected to tend to raise asset betas. By contrast, we do not believe that other factors, such as changes to risk asymmetry or the general thrust of UK economic regulation, imply any material shift, either up or down, in asset betas.

1.2 Gearing

Given the general stability in gearing levels across the UK non-financial corporate sector and in gearing at HAL, our recommendation is that CAA continue with an initial working assumption of 60 per cent for the notional gearing, and then revises that assumption in the light of its financeability analysis. We recommend that enterprise value gearing be used in the initial assessment of asset betas, and that asset betas are then re-levered into equity betas at the 60 per cent notional gearing level.

1.3 Cost of debt

For NERL's cost of debt we consider a NATS bond and a constructed Europe Economics estimate of the yield of A rated UK utilities. After applying certain adjustments, we conclude for a range of 3.03 to 3.46, or a point estimate of 3.25 for the cost of new debt excluding transactions costs. Based on the findings of a detailed analysis of issuance and liquidity costs we conducted for Ofwat, and taking into account of the specificities of NERL we propose a transaction cost uplift to the cost of debt of 7bps. Thus the cost of new debt we propose is 3.32 per cent.

We estimate the debt beta from the debt premium implied by our central cost of debt estimate as 0.19, within a broader range of 0.13-0.22. Bearing in mind debt betas estimated in past advice to the CAA, we consider for a range for debt beta of 0.1-0.19.

1.4 Asset beta

We believe that NERL's asset beta should be expected to be lower than that of UK airports. This is due to the fact that NERL's demand diversifies fluctuations in individual airport demand and is also more globally diversified. Furthermore the regulatory arrangements to which NERL is subject provide partial protection from demand risk. We believe that NERL's asset beta should be expected to be no lower than that of UK utilities, because (i) although such utilities are subject to an analogous regulatory regime to NERL's, whereas typical utilities outside the aviation sector face no volume risk under their revenue caps, NERL also faces demand risk; and (ii) NERL may have higher operational leverage than is typical of a regulated utility. These two bounds (UK utilities and UK airports) set a "Constraint Range" within which NERL's asset beta should be expected to lie, and which we find to be 0.46-0.54.

Our judgment is that ENAV can, after some adjustments are applied to determine the notional en route portion of ENAV's beta, be used a direct comparator for determining NERL's asset beta. We find this "Comparator Range" (including adjustments) for the asset beta to be 0.29-0.54. Therefore our recommendation is that the Comparator Range, within which the regulatory determination should lie, is 0.29-0.54, and that he chosen value within that range should be consistent with the Constraint Range of 0.46-0.54. We emphasize that this is not quite the same as recommending a range of 0.46-0.54, because that might make it seem that the centre of the range would be 0.50. In fact, the centre of the range (i.e. the Comparator Range, 0.29-0.54) is 0.42. We are recommending that a value should be chosen that lies above the mid-point of the Comparator Range, at 0.46 or higher. We note that this also encompasses differences between the asset betas of ENAV and NERL that might be associated with differences in operational leverage.

1.5 Recommendations

Table 1.1 Europe Economics' recommendations for RP3

	RP3 (Comparator range)	RP3 (Overlap between Comparator and Constraint Ranges)	RP2
Gearing	60%	60%	60%
Debt beta	0.10-0.19	0.10-0.19	0.10
Asset beta	0.29-0.54	0.46-0.54	0.50
Equity beta	0.44-1.20*	0.87-1.20**	1.11
Cost of new debt	3.32 (nominal)	3.32 (nominal)	1.9% ("real" RPI-deflated)

* The lower bound is obtained using an asset beta of 0.29 and a debt beta of 0.19, whilst the upper bound is determined by an asset beta of 0.54 and a debt beta of 0.1. ** The lower bound is obtained using an asset beta of 0.46 and a debt beta of 0.19, whilst the upper bound is determined by an asset beta of 0.54 and a debt beta of 0.1. We emphasize that the overlap between the Comparator and Constraint ranges is not a range, per se. Rather, it is a constrained subsection of the Comparator range. There is, for example, no suggestion that a figure towards the middle of the overlap should be preferred. See discussion in Section 8.

2 Introduction

This was commissioned from Europe Economics by the Civil Aviation Authority (CAA). For this report, the CAA has asked us to

- estimate the beta that should be applied to NERL during the RP3 control period;
- estimate NERL's cost of debt.

As part of this, we have been asked to comment on NERL's gearing and various methodological issues relating to beta estimation and cost of debt assessment, which we address in the report as they arise.

2.1 Gearing, debt beta and asset beta at RP2

In Table 2.1.1 CAA's RP2 decision we report the decisions for RP2 regarding NERL's gearing, debt beta, asset beta and equity beta, as well as the the figures that NERA (NERL's adviser) recommended for RP3.

Table 2.1.1 CAA's RP2 decision

	RP2 Decision	NERA/NERL Recommendations for RP3
Gearing	60%	60%
Equity beta	1.11	1.33-1.58
Asset beta	0.50	0.56-0.66
Debt beta	0.10	0.05

Source:https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332607/uk-ireland-rp2-performance-plan-supporting.pdf, NERA (September 2018) "Updated Weighted Average Cost of Capital for NATS (En-Route) plc at RP3",.

CAA continued with its RP1 notional gearing of 60 per cent. PwC found the 60 per cent assumption to be consistent with the evidence on regulatory precedents and the average across other utility companies with an A-rating.

For debt beta CAA relied on the value that was used by the UK Competition Commission in recent inquiries at the time of RP2, namely a debt beta of 0.1. The value of 0.1 was also recommended to them by their consultants at the time (they found it to be consistent with the academic literature and regulatory precedents).

The approach used to estimate NERL's asset beta was composed of different stages, since there were no direct comparators, as recommended to the CAA by PwC.[1]

First, PwC used the UK airports' exposure to aeronautical and demand risk to obtain a benchmark for NERL's risk exposure and to analyse it. In doing this, they used the regulatory determination and the Final determinations for RP2 on Designated Airports. To account for NERL's exposure to an aeronautical risks on a national level, PwC used the weighted average of the UK Airports' asset betas.

Second, they considered the regulatory regime and compared it to the regulation in other sectors. More specifically, they compared the regulatory regimes in relation to the approach to the demand risk. To estimate NERL's beta they combined benchmarks from sectors which have a some exposure to demand risk with benchmarks from the aeronautical sector, obtaining an estimate consistent with NERL's exposure to demand risk. The weights were calculated by simulating the proportion of risks that NERL could bear in future.

[1] PwC, 2014 "Estimating the cost of capital for NERL A report prepared for the Civil Aviation Authority (CAA)"

Third, PwC compared NERL's operating leverage with the operating leverage of Designated Airports to check for the necessity of other adjustments.

Finally, in order to check for further adjustments to the asset betas, they compared NERL with other regulated entities from different sectors across other risk drivers (i.e. IT risks, likelihood of government support, bad debt risk and pension risk).

For RP2 the CAA estimated a range of 0.5 to 0.6 for the asset beta. The CAA also noted that NERL was expected to generate more cash during RP2 than the previous five years[2] and therefore chose an asset beta of 0.5 for RP2, i.e. the lower end of its range. To convert this asset beta determination into an equity beta for RP2, the CAA used its estimates of 0.1 for debt beta and 0.5 for asset beta, bearing in mind the gearing assumption of 60 per cent. PwC estimating a range for equity beta of 1.08 to 1.15 (at 60 per cent gearing). CAA concluded that it was appropriate to take the midpoint of the PwC range and concluded on an equity beta of 1.11 for NERL.

[2] See pg 255 of https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/332607/uk-ireland-rp2-performance-plan-supporting.pdf

3 Context

3.1 NERL's position

In March 2018 NERA produced the report "The Weighted Average Cost of Capital for NATS (En-Route) plc at RP3" for NATS. In September 2018 NERA produced an additional report "Updated Weighted Average Cost of Capital for NATS (En-Route) plc at RP3", which updates the analysis conducted in March 2018. Both papers included consideration of the risk-free rate and total market return as well as the asset beta, the gearing and the cost of debt. Here we focus on the latter aspects.

3.1.1 Asset beta

NERA argues that Heathrow, Gatwick and UK regulated utilities are not appropriate benchmarks for NERL.

- They note that the main UK airports are not listed, which they suggest means there are two dimensions of estimation error induced by comparing NERL to these UK airports: the error for estimating the UK airports' betas; then the error in modifying those betas to apply to NERL. Instead, NERA argues that the CAA should directly compare NERL to the international listed airports.[3]
- They argue that UK utilities are not appropriate benchmarks for NERL because UK water and energy networks are regulated under revenue caps, and thus not exposed to volume risk, whereas NERL is regulated via a price cap and so exposed to traffic volume risk. They suggest this means NERL bears more market risk than utilities, so NERL's asset beta should be higher. Furthermore, they argue that NERL has higher operating leverage than utilities (owing to its fixed staff costs). NERA claims that it is not viable to estimate NERL's asset beta by adjusting UK utilities' asset betas to take account of operating leverage differences, noting that this is typically feasible only within an industry.

NERA also considers market evidence from the Italian ANSP ENAV, which is treated as a comparator for NERL. However, NERA also argues that there are key differences between ENAV and NERL, including:

- ENAV having more upside than NERL;
- ENAV being less exposed to cyclical economic events because of its greater dependence on low-cost carriers; and
- Empirical evidence that NERA claims suggests betas for Italian listed utilities are lower than betas for equivalent utilities in other countries.

NERA claims these differences would tend to mean ENAV's asset beta would be an underestimate for NERL's asset beta.

NERA's lower bound for the asset beta is derived from a two-year asset beta for ADP of 0.56. NERA contends that, because of NERL's high operational leverage, NERL's asset beta should be expected to to be above that of ADP.[4]

NERA's proposed upper bound is 0.66, based on the betas of a selection of international listed airport betas.

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3 NERA also notes that at RP2 one of the arguments the CAA offered for comparing NERL to Heathrow and Gatwick was that these airports' betas had already been reviewed by the Competition Commission. It contends that this argument will not apply in RP3.

4 NERA argues that Fraport is a poor comparator for NERL, since Fraport benefits from a regime where it can seek a review of the rate at any time, with the result that it is insulated from risks that NERL is exposed to.

NERA finds ENAV's asset beta range to be 0.52-0.66 and notes that this broadly supports its final asset beta range, even before any adjustments for the differences in relative risks between ENAV and NERL.

NERA notes that airport asset betas have risen since RP2, but it also contends that CAA made a mistake at RP2 in not adjusting for NERL's operating leverage.

NERA also notes that there are additional risks that it has not adjusted for, including the risk of changes to the regulatory framework (including the traffic risk sharing mechanism), regulatory changes following Brexit, and changes to NERL's real options.

3.1.2 Cost of new debt

NERA found the NATS bond had a 1.73 per cent nominal spot yield. This figure was subject to a series of adjustments:

- It added 78 basis points to reflect a term premium because the NATS bond had a five year maturity but future bond issuance is likely to be at longer maturities.
- It added 63 basis points to reflect forwards market evidence suggesting a rise in yields over RP3.
- It added 50 basis points to reflect the impact of a reduction in the licence termination notice period.

Drawing these effects together, NERA estimates the nominal cost of new debt at 3.64 per cent.

In addition, they propose a "transaction cost allowance" of 15 bps.

3.1.3 Cost of debt indexation mechanisms

NERA argues that cost of debt indexation is not as practical for NERL as for other UK regulated entities. They argue the practical challenges in identifying an index with the appropriate credit rating and tenor means that debt indexation may not be as practical for NERL as it is for other GB regulated sectors.

3.2 Developments in risks affecting the aviation sector

3.2.1 Macroeconomic context

At the time of RP2, UK GDP growth was at its recent annual high-point. It has subsequently fallen back to the levels typical in 2011 and 2012. This slower growth period is expected to persist across most of RP3.

Figure 3.1 UK real GDP growth

Source: Thomson Reuters

3.3 CAA approach in RP2 for traffic risk

NATS en route PLC (NERL) is the sole provider of civilian en-route air traffic control over the UK. Its revenue comes from Eurocontrol route charges for the provision of air traffic services. NERL operates via control centres. The London Area Control Centre and the London Terminal Control Centre at Swanwick control upper level en-route traffic across England and Wales (up as far as the Scottish border) and low-level traffic in London and the South-East (including, in particular, aircraft on approach to or departing from Heathrow and Gatwick).

The Scottish Area Control Centre controls traffic over Scotland, Northern Ireland, and Northern England. The Prestwick Oceanic Area Control Centre provides procedural control for North Atlantic traffic.

NERL revenues thus arise from both traffic on approach to or departing from airports and traffic flying through UK airspace (without either landing or taking off) en route to other destinations. Therefore, the volatility in this traffic produces NERL's traffic risk. It is for that reason that, at the time of the RP2 decision, CAA used international airports as a reference for NERL.

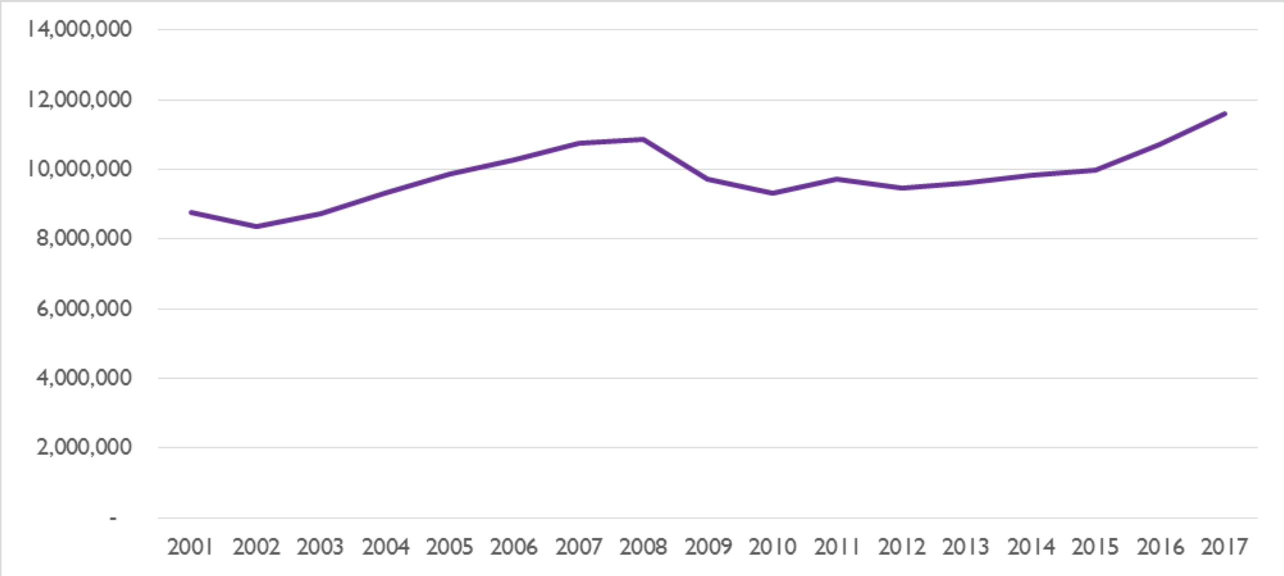
At RP2, CAA looked at overall passenger volatility for the listed airports and compared it to the volatility of NERL's chargeable service units (CSUs), believing that the volatility in CSUs would be most representative of the demand volatility that NERL faced. Figure 3.2 shows the data for the yearly total CSUs for NERL.

3.4 How NERL's traffic has evolved over time, and how much it deviates from trend each year

When we consider

Figure 3.2, there is a fairly clear drop at the time of the Great Recession in 2008/09. Given that there is such a clear series break, we divide our trend analysis into trends for two separate periods (i.e. up to 2008 and 2009-onwards).

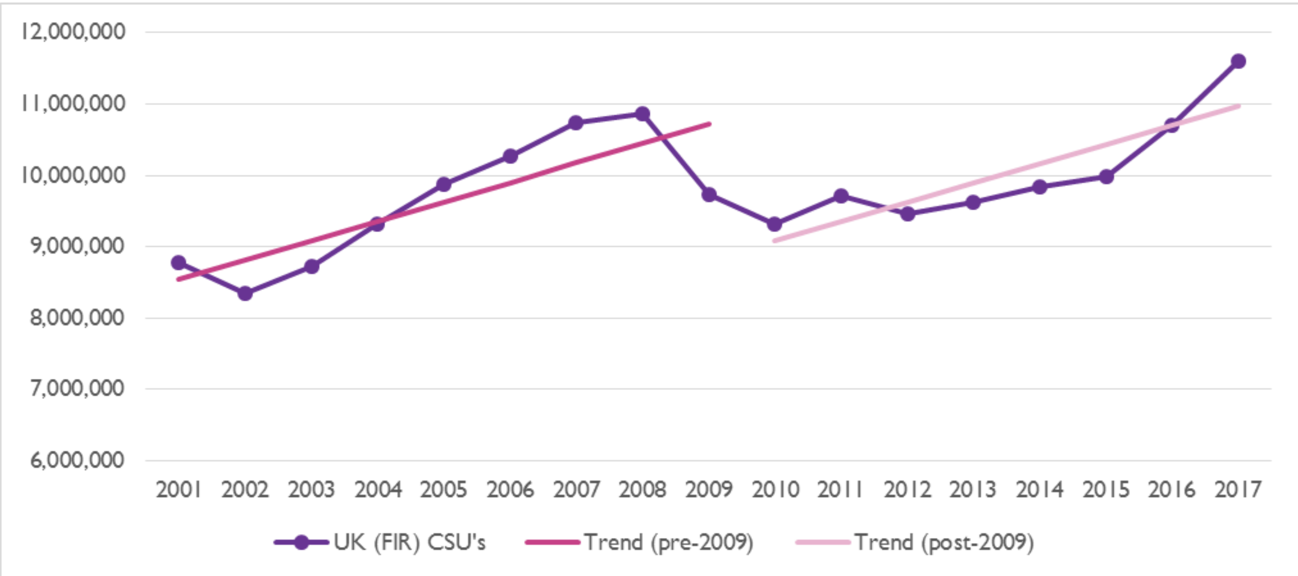
Figure 3.2 UK Flight Information Region (FIR) chargeable service units (CSUs)



Source: CAA.

In order to analyse traffic risk, we began by taking the trend for both pre-2009 (with 2009 included) and post-2009 CSU amounts. These are reported in the chart below.

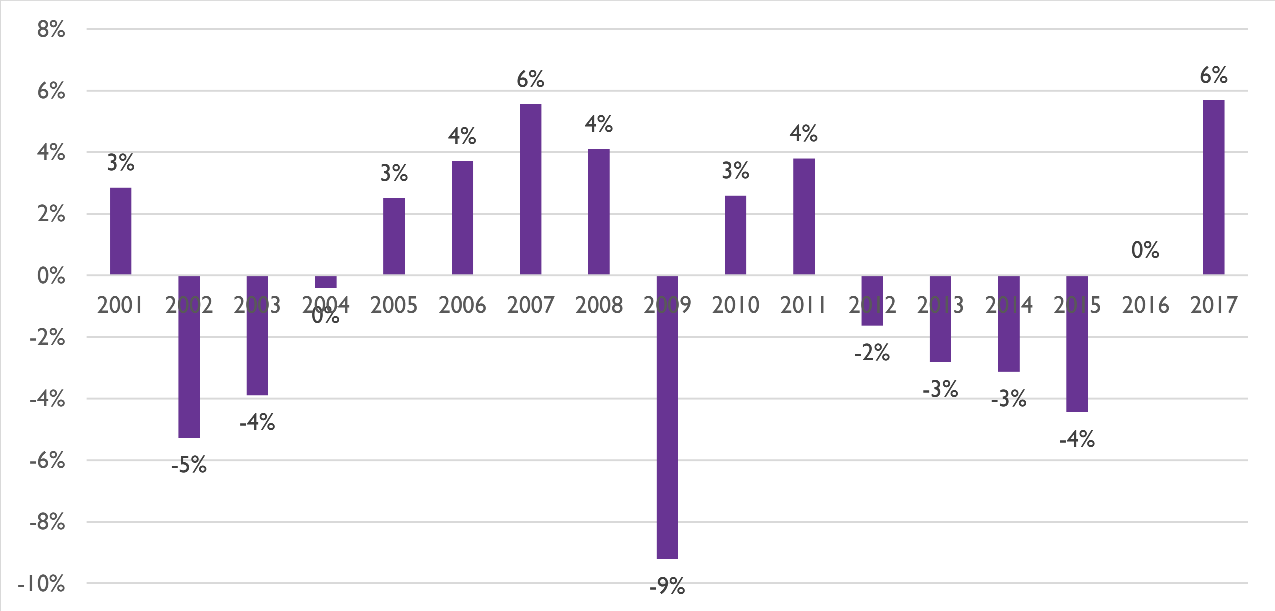
Figure 3.3 Deviation from trend



Source: CAA and Europe Economics Calculation.

After that, we took the percentage deviation of the actual CSU's from the pre 2009 trend and did the same for the after 2009 period. These are reported below.

Figure 3.4: Percentage deviation from the trend



We can see from Figure 3.4 that it is uncommon but not unknown for traffic to deviate by more than 5 per cent from its trend. Since 2001, that has happened in the years 2007, 2009, and 2017.

3.5 How traffic risk is shared between NERL and consumers

3.5.1 Current risk sharing mechanism

The current mechanism for risk sharing that has been in place in the UK since 2003 is the following:

- NERL bears 100 per cent of the risk / reward for first 2 per cent traffic variance; this is known as the 'Deadband'.
- For variances of between 2 per cent and 10 per cent NERL bears 30 per cent of the total risk while the remaining 70 per cent is borne by the airspace users (i.e. reflected in changes in prices).
- After 10 per cent variance NERL bears no risk and 100 per cent of the risk is reflected in changes in prices.

Such a risk sharing mechanism means that NERL has some protection against unforeseen change in demand. In its report for NERL, NERA estimates that in practice NERL takes on about two-thirds of the traffic risk, given the RP2 regime in place and the profile of traffic. From NERA calculations, this implies about 2.7 per cent volume risk per annum for NERL, after taking account of the risk sharing arrangements (reported in the next section) in place and the outturn versus forecast traffic volumes between 2011 and 2017.

3.5.2 Risk sharing mechanism proposed for RP3

NERL in its business plan sets out the emerging proposals for how the EC could change the risk sharing mechanism. The changes are as follows:

- The region where NERL bears 30 per cent of the risk would be increased such that the upper limit moved from 10 to 15 per cent.
- The CAA would be able to adjust the risk sharing ratio i.e. the 30:70 ratio.

- The CAA would be able to adjust the deadband of 2 per cent though the upper limit of 15 per cent will be fixed (i.e. the CAA could only change the risk sharing bracket by changing the deadband not the upper limit)

These possible changes in the mechanism would mean that in practice, the RP2 mechanism had a maximum of 4.4 per cent of applicable revenue at risk (=100% sharing * 2% deadband + 30% sharing * (10% cap – 2% deadband)), but the maximum revenue that NERL loses increases to 5.9 per cent under the EC's potential change to the RP3 mechanism i.e. (=100% sharing * 2% deadband + 30% sharing * (15% cap – 2% deadband)).

In Table 2.1 we report the revenue loss NERL incurred under the previous risk sharing mechanism and the revenue loss that NERL would have incurred if the proposed mechanism had been in place, assuming the CAA left the deadband at 2 per cent. For the purposes of the table we calculate the change in traffic by taking the percentage difference in the CAA assumption of the CSUs and the actual CSUs, using that as the determinant of revenue gain/loss under the risk-sharing mechanism. Even though the amounts of "revenue loss/gain" produced by this method will not match the actual revenue loss/gain under the mechanism, the difference between the results produced for the two mechanisms, under this calculation method, should be a rough approximation of their broad materiality.

Table 3.1 Revenue loss under the current and proposed traffic sharing mechanism (2% deadband scenario)

Year	CAA Assumption	Actual	Difference between actual and CAA assumption	% Revenue gain/loss (under the RP2 mechanism)	% Revenue gain/loss (under the potential RP3 mechanism)
2017	10,449	11,610	11.11%	**4.44%**	**4.73%**
2016	10,301	10,712	3.99%	**2.60%**	**2.60%**
2015	10,110	9,996	-1.13%	**1.10%**	**1.10%**
2014	10,860	9,858	-9.23%	**-4.17%**	**-4.17%**
2013	10,493	9,625	-8.27%	**-3.88%**	**-3.88%**
2012	10,151	9,475	-6.66%	**-3.40%**	**-3.40%**
2011	9,797	9,715	-0.84%	**0.80%**	**0.80%**
2010	11,293	9,317	-17.50%	**-4.44%**	**-5.90%**
2009	10,876	9,728	-10.56%	**-4.44%**	**-4.57%**
2008	10,504	10,873	3.51%	**2.45%**	**2.45%**
2007	10,198	10,739	5.30%	**2.99%**	**2.99%**
2006	10,015	10,269	2.54%	**2.16%**	**2.16%**

Source: *RP2 Performance Plan ** Regulatory Accounts: years 2012-2017 *** CAA

We see that revenue gains/losses under the new proposed mechanism differ from those arising under the current mechanism only in three years (2009, 2010, and 2017). That suggests that the new regulation increases risk, but only occasionally and then only marginally.

3.6 Is NERL an asset-light firm?

Most regulated utilities (e.g. water companies, airports, telecom operators, etc.) own large network infrastructure and therefore are asset-heavy companies with a relatively large RAB. Traditionally these asset-heavy utilities are regulated through a return on assets approach, in which the cost of capital is applied to the asset base.

"Asset-light" businesses are firms with low proportions of fixed assets to enterprise value (EV). The enterprise value (EV) of the firm is the sum of total market capitalisation and outstanding debt reflecting the total value of its tangible and intangible assets. For asset-light utilities, it is sometimes argued that either there should be special adjustments to the asset beta or that other regulatory approaches — such as, e.g. a margin based approach — might be preferred.

The question arises, therefore, whether NERL should be regarded as being closer to a conventional asset-heavy utility or to an asset-light firm.Three oft-quoted examples of asset light firms are System Operator for Northern Ireland (SONI), the Irish company Eirgrid, and certain Royal Mail postal services.

In the case of SONI, for example, in 2015 its ratio of opex to RAB was 733 per cent. For NERL that same ratio in 2017 was about 30 per cent, suggesting that NERL is much closer to a conventional asset-heavy utility than to standard asset-light firms.

If we compare NERL's ratio of return on capital to opex and of return on capital to total revenues to that of Eirgrid and other regulated entities, as we see in the following table, we find that NERL's return on capital as a proportion of its operating expenditure (the fifth column in the table below) is relatively low compared with traditional utilities, but nonetheless very much higher than that of EirGrid (as we can see in the sixth column, NERL's ratio is some 13 times that of EirGrid, only a little lower than that of Affinity Water, at 19 times, but far below that of HAL, at 71 times) — suggesting that whilst it might be at the lighter end of the utilities spectrum, it still sits most naturally within that group. That point is reinforced more strongly if we consider the ratio of return on capital to allowed revenue (the seventh column), for which NERL's figure is 26 times that of EirGrid, sitting squarely amongst other utilities (and indeed this time closer to that of HAL, 29 times, than Affinity Water, 13 times).

Table 3.2 Return on Capital Ratios for a range of companies

Country	Regulatory period	Company	Sector	Return on capital / Operating Expenditure	Multiple of EirGrid	Return on capital / Total allowed revenue	Multiple of EirGrid
Ireland	2011-2015	EirGrid	Electricity (TSO)	0.011		0.011	
UK	2020-2024	NERL	Aviation	0.294	13	0.145	26
Ireland	2011-2015	ESB Network	Electricity (TAO)	1.827	166	0.496	45
Australia	2014-2019	ActewAGL	Electricity (distribution)	0.993	90	0.389	35
Australia	2014-2019	ActewAGL	Electricity (transmission)	1.154	105	0.432	39
UK	2016-2023	UK Power Network (South East)	Electricity (distribution)	0.56	51	0.168	15
UK	2016-2023	London Power Networks	Electricity (distribution)	0.403	37	0.143	13
UK	2016-2023	Scottish Hydro Electric Power Distribution	Electricity (distribution)	0.379	34	0.142	13
UK	2013-2021	SP Transmissions	Electricity (transmission)	1.786	162	0.285	26
Ireland	2012-2017	Bord Gáis Network (Onshore)	Gas (transmission)	1.277	116	0.435	40
Ireland	2012-2017	Bord Gáis Network (Inch)	Gas (transmission)	0.491	45	0.243	22
Ireland	2012-2017	Bord Gáis Network (Interconnectors)	Gas (transmission)	3.523	320	0.729	66

Country	Regulatory period	Company	Sector	Return on capital / Operating Expenditure	Multiple of EirGrid	Return on capital / Total allowed revenue	Multiple of EirGrid
UK	2014-2021	Wales and West Gas Distribution Network	Gas (distribution)	0.414	38	0.201	18
UK	2014-2021	Northern Gas Distribution Network	Gas (distribution)	0.444	40	0.203	18
Australia	2011-2016	NT Gas	Gas (transmission)	0.637	58	0.337	31
UK	2015-2020	Affinity Water	Water	0.213	19	0.143	13
UK	2015-2020	Yorkshire Water	Water	0.436	40	0.34	31
UK	2015-2020	Dee Valley Water	Water	0.256	23	0.14	13
UK	2015-2023	NI Water	Water	0.573	52	0.213	19
UK	2014-2019	Heathrow	Airport	0.777	71	0.318	29

Our interpretation of these data is that NERL is not an asset-light company.

3.7 Operating leverage

A firm's operating leverage refers to the level of its fixed costs relative to variable costs.

It is well established in finance theory that firms with a high ratio of fixed costs to asset value will tend to have a higher asset betas, other things being equal (for a technical discussion of this results we refer to Appendix 3, Section 11.1). This is most relevant in contexts where there is data available on the asset beta for a firm exposed to the same basic underlying systematic risks as the firm of interest, but that other firm has a profoundly different business model involving markedly higher or lower operating leverage.

NERA contends that NERL has high operating leverage, based on three metrics i.e. capex as a percentage of opex, capex as a percentage of RAB and opex as a percentage of RAB. These were the same metrics that PwC used at the time of RP2. NERA suggests that the numbers are broadly the same as the time of RP2, and that this shows that NERL continues to have more operating leverage, and so is exposed to greater profit volatility as a result of demand shocks, than airports.

To support its position, NERA reported two examples in which higher level of asset beta were allowed thanks to higher level of operating leverage.

First, NERA reported two CMA determinations from 2010 and 2015[5] for Bristol Water, in which the Authority accepted that higher operating leverage could results in higher asset betas. The CMA adjusted the Bristol Water's asset beta without calculating a perfect measure for the operating leverage. Indeed, Bristol Water had a proportion of operating cash flow to revenue 13 per cent lower than the rest of the sector. The CMA therefore allowed a revision of the Bristol Water's asset beta by 13 per cent upwards relative to the rest of the sector.

Second, NERA reported a similar precedent, in which the French energy regulator CRE set higher asset beta for RTE thanks to RTE's higher operating leverage.

[5] CMA, 2015: "Bristol Water plc: A reference under section 12(3)(a) of the Water Industry Act 1991"

In light of these examples, NERA considers as inconsistent the CAA's approach at RP2, concluding that CAA should set higher level of asset beta in RP3 in order to counterbalance the NERL's higher operating leverage.

We accept the principle that operating leverage might have an impact on beta. However, we regard it as of most relevance when considering two firms exposed to the same underlying risks but deploying different business models in responding to them. If, for example, there were a comparator for NERL that was exposed to the same business risks as NERL, but used a business model with higher fixed operating costs than NERL's, we should expect that comparator to have a higher asset beta than NERL's (and vice versa).

Matters become more complex when comparing two firms at different points in a supply chain (e.g. say an airport and an airline) where some of the basic industry risks might be common but there is no implicit assumption that the use of a firm as a comparator implies that that firm has the same business model (since the activities are, by definition, not the same). In the case of NERL and UK airports we are even more distant from the standard situation in which operating leverage adjustments are most applicable, because although the riskiness of NERL's demand is likely to be in some way related to the riskiness of UK airports, it is more a matter of supplying services to a common set of customers (in this case, airlines, passengers and freight) than different points in a supply chain. It will be seen in what follows that, although we have not estimated a precise adjustment for operating leverage, we have considered it in forming and calibrating our asset beta ranges.

For example, suppose there were two firms: one that supplied car wash services; and one that supplied repair services. For both firms, the general state of the UK car market and the extent to which people were driving would be common points of relevance. One could imagine that, if there were no car wash services firms with listed equity, an assessment of the asset beta of car wash services might take account of the asset beta of listed repairs services firms. But it is not clear how operating leverage would be of relevance. The general balance of demand versus cost risk may well be of relevance, and how risky costs were for car wash firms relative to repairs firms could also be very important. There might also be some consideration of how important operating cost risks were relative to capital cost risks. But it is not clear that operating leverage would be of its own relevance except insofar as it was automatically taken into account in considering these other factors. In the case of comparing NERL with UK utilities, we would be effectively comparing the features of business models (in this case operating leverage) across firms that operate in very different business sectors (i.e. aviation vs utilities).

3.8 Asymmetric risks

Asymmetric risks could affect returns in two key ways. They could affect the expected value of returns, which would be relevant in the price control process as a whole (in affecting how much return was associated, in expectation, with any given price or revenue cap) but would not affect the WACC in general or asset beta in particular. It is important to note that this effect (changing the expected value of returns) could occur whether the asymmetries in question were specific or systematic in nature.[6]

NERA argues that specific risks could affect NERL returns. For example, changes in the incentives scheme resulting in asymmetric bonuses and penalties could lead to asymmetric distributed expected returns for NERL. NERA suggests this implies that the CAPM could underestimate the real cost of equity.

[6] It is perhaps worth noting that the UK Competition Commission, in the determination of Phoenix Natural Gas' price review, stated that the asymmetry given by capped increase in returns and the absence of a limits in downside of returns should be compensated with a maximum allowed rate of return above the WACC. Competition Commission (28 November 2012): "Phoenix Natural Gas Limited price determination"

NERA also argued that CAPM does not reflect the risks linked to cash flows timing. NERA noted that at PR09 Ofwat determined a lower gearing for water-only companies, arguing that these firms could face asymmetric risks due to higher asset and revenue concentration and the exposition to event risks.

NERA also referred to OPTA's decision to allow a WACC 3.5 per cent higher in order to account for asymmetric risk of new generation access networks. In the Note[7], OPTA highlighted that some authors state that the access at a cost based charges could be considered as a risk free option which allow entrants to enter the market with no fixed costs.

We agree that insofar as asymmetry in risks means that the expected return is elevated or reduced, that needs to be reflected in the design of the overall price cap. That will not, however, affect the WACC or asset beta in particular, and hence falls outside our scope here.

A second way in which asymmetric risks could in principle be relevant is if returns were (systematically) skewed — i.e. if market returns are such that, for a given expected return there tended to be more upside opportunity than downside (an "upwards skewed" distribution) or more downside opportunity than upside (a "downwards skewed" distribution).[8] According to standard microeconomic theory investors should prefer upwards skewed distributions to downwards-skewed ones, but in the standard Capital Asset Pricing Model (CAPM), it is assumed that investors care only about the mean and variance of returns. They place no weight upon skewness. The third moment CAPM addresses the possibility that investors have preferences over the distribution of returns that go beyond mean and variance, in particular taking account of skew. More specifically, if market returns were downwards skewed, then investors would require an additional premium in order to invest in companies whose returns are more negatively skewed than those of the market.

We agree that skeweness could in principle affect the cost of capital. However, we note that in the Q6 determination, the third moment CAPM was proposed by HAL, in order to take into account for skewed equity returns. After analysing on the matter, CAA concluded that, even if coskewness could have been relevant, there was not sufficient data to model robustly how much return should be affected by it. We do not regard the data available to us in this determination as coming remotely close to the high threshold this previous CAA judgement sets for the use of a third moment CAPM model.

3.9 Brexit and other political risk

A further potential source of systematic risk is the United Kingdom's departure from the EU in March 2019. At the time of writing the UK and EU have not produced a settled Withdrawal Agreement and there is widespread speculation of "no deal". Much public commentary contends that the aviation sector is especially exposed to Brexit no deal risk. For example, in July 2018 there was extensive coverage of comments by Irish Taoiseach Leo Varadkar who, in the context of journalists questions about the status of the Single European Sky in the event of no deal, stated "ultimately it is the UK that has decided to leave the EU [and] decided to leave the Single European Sky. And if they want their planes to fly over our sky, they would need to take that into account. You can not have your cake and eat it. You can't take back your waters and then expect to use other people's sky." This was reported in the Sun newspaper under the headline "Irish PM: I'll ban British planes as revenge for Brexit".

Analysing to what extent aviation might become impaired as a result of a no deal Brexit falls outside our scope here, except to the extent that speculation about it might have an impact on the cost of capital for NERL and for comparators to NERL.

7 OPTA, May 2010 "Regulation, risk and investment incentives Regulatory Policy Note 06"

8 More strictly speaking, this would be skewness in the systematic component of returns — i.e. a skewness in non-diversifiable risks that contributes to or subtracts from overall market skewness.

Europe Economics' working assumption is that, although a no deal Brexit might have some negative impact on both UK and European aviation, the impact on UK aviation would be larger.[9] We regard this effect as likely to be modest at this stage — for example, we note that Heathrow Airport has not reacted to speculation about a no deal Brexit by calling for a delay in the building of the third runway until after Brexit's implications become clearer, which suggests that it is not currently budgeting for a large impact in the event of a no deal scenario.

3.10 UK regulated sectors decisions

In Table 3.3 we present equity and asset betas used in various recent regulatory decisions.

Table 3.3 UK regulated sectors decisions equity beta and asset beta

Regulator	Sector	Year	Equity beta	Asset beta	Change in asset beta from previous determination (up/down/same)
ORR	Rail network	2013	0.95	0.37	N/A
CAA	Airports	2014	1.10	0.50	Same
CAA	Airports	2014	1.13	0.56	Same
CAA	Air traffic control	2014	1.11	0.50	N/A
CC	NI Electricity	2014	0.70	0.40	Down
Ofcom	LLU WLA Telecoms (Openreach)	2014	0.69	0.50	N/A
Ofwat	Water and sewerage	2014	0.80	0.30	Down
UR	Water and sewerage	2014	0.83	0.44	Same
Ofcom	Telecoms	2015	0.93	0.60	Up
CMA	Water	2015	0.85	0.32	Down
Ofcom	LLCC Telecoms (Openreach copper)	2016	0.74	0.55	Up
UR	Gas	2016	0.77	0.4	N/A
CMA	Health	2016	N/A	0.5 – 0.7	N/A
Ofwat	Water & sewerage	2017	0.77	0.37	Up
Ofgem	Energy & power	2018	0.71 – 0.80	N/A	N/A
Ofcom	WLA (Openreach copper access)	2018	0.80	0.59	Up
Ofcom	LLCC (Openreach copper access)	2018	0.81	0.56	Up

Source: UKRN (2018), "Cost of Capital — Annual Update Report".
https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Final-methodology-1.pdf,
https://www.ofgem.gov.uk/system/files/docs/2018/03/riio2_march_consultation_document_final_v1.pdf,
https://www.ofcom.org.uk/__data/assets/pdf_file/0017/124730/bcmr-annexes-1-22.pdf
https://www.ofcom.org.uk/__data/assets/pdf_file/0020/112493/wla-statement-annexes-17-27.pdf
https://www.ofcom.org.uk/__data/assets/pdf_file/0017/124730/bcmr-annexes-1-22.pdf.

We see that other regulators have used a rather wide range of asset betas, between 0.3 and 0.83. In some sectors, such as telecoms, there has been a fairly clear tendency for asset betas to rise in recent years.

In other sectors, rises in official asset betas are more a result of quasi-definitional (or methodological interpretational) changes than changes in substance. For example, although Ofwat's latest determination on the value of asset beta in 2017 might appear to have implied a rise in its value since 2014 (from 0.3 to 0.37),

[9] We note that the CAA has not shared a view with us on this point and the assumption used here is entirely of Europe Economics origin.

that was solely the result of Ofwat's using a zero debt beta assumption in its 2014 price review whereas in its latest calculation it assumed a debt beta value of 0.1.

3.11 Conclusion

Our interpretation of the various factors considered in this section is that none of them justifies any special additional adjustments to NERL's asset beta or cost of debt, either upwards or downwards.

4 Relevant comparators for NERL

Comparators can help inform an estimate for NERL's asset beta in a number of ways:

- We might be confident that NERL's beta should be lower than that of certain comparators.
- We might be confident that NERL's beta ought to be higher than that of certain other comparators.
- Some firms might be sufficiently similar to NERL, in relevant dimensions, that we can use an estimate of that firm's beta directly to estimate NERL's beta.
- There might be no one comparator that is appropriate, alone, for NERL but there might be reason to believe NERL should be similar to some weighted combination of other firms.

When thinking about what might make a comparator firm similar to or different from NERL, there are a number of different potentially relevant criteria. These include the following.

- Similarity to NERL in terms of operational and economic characteristics. Natural candidate comparators in this respect would be other listed ANSPs.
- Since demand (traffic risk) is the main driver of systematic risk to for NERL, comparators can be chosen on the basis that their exposure to traffic risk is similar to the one NERL faces. Natural candidates in this areas would be airports and, possibly, airlines.
- A third criterion is that there might be country-specific differences in potential shocks or in the exposure of airports to those shocks. For example, an Continental European comparator might not be exposed to special shocks that the UK might be exposed to, or might not be as exposed to Europe-wide shocks as the UK is.
- A fourth criteria for selection would be the similarity in the regulatory regime. Potential comparators in this category would be UK regulated utilities.

4.1 Firms that we would expect to have a higher asset beta than NERL

We note that previous work for the European Commission has argued that the betas of ANSPs are likely to lie between those of airports and utilities.[10] In this subsection and the following one, we shall argue that this is, in the restricted sense we shall describe, appropriate.

Other things being equal, we would expect NERL to have a lower asset beta than that of the airports in the geographic area it serves. A key reason for this is that a portion of NERL traffic will be purely global, neither departing from nor terminating at a UK airports. Whilst UK airports are exposed to UK-specific events, traffic travelling through UK airspace is more internationally diversified, and hence should be expected to have lower volatility and in particular lower correlation of volatility with UK macroeconomic volatility (and thus less of the risk in such traffic will be systematic in nature). Another reason is that NERL benefits from a risk-sharing mechanism that UK airports do not.

Hence, we should expect that (setting aside issues such as differences in business model, which we shall come to below), NERL's asset beta should be lower than that of UK airports.

[10] For example, at paragraph 5.44 of: https://ec.europa.eu/transport/sites/transport/files/modes/air/single_european_sky/doc/2014_03_25_final-report-cost-of_capital-and-pensions-v2-25march2014.pdf, the authors state "we consider that revenue and cost risks for ANSPs are broadly similar as for electricity, gas and water utilities. On the other hand, the risks faced by ANSPs are likely to be lower than for airport operators".

4.2 Firms that we would expect to have no higher asset beta than NERL

We would expect typical UK utilities (such as electricity and water companies) to have no higher an asset beta than NERL's, and potentially lower. The key reason for this is that although such utilities are subject to an analogous regulatory regime to NERL's, typical utilities outside the aviation sector face no volume risk under their revenue caps whereas NERL also faces demand risk.

A second, more tentative, reason to believe that NERL might have an asset beta higher than that of utilities is that NERL is argued to have a somewhat different business model, including higher operational leverage. Operational leverage differences are most straightforwardly applicable when two firms subject to the same cost and demand risks have different business models for responding to those risks, with one business model involving markedly higher operational leverage than the other. It is not straightforward to argue that, when a business operates in a markedly different sector, differences in operational leverage translate into differences in asset beta. However, it may be indicative.

Some potential utilities comparators might have asset betas closer to or than that of NERL. That might in particular include firms such as SONI, that provide systems operation services, often involving extensive use of IT equipment, systems management and balancing techniques. It is perhaps worth observing that some such comparators also have higher operational leverage than that of a typical utility.

These operational leverage considerations might suggest that, amongst utilities, NERL should be expected to have an asset beta at least equivalent to that of some of the higher asset beta utilities.[11]

4.3 Firms that might be used as direct comparators for NERL

The most natural direct comparator for NERL would be another ANSP. The only listed ASNP is the Italian firm ENAV. An assessment of the similarity between ENAV and NERL can be found in the 2016 ACE Benchmarking Report, which compares the cost efficiency, among other things, of the various European ANSPs.[12] That report groups together the five largest ANSPs (ENAIRE, DFS, DSNA, ENAV and NATS) for comparison purposes. Its stated rationale for this is "their weight in the Pan-European system and their relatively similar operational and economic characteristics (size, scope of service provided, economic conditions, and presence of major hubs)".

NERL and ENAV:

- have very similar and operational and economic characteristics;
- operate under the same EU-wide regulatory framework (Single European Sky);
- have similar key performance areas relating to safety, environment, capacity and cost efficiency; and
- are subject to the same risk-sharing mechanism.

The ACE report also states that there are no major risks identified in ENAV's discussion of risks that would not apply to NERL.

[11] We shall see in Section 7.3.2, the approach we use to determine the UK utilities beta above which we would expect NERL's beta to lie involves calculating a beta value which is effectively "above" the typical level of a utility.

[12] Source: http://www.eurocontrol.int/sites/default/files/publication/files/final-ace-2016-benchmarking-report.pdf

Table 4.1 ENAV's main identified risks

Risk	Nature of risk
Risk associated with air navigation	Fundamental to the business
Risk associated with technology and infrastructure development	Dealing with a complex geographic area, but needs to respond to developing regulatory framework and threats of delay
Risk associated with traffic cost and governance	It identifies the post 2019 regulatory risk relating to the new performance plan, i.e. the possibility that it will be set a more challenging set of targets. It comments that its traffic volume risk mitigated by the traffic risk sharing regimes and that it is taking measures to improve operational responsiveness
Risks associated with human and organisational capacity	It comments on the need to adapt to evolving technologies, i.e. staff have to be trained

We also note that NERA's September 2018 report argues that, whilst ENAV's beta is a useful comparator, there are key differences between NERL and ENAV which indicates that ENAV's beta may underestimate NERL's beta. Such differences are listed below. .

- There is potential bias in Italian utilities' beta estimates which results in Italian utilities' betas being lower than that of other European utilities (in its March 2018 Report NERA mentions idiosyncratic political risk, liquidity risk in and country risk, and the country risk as potential reasons for such bias).
- ENAV's CSUs have a higher upside risk relative to NERL.
- ENAV is less sensitive to demand risk compared to NERL because it relies more heavily on low cost carriers whose demand is less correlated with the wider economy.

Our response to these points is as follows.

- We have tested Italian utilities betas relative to UK utilities and to ENAV, and report the results in Appendix 1. We shall see that Italian utilities do not appear to exhibit any significant downward bias, and ENAV's beta, relative to that of Italian utilities, seems broadly in line with our qualitative priors for an ANSP, as set out above.
- We are not persuaded that ENAV CSUs have a materially higher upside risk than NERLs or that, if they did, that would necessarily imply that ENAV's beta was downwards biased. (Whether it was so might depend on the price of skewness for Italian investors.)
- We are not fully persuaded that ENAV's greater exposure to low-cost carriers implies a lower asset beta, but in any event believe that effect would be offset by the likelihood that a higher proportion of NERL traffic is world-economy exposed and hence of more globally diversified risk than ENAV traffic.[13]

[13] To support the intuitive idea that NERL traffic is more world-economy exposed than ENAV traffic, we can consider the difference in the traffic that ENAV and NERL face. In the following tables we compare the breakdown of the CSU's for both NERL and ENAV. First we consider NERL's CSU's. More than 50 per cent of the traffic that NERL faces comes from international flights whereas only about 10 per cent comes from domestic soureces.

Table: NERL's CSU's breakdown

Year	Domestic	International	Overflights	Total
2016	1,075,094	5,964,449	3,671,281	10,710,824
2017	1,079,361	6,351,572	4,175,407	11,606,340
2016	10%	56%	34%	100%
2017	9%	55%	36%	100%

On the other hand, we believe that ENAV may not be a perfect comparator for NERL, for two main reasons.

- First, whilst about 80 per cent of ENAV's revenues are attributable to en route traffic (the remaining revenue being mainly from terminal services). However the purpose of our analysis is to estimate the beta of the regulated part of the NERL's business, i.e. a hypothetical company whose revenue is by definition entirely generated from *en route* activity. This implies that that ENAV's beta estimate (which reflects exposure to systematic risks arising from *en route* traffic and other activities) must be adjusted to reflect the risk of a notional entity that is exposed only to *en route* traffic risk).
- Although Brexit-related impacts (both from general macroeconomic shocks and also from special factors such as the disruption of aviation in general and air traffic services in particular in the event of no deal) could well affect both NERL and ENAV, NERL is probably more exposed to Brexit-related risks than ENAV is. This may not be fully offset by the possibility that ENAV's beta embodies Italian-specific transport sector political risks (e.g. the risk that relevant infrastructure is not funded owing to disputes between the Italian government and the European Commission)[14].[15]

Accordingly, we believe it is worth exploring how ENAV's beta should be adjusted to provide an insight into NERL's asset beta and that, furthermore, we should still make use of the bounds created by UK utilities and UK airports asset betas.

4.3.1 ENAV's operational gearing

NERA's analysis of NERL's operational gearing is based on an assessment of the firm's operational intensity as proxies by three different metrics: Opex/RAB, Capex/RAB and Capex/Opex. The evolution of these metrics is provided below.

Source: CAA analysis, based on data from Eurocontrol

If we compare this to ENAV (as seen in the table below) we see that the CSU's stemming from international flights are only 43 per cent of the total CSU's whereas domestic flights account for 20 per cent of the traffic.

Table: ENAV's CSU's breakdown

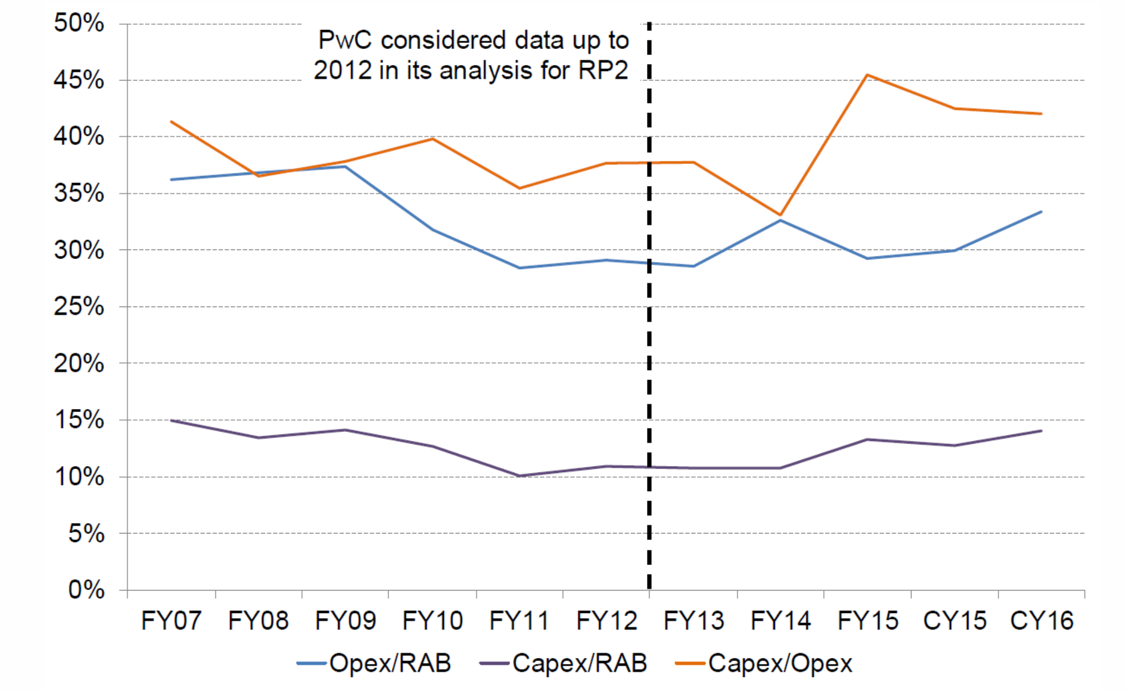
Year	Domestic	International	Overflights	Total
2016	1,597,509	3,478,877	3,076,031	8,152,417
2017	1,642,819	3,581,084	3,257,728	8,481,631
2016	20%	43%	38%	100%
2017	19%	42%	38%	100%

Source: CAA analysis, based on data from Eurocontrol

[14] We note that this argument depends upon the notion that the aviation sector is especially exposed to these scenarios. Insofar as Brexit risks run across the whole economy (whether the whole UK or Italian economy) they will raise the ERP rather than the beta.

[15] We note that other factors such as political risk and sovereign debt risk might affect the country's equity risk premium but should not be expected to affect the beta.

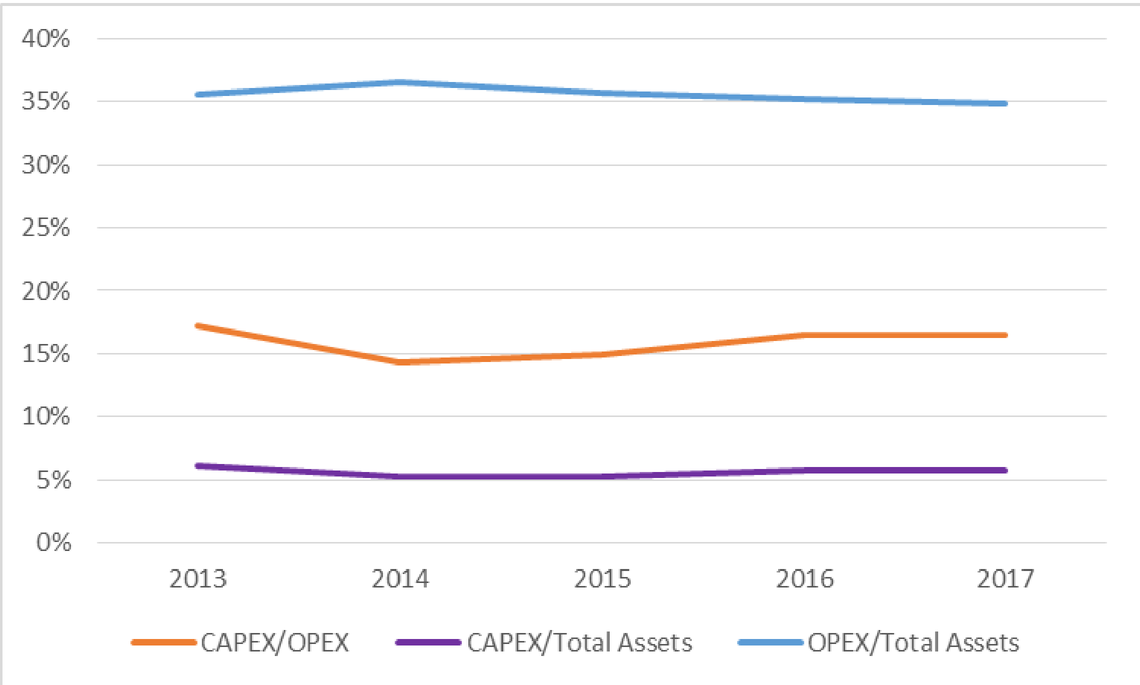
Figure 4.1: NERL's operational intensity



Source: NERA analysis NERL regulatory accounts and NERL data

We have calculated similar metrics for ENAV, these are reported below.

Figure 4.2: ENAV's operational intensity



Source: Thomson Reuters and Europe Economics analysis

From a comparison of the two charts above see that:

- ENAV and NERL have a similar values for Opex/RAB (around 30-35 per cent)
- NERL has a higher value of Capex/Opex (around 35-45 per cent) compared to ENAV (around 15-17 per cent).

- NERL has a higher value of Capex/RAB (around 10-15 percent) compared to ENAV (which is around 5-6 per cent).

Overall based on the metrics above we might expect NERL to have a slightly higher operational intensity compared to ENAV.

We explain in Appendix 3 that if we have two comparable firms subject to the same revenue risks but differing only in their operational leverage, the ratio of their asset betas will be the same as the ratio of 1 + their operating leverages. We compare the impact of this for our different operational gearing definitions in the following table.

Table 4.2: Impacts of operational leverage differences upon asset beta

	ENAV	NERL	Ratio of NERL asset beta to ENAV asset beta
CAPEX/OPEX	16%	40%	1.21
CAPEX/Total Assets	5.5%	12.5%	1.07
OPEX/Total Assets	32.5%	32.5%	1.00
Average			**1.09**

4.3.2 How to use a weighted combination of firms' asset betas to estimate a range for NERL

Since the NERL revenues we are considering here are by definition 100 per cent en route, but only 80 per cent of ENAV's revenues are attributable to en route traffic, the remaining revenue being mainly from Italian terminal services, we should adjust for this effect.

$\text{Beta}_{\text{ENAV}} = 0.8 \times \text{Beta}_{\text{en route}} + 0.2 \times \text{Beta}_{\text{Italy\_terminal}}$

We assume that a UK equivalent of ENAV ("UK_ENAV") would have a form such as

$\text{Beta}_{\text{UK\_ENAV}} = 0.8 \times \text{Beta}_{\text{NERL}} + 0.2 \times \text{Beta}_{\text{UK\_terminal}}$

We believe that a reasonable estimate of the asset beta for UK terminal services, sufficient for our purposes here, is that it is equal to an average asset beta for a selection of the main UK airports.

$\text{Beta}_{\text{UK\_ENAV}} = 0.8 \times \text{Beta}_{\text{NERL}} + 0.2 \times \text{Beta}_{\text{UK\_Airports}}$

If we assume that a UK version of ENAV would have the same asset beta as ENAV, we can then calculate an adjusted asset beta for NERL (prior to applying the upper and lower bound constraints discussed in previous sections about and prior to other adjustments that we shall discuss later), as follows.

$\text{Beta}_{\text{UK\_ENAV}} = \text{Beta}_{\text{ENAV}} = 0.8 \times \text{Beta}_{\text{NERL}} + 0.2 \times \text{Beta}_{\text{UK\_Airports}}$

⇨ $\text{Beta}_{\text{NERL}} = (\text{Beta}_{\text{ENAV}} - 0.2 \times \text{Beta}_{\text{UK\_Airports}}) / 0.8$

4.4 Conclusion

Our judgement is that ENAV can be used as a direct comparator for NERL, with some adjustment to take account of differences in their relative expose to en route traffic. We believe that NERL's asset beta should be expected to be lower than that of UK airports (since NERL's demand diversifies fluctuations in individual airport demand and is also more globally diversified). We believe that NERL's asset beta should be expected to be no lower than that of UK utilities, because (i) although such utilities are subject to an analogous regulatory regime to NERL's, whereas typical utilities outside the aviation sector face no volume risk under their revenue caps, NERL also faces demand risk; and (ii) NERL may have higher operational leverage than is typical of a regulated utility.

5 Gearing

5.1 Different gearing concepts

A firm's gearing is the proportion of its debt and equity that is constituted by its debt. For our purposes here there are two main areas in which a clear and correct understanding of gearing will be important.

- First, we need a view as to the gearing of the firms we use as comparators in estimating our asset beta. We cannot observe asset beta directly. We can only observe equity beta and, to some extent, debt beta, but each of these (equity beta in particular) varies with gearing, and in order to convert our equity beta and debt beta observations into an asset beta for the firm, we need an estimate for gearing.
- Second, we need a gearing when we convert the asset beta we assign for the firm into an equity beta.

Each of these areas presents its own distinct challenges, and, as we shall see, the concept of gearing that is most relevant will differ between them. That creates a complexity to the calculation that we shall explore below.

5.2 The definition of gearing

Gearing can be defined in a number of ways, of which three relevant here are:

- book value of net debt to RAB (which we shall refer to as "RAB gearing");
- book value of net debt to book value of net debt plus market capitalisation (referred to in standard financial data-provider sources as "enterprise value", so we refer to this as "enterprise value gearing");
- fair value of net debt to fair value of net debt plus market capitalisation (which we shall refer to as "fair value gearing").

Enterprise value gearing is most abundantly and straightforwardly available at high frequency, as it is the "gearing" measure quoted by standard financial data-providers. For beta estimation, the standard approach has long-been to use 2-year rolling averages of enterprise value gearing. We quote enterprise value gearing figures here both for consistency with past estimates and in order to increase comparability with data on other firms available via standard financial data providers.

Fair value calculations can only be done via a time-consuming exercise of consulting company accounts and performing recalculations. For our purposes here it has not been proportionate to create a full fair-value gearing series.

5.2.1 Notional gearing

There is no one standard approach to estimating notional gearing in UK regulation. Some regulators focus more upon the actual gearing of companies (e.g. Ofcom in its regulation of BT). In other sectors, the "notional" level chosen takes more account of wider factors such as what level of gearing the regulator feels comfortable will not give rise to financial distress over the control period and a request to re-open the control or, even worse, a need to enact special resolution measures.

In practice, this means that the regulator chooses a level of credit rating for the company that it considers compatible with the companies' obligations under their license, with the regulators' duties (if they exist) to ensure that the functions of regulated entities are financeable, and with appropriately low risk for customers that price controls are re-opened or customer services are degraded as a result of companies becoming bankrupt between price reviews.

Based on this credit rating, the notional level of gearing is set such that the notional company could secure that credit rating at the overall determined WACC.

5.2.2 Actual versus notional gearing

It is necessary to distinguish between notional gearing (i.e. the gearing determined for the notional entity's capital-raising at the margin) and actual gearing (i.e. the average gearing of actual firms). There are two key ways notional and actual gearing differ.

First, the actual gearing of firms may not be technically or socially efficient. By 'not being technically efficient' we mean that, as with other parts of the price review such as operational expenditure, firms may not arrange their financial structure so as to provide optimal cost, risk and quality. Notional gearing may differ from actual gearing in being closer to the gearing of a reasonably efficient firm.

Second, a firm's actual gearing, even if debt and equity were raised efficiently when they were raised, may not be in the optimal ratio for new capital raising at the margin now. Notional gearing should be set at a level that would be efficient at the margin.

Within most UK regulated utilities notional gearing has tended to be lower than actual gearing, in some cases due to the fact that companies rely on financial engineering (this has historically been the case for HAL). Other reasons include that regulators have regarded very high levels of gearing as possibly an attempt to game the regulatory framework by reducing financial resilience in the expectation that if risks crystallised adversely, that would trigger some kind of price re-opener or a bailing out of the firm by the state.[16]

5.3 Gearing at RP2

At RP2 CAA continued with its RP1 notional gearing of 60 per cent. PwC found the 60 per cent assumption to be consistent with the evidence on regulatory precedents and the average across other utility companies with A-rating.

NERL's current regulatory gearing (defined as net debt over RAB) is around 30 per cent[17] and, the company's key financial metrics (i.e. adjusted net debt/RAB, FFO/net debt, AICR, and FFO/net cash interest payable) are currently compatible with a credit rating of A2 (Moody's) and A (S&P). While NERL's RP3 business plan indicates that it expects its gearing level to increase over RP3, we note that NERL's Licence conditions include a maximum level of gearing of 65 per cent.

5.4 Trends in gearing in the UK corporate sector

OECD data on debt to surplus ratio[18] (which we provide in the next chart and which should be interpreted as a proxy for gearing) suggests that overall gearing for non-financial corporations in the UK has been broadly

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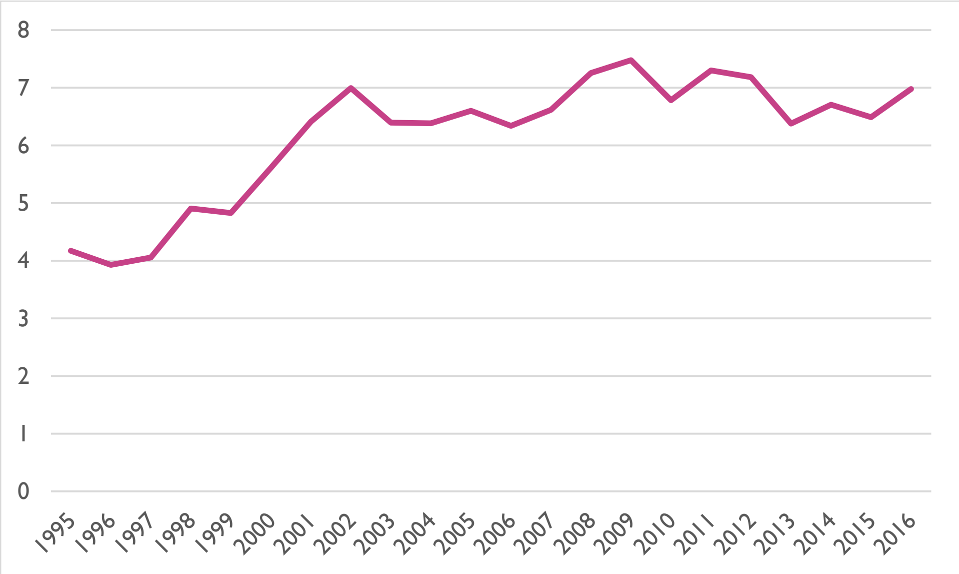
[16] For more on this, see "*Note for the CAA by Europe Economics — Emerging Conclusions on Regulating Finance*", 20 October 2009.

[17] NERL, 2018: "Regulatory Accounts 2017", https://www.nats.aero/wp-content/uploads/2018/08/NERL-Regulatory-Accounts-2017.pdf

[18] As per OECD definition, "*Debt is defined as a specific subset of liabilities. All debt instruments are liabilities, but some liabilities such as shares, equity and financial derivatives are usually not considered as debt. Debt is thus usually obtained by adding up the following liability categories: securities other than shares except financial derivatives, loans, and other accounts payable. Consolidated data are used for this indicator. Gross operating surplus measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise; it differs from profits in company accounts. The non-financial corporation sector […] includes all private and public enterprises that produce goods and/or provide non-financial services to the markets. If a non-financial*

stable in the past few years, perhaps edging up slightly, having fallen in the aftermath of the late 2000s financial crisis. That would tend to suggest, *ceteris paribus*, we should expect no change in NERL's gearing.

Figure 5.1: Non-Financial corporations debt to surplus ratio



Source: OECD https://data.oecd.org/corporate/non-financial-corporations-debt-to-surplus-ratio.htm#indicator-chart

5.5 Implications of asset beta for gearing

There is no consensus theory of how optimal gearing is determined for firms. There is, however, a broad rule of thumb, namely that, within a given sector, firms tend to have higher gearing the more quasi-securitisable is their earnings stream. Or to put the point another way, other things being equal firms often have higher gearing when their risk exposure is lower.

It is important to emphasize that this is only a rough relationship. Its significance for us here is that if we had observed a large move in asset beta, we might naturally expect that to be associated with a change in gearing even if (as we have seen above) non-financial corporate sector gearing levels are broadly unchanged. If asset beta had risen markedly, we might naturally expect gearing to fall, and if asset beta had fallen markedly we might naturally expect gearing to rise.

We shall see in later sections (Sections 6 to 8) that neither of these is the case. Asset beta is not identical to that at the time of the RP2 review, but the change is not so large as to indicate a material shift in gearing.

5.6 Trends in gearing in UK utilities

The following graph summarises gearing determinations for UK utilities since 2013.

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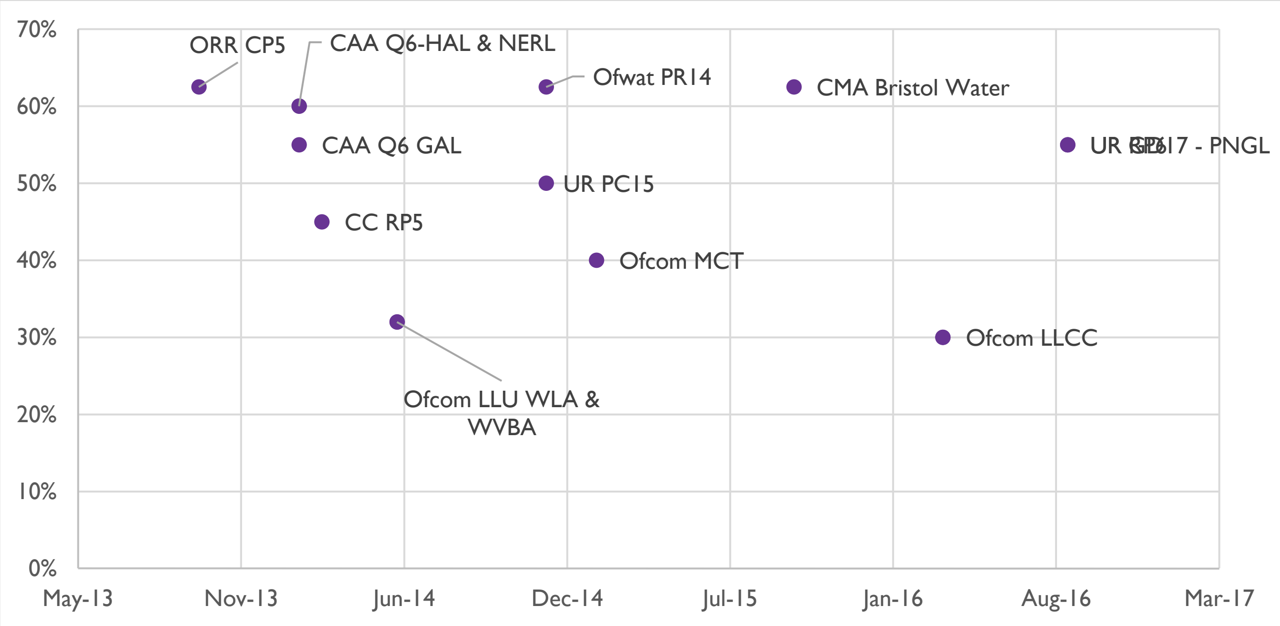
corporation's ratio is 2.5 it means that the debt outstanding is 2.5 times larger than the annual flow of gross operating surplus" See https://www.oecd-ilibrary.org/economics/non-financial-corporations-debt-to-surplus-ratio/indicator/english_dc95ffa7-en

Figure 5.2: Gearing determinations for UK utilities



Source: UKRN

The significance of these findings for our purposes here is simply that they illustrate that a gearing level of 60 per cent, as CAA determined at RP2, lies within the regulatory norm of recent years. Had other regulators been consistently choosing gearing levels above or below that level, we might have had the concern that 60 per cent was not within the norm for regulated firms. That concern does not apply here. Water and rail sector determinations have used gearing levels higher, whilst a number of other sectors have used gearing levels lower than that.

5.6.1 Iterating using financeability analysis

There is little consensus regarding theories of optimally efficient gearing and regulators typically do not consider calculations of optimally efficient gearing feasible. Instead, they seek to provide a notional gearing that is reasonable. That point is reinforced by the Modigliani-Miller Capital Structure Irrelevance theorem that suggests that (under certain assumptions) capital structure makes no difference to firm value. Although it is widely believed that the Modigliani-Miller theorem cannot be a literal representation of the practical reality for firms in capital-raising, it does seem plausible that for many firms there will be a wide range of capital structures over which the precise capital structure makes relatively little difference.

Let us make this thought concrete with a stylised example. The normal assumption is that, although perhaps for some reason, say, 53 per cent gearing might be the truly optimal level for firm Z, the difference between gearing being 45 per cent and being 60 per cent might be quite small. So it might make little practical difference whether the regulator determined gearing at say 50 or 55 per cent, provided the figure the regulator chose was consistent with figures chosen elsewhere in the review. For example, if the regulator chose a notional gearing of 55 per cent and assumed a credit rating of BBB+, the firm concerned had better be able to achieve a credit rating of BBB+ at 55 per cent gearing, otherwise there is an inconsistency.

The implication here is that, although the regulator may have some latitude to choose gearing in a fairly coarse-grained and to some extent arbitrary manner, it is important to check that the gearing chosen is consistent with the rest of the review. We recommend that the best way to do this is to conduct a financeability analysis using the gearing chosen with the flexibility to adjust the gearing assumption if the financeability analysis reveals an issue. Or to put the point another way, we recommend the gearing assumption should be developed iteratively, beginning with a figure informed by the firms' actual net debt to

RAB and then using financeability analysis to hone that figure once the price control is sufficiently advanced that financeability models including opex, capex and their associated cash-flows, can be developed.

A further point to note regarding gearing concerns how much is it reasonable for a regulator to change notional gearing between one review and another. One basis for consideration here is how much firms have changed or do change their own gearing. Firms themselves sometimes make very marked step changes in their gearing — e.g. if there is a leveraged buy-out or if a firm goes to a zero-equity basis or just engages in some more modest but still significant capital restructuring. Such shifts can be rather large — for example, the ADI takeover of BAA in 2006 changed BAA's gearing from around 54 per cent in 2005 to around 89 per cent in 2006.[19] Regulators might not want to change gearing as much as this at one go (and under some circumstances it may be easier to raise gearing than to reduce it — e.g. if debt is more readily available than equity), but what firms have actually done is important context in considering what is feasible for them to do or to assume would be feasible for a notional firm to do.

5.7 Conclusion

Given the general stability in gearing levels across the UK non-financial corporate sector, and NERL's RP3 business plan projections, our recommendation is that CAA continue with an initial working assumption of 60 per cent for the gearing, and then revises that assumption in the light of its financeability analysis.

[19] Gearing defined as a ratio of net debt to net assets. See BAA plc, BAA results for the year ended 31 March 2006.

6 Calculating the cost of debt for NERL and for selected comparators

6.1 Cost of new debt

In considering our base for the cost of new debt for NERL, we take account of four sources of evidence:

- The yield on NATS' own bond
- The yield on ENAV's bond
- The assigned cost of debt of utilities
- The yield for bonds of a similar rating to NERL, from iBoxx

6.1.1 The yield on NATS' own bond

We report in the chart below the nominal yield on NATS' bond, which is rated A+ and matures in March 2026.[20]

Figure 6.1: Yield (%) on NATS bond

The latest point estimate for the yield is 1.71 per cent, nominal. Over the past two years, the maximum has been 1.97 per cent and the minimum 1.14 per cent. The average yield over the last three months (i.e. over the period 10-Mat-2018-18-Aug-2018) is slightly higher, 1.77 per cent, whilst the average yield over the last year is slightly lower, i.e. 1.68 per cent.

[20] NATS "RP3 initial Business Plan for customer consultation 2020-2024", Appendix N, p102.

Since the NATS bond has around 5 years left to maturity[21] we need to convert its yield to reflect differences between those on a 5 year bond and a 10 year bond, since the latter forms our benchmark timescale. As at our cut-off date of 17 August 2018, according to Bank of England Yield Curve data[22], the yield on a government bond with 5 years to maturity was 0.95 per cent whilst the yield on a 10 year bond was 1.35, a difference of 40bps. We add this to our NATS bond yield to obtain a 10 year equivalent, giving a point estimate of 2.11 per cent.

In order to determine how bond rates are expected to develop over the period to mid-RP3 (i.e. over the next approximately 4 years from the time of our data cut-off), we make use of the yields on different maturity gilts in order to estimate the forward rates for relevant length gilts, to estimate how risk-free yields are expected to evolve in the future. A rise in risk-free yields will convert into a rise in the cost of debt to the extent that the debt premium is constant (which we assume for our purposes here that it is). The forward rate captures the implied future yield on an investment made in a certain number of years' time. Under the so-called "Expectations hypothesis", forward rates can be calculated using the following formula:

$$f_{t.T} = \left(\frac{(1+r_T)^T}{(1+r_t)^t}\right)^{\frac{1}{T-t}} - 1$$

where t is the time from present to the date at which the risk-free rate is being estimated, and T is that timeframe plus the duration of the gilts of interest (e.g. for a 10 year gilt, $T = 4 + 10 = 14$). Thus in the case of the forward rate for a 10 year gilt, the formula solves for the forward rate ($f_{t.T}$) that would equalise the yield (r_t) on a gilt taken out today with 4 years to maturity (and then reinvested in a gilt, in 4 years' time, with 10 years to maturity), and the yield (r_T) on a gilt taken out today with 14 years to maturity.

As at 17 August 2018, a UK government bond with 4 years to maturity had a yield of 0.86 per cent, whilst a UK government bond with 14 years to maturity had a yield of 1.58 per cent. Applying the formula above, that implies that the expected yield between 4 and 14 years is 1.87 per cent.[23] As at that same date the yield on a 10 year bond was 1.35 per cent. So the premium was 52bps.[24]

The above calculation is based on the "Expectations hypothesis", namely that that investors set interest rates in such a way that the implied forward rate equals the spot rate expected by the marketplace a year from now. An alternative hypothesis, usually regarded as better supported by empirical data, is the so-called "Liquidity preference hypothesis", which holds that because of factors such as risks associated with increasing uncertainty about the future as one looks further ahead, yields on longer term bonds will tend to carry a premium, which means that the above equation would exaggerate expected yield rises.

Pflueger and Viceira (2015)[25] estimated that the average liquidity premium on UK government bonds over 1999-2014 was 50bps, but declined to around 10bps towards the end of the series. Golden et al. (2010)[26] decompose nominal and real rates, estimating the average inflation risk premium on UK gilts over 1985-2009 period to be 35bps. The increase in the inflation premium as term increases would therefore be less than

21 NATS' bond maturity is around 7.5 years, however since it is a sinking fund bond the effective maturity is shorter and closer to 5 years.

22 https://www.bankofengland.co.uk/statistics/yield-curves GLC Nominal Daily Data, UK Nominal Spot Curve.

23 $(1.0158^{14}/1.0086^{4})^{1/10} - 1 = 0.0187$

24 Given the high correlation between UK 10Y gilt yields and NERL's bond yield, NERA concludes that a similar increase in NERL's bond yield in RP3 should be expected. NERA relies directly on the forward curve of 10-years Gilts obtained by Bloomberg. This data suggest an increase in UK gilt yields of around 78bps in the period up to the end of RP3. Our approach here would give 72bps to the end of RP3, very similar to NERA's figure, but we take the mid-point rather than the end of RP3 as our reference.

25 Pflueger and Viceira (2015), "Return predictability in the Treasury market: real rates, inflation, and liquidity".

26 Golden et al. (2010), "Forecasting UK inflation: an empirical analysis", Heriot-Watt University.

this. Here we assume a total premium, combining liquidity and inflation risk term effects, of 10bps at a four year ahead timescale.[27] This takes our premium down to 42bps.

This takes the point estimate from 2.11 to 2.53 per cent.

Furthermore, future NATS bond issues might be affected by the change in the licence termination notice period, potentially raising the cost of debt for longer-term debts by some 50 basis points.[28] Adding this to our 2.53 per cent produces a final estimate, for the middle of RP3, of 3.03 per cent (on a nominal basis).

6.1.2 The yield on ENAV's bond

ENAV's bond is only rarely traded. The most recent yield, as of the date of this report, was 1.93 per cent, nominal, fairly close to the yield on NATS' bond, before the forwards market and licence period change adjustments.

6.1.3 The assigned cost of debt of UK utilities

Table 6.1: Cost of Debt assigned to UK utilities

Date	Feb-14	Feb-14	Dec-14	Dec-14	Oct-15	Sep-16	Sep-16	Jun-17	Dec-17
Regulator	CAA	CAA	Ofwat	UR	CMA	UR	UR	UR	Ofwat
Cost of new debt (RPI-deflated)	2.50%	2.75%	2%	1.28%	1.60%	2.45%	3.04%	0.19%	0.38%
RPI assumption	2.8%	2.8%	2.8%	3.40%	2.6%	3.20%	3.20%	3.20%	3%
Nominal	5.4%	5.6%	4.9%	4.7%	4.2%	5.7%	6.3%	3.4%	3.4%
Real at assumed CPI of 2%	3.3%	3.6%	2.8%	2.7%	2.2%	3.7%	4.3%	1.4%	1.4%

This illustrates that the cost of debt assigned to UK utilities has fallen quite significantly in the last five years, with levels of around 3.4 per cent in nominal terms, or 1.4 per cent in real terms, being typical in the most recent determinations (or, in the case of Ofwat's December 2017 figures, guidance).

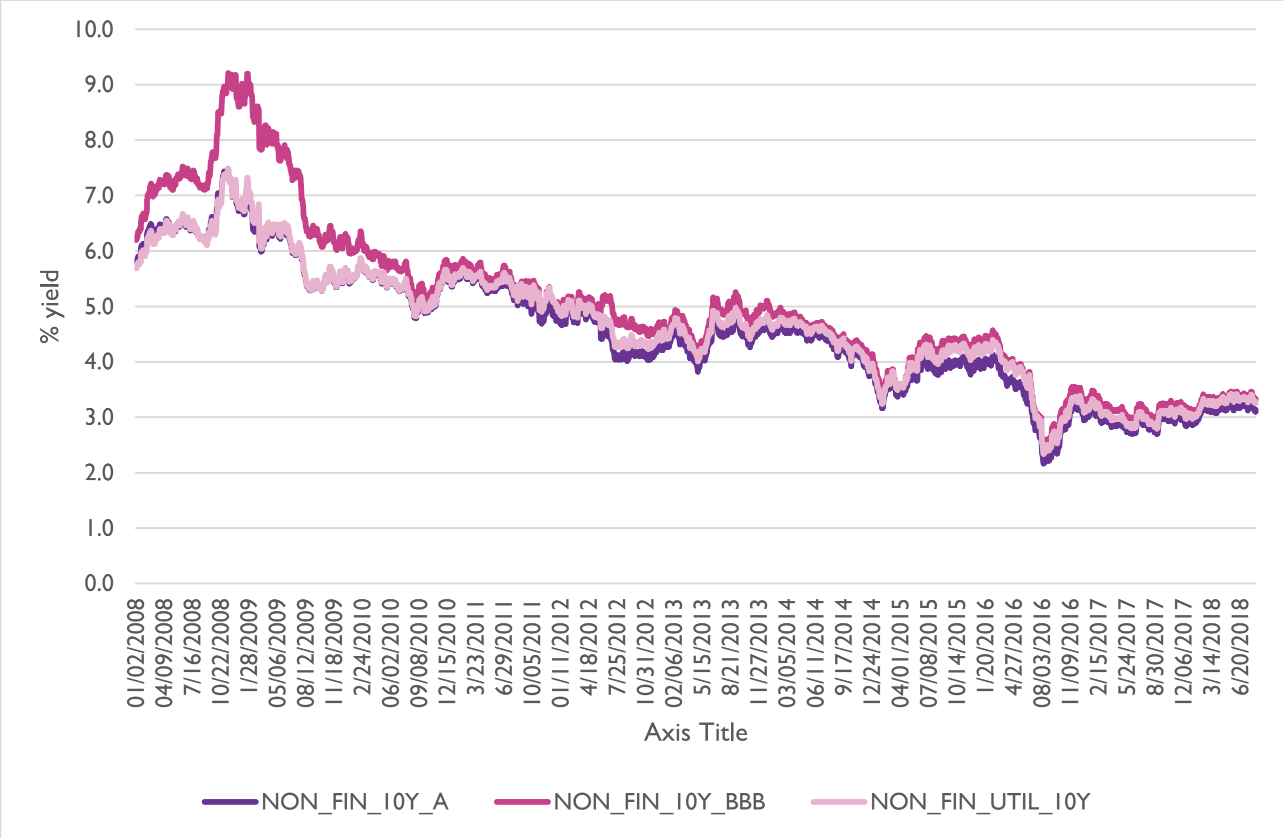
6.1.4 The yield on bonds of a similar rating to NERL

To estimate the debt premium for bonds of different credit ratings, we obtained yields data from iBoxx (the iBoxx 10 years non-financials A and BBB series and the non-financials utilities series), reported, below.

[27] We note that this is in line with the approach adopted by Ofwat in its December 2017 "initial view" of the cost of capital. NERA does not include an adjustment for liquidity preference.

[28] See "Implications for debt-raising and the cost of debt of changing the minimum termination notice period for NERL's licence", Europe Economics, September 2015.

Figure 6.2: iBoxx ten-year bonds data



As a regulated entity with a high credit rating, we would expect NERL to be more similar to utilities than to non-financials in general. However, NERL is A rated whilst the iBoxx Utilities series is for all utilities bonds (i.e. BBB and above). Since the iBoxx data does not include an index for A rated utilities, we therefore constructed our own approximate "A-and-above Utilities index", as follows. First we constructed an effective "Average A and BBB" series from these data and compared that to the Utilities series. This gave a "wedge", which we then applied to the non-financials A series to derive an effective "wedge", i.e. an amount by which the utilities series is above the average of the constructed "Average" series. For example, for 31 July 2018 the the iBoxx non-financials BBB 10+ index had a yield of 3.425 per cent and the A 10+ index had a yield of 3.221, so the average was 3.323 per cent. The iBoxx Utilities 10+ series has a yield of 3.369, so the wedge versus the constructed average non-financials index was 0.046. When we average such wedges over the year to 31 July 2018 we obtain an average wedge of 0.0177 per cent.[29] If we add 0.0177 to the iBoxx A 10+ non-financials index value of 3.221 we obtain 3.24 per cent. That constitutes our estimate of an A-and-above Utilities values.

If we then add the 42 basis points for expected interest rate rises, and then deduct 20 basis points for the effects of term associated with the 10+ iBoxx series including bonds longer in maturity than 10 years, we obtain an overall figure of 3.46 per cent.

We note that the iBoxx Utilities index will contain regulated entities with a mix of license periods — some longer and some shorter than NERL's. Hence we do not need to include an additional adjustment for that here.

[29] We note that there was an extended period in the latter half of 2017 when the wedge was negative.

6.2 Issuance and liquidity costs

In a recent detailed anaylsis of issuance and liquidity costs we conducted for Ofwat (we refer to Appendix 7 for more details), we concluded that for a traditional utility firm an appropriate issuance cost range of would be 3-6 bps.

In addition to issuance costs, companies also bear a cost of maintaining financial liquidity, e.g. by having access to revolving credit facilities. We ssumed that the cost of such facilities is a good approximation of liquidity costs in general and concluded that, for a water company the appropriate liquidity cost is around 3.5-4.5 bps. Combining debt issuance and liquidity cost gave a range of 6.5-10.5 bps.

We assume that differences in the nature of the business means that NERL would have less need of revolving credit facilities than water companies do, so we take the lower end of the 3.5-4.5bps liquidity cost range. Given that NERL's debt is assumed to be A+ and hence relatively less complex to find buyers for, we assume that issuance costs are at the lower end of the 3-6bps range. That gives us an overall combination of 6.5bps, which we round to 7bps.

6.3 Conclusion on cost of debt

The NATS bond has a materially lower cost of debt than has been assigned to utilities in recent determinations largely because at A+ it is of much stronger credit rating than the "comfortable investment grade" usually assumed.[30] We estimate a value of 3.03 by the middle of RP3 directly from NATS data, to which we add our 7bps for transactions costs to obtain 3.1 per cent, which we use as a lower bound to our range.

Our alternative calculation was derived from utilities data, suggesting that a UK A-or-above rated utilities bond would, by the middle of RP3, have a yield of 3.46, to which we add our 7bps for transactions costs to obtain 3.53 for the upper bound to our range.

We conclude for an overall range of 3.1 to 3.53 for the cost of new debt. We find no strong reason to favour any part of this range, and hence recommend a point estimate of 3.32 per cent, the mid point of this range.

We note that this is based on an assumed rating of A or above. Accordingly, that should be the standard required in any subsequent financeability testing. Should an A grade standard not be deliverable, we would recommend in the first instance revisiting the assumption of an above-A grade rating, before adopting alternative adjustments (such as a lower gearing).

6.4 Cost of debt indexation

In recent years a number of regulators have adopted mechanisms to index the cost of debt (e.g. Ofgem and Ofwat both now have well-established cost of debt indexation mechanisms). The precise operational details can differ, but the central principle is that once a starting level for the cost of debt is known, and provided that there is a sufficiently concrete basis for setting that starting level (e.g. the yield on some specific assets) that can be related to some sufficiently liquid and well-established index (where "related" means that a fairly consistent wedge can be calculated for the different between the index and the data basis for the opening cost of debt), the cost of debt can be updated, within the price control period (e.g. once per year) according to the movements in the index.

The index could be an index for the cost of debt of bonds of the relevant rating (such as an iBoxx index), or it could be a measure of the risk-free rate (such as the yield on ten-year gilts).

30 Although the ENAV bond does not appear yet to have a rating, we assume that it, too, would be rated materially higher than "comfortable investment grade".

6.4.1 The position of NERL and NERA

NERA argues that cost of debt indexation is not as practical for NERL as for other UK regulated entities. They argue the practical challenges in identifying an index with the appropriate credit rating and tenor means that debt indexation may not be as practical for NERL as it is for other GB regulated sectors. Traditionally the CAA has used the weighted average approach to setting the cost of debt.

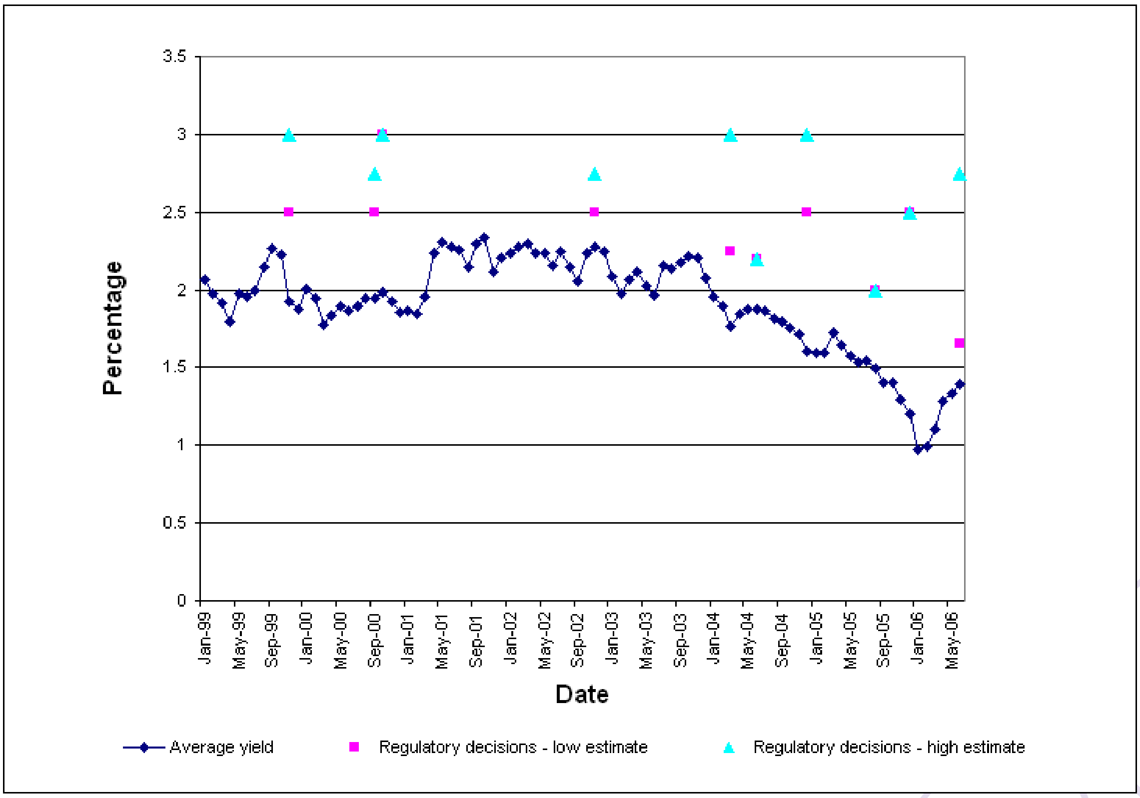
6.4.2 Our view

In Appendix 4 we set out various pros and cons of cost of debt indexation. We do not agree with NERA that cost of debt indexation necessarily presents particular challenges in respect of NERL. It would be feasible to implement such a method for NERL.

On the other hand, in principle, if regulators were able to be symmetric in their exercise of discretion (not using it either to tend to produce too high or too low a number, nor to produce too high a number at some points in the economic cycle and too low at others), cost of debt indexation should ideally be avoided. Firms are better placed to absorb the risks of mis-estimation of cost of capital components than are consumers.

However, the experience of regulators over the past two decades suggests that regulators have in fact frequently felt pressure to provide headroom. It is important to emphasize that this point is not simply one that has arisen since the Financial Crisis of 2007-09 and subsequent debates about the impacts of quantitative easing or other financial regulation in distorting market signals about the risk-free rate and the cost of debt more generally. For example, the following is a figure from a Europe Economics report on behalf of the Civil Aviation Authority in 2006, more than 2 years before the 2008 financial crisis and two and half years before QE commenced.

Figure 6.3: Real risk free rate vs. regulatory decisions



Source: Europe Economics, August 2006

This graphic illustrates that regulators systematically preferred risk-free rate estimates for which even the lower bound was far above the market evidence, as far back as the late 1990s. Regulators systematically deployed their discretion (long before anyone had discussed "quantitative easing" or other similar rationales for setting aside the market evidence) to choose risk-free rate estimates far above market data.

Insofar as risk-free rates tended to be over-stated in this period, a cost of debt indexation approach might have had merit as an alternative to "headroom". If regulators were always nervous that risk-free rates might "normalise" to 1990s levels over a price control period, threatening the financeability of firms, it could have insured the firms against such movements through indexation, rather than protected firms from such movements via headroom (the approach actually taken). With the benefit of hindsight, it seems very likely that this would have been a superior approach through much of the twenty years from 1995 to 2015.

Regulators have more recently, however, adopted the "observed asset" approach to risk-free rate estimation, using the best real-world proxy for a risk-free asset (typically UK gilts) as their basis for estimation. Under the UKRN recommendations this approach can be expected to become near-universal. That means that past (systematic and significant) forecasting errors with respect to cost of capital building blocks may be a poor indication of future forecasting errors, and that this rationale for the use of indexation is, at this stage, a "generals fighting the last war" solution to a threat that is already obsolete.

The forecasting errors-based argument for indexation now is, if any, the opposite one, namely that the observed asset approach now favoured, although it does make use of implied yield curve data to assess future expected changes in rates as well as current rates, might in principle produce an under-shoot, rather than over-estimate, of rates. (After all, it is intended to be a central estimate, so could prove to be an under-estimate as easily as an over-estimate.) If a review cohort of price controls, across UK regulators, were to proceed without indexation but based on very low contemporaneous market data, with no allowance for any "downwards distortions", and market developments were to prove significantly more positive (i.e. it turned out that the observed asset approach had produced much too low a risk-free rate), could that undermine confidence in the use of contemporaneous market data and create pressure for regulators to return to "headroom"?

Reflecting the above, given that it did not adopt an approach to indexation in the period when it might have made the most difference, given the costs and risks of adapting to such a change, given the costs of implementing cost of debt indexation, and given that the recent change in the treatment of risk-free rates now arguably makes the risk of under-stating risk-free rates greater than the risk of over-stating them, our view is that switching into the use of cost of debt indexation is unlikely to be proportionate, at this stage, for NERL. It would be better to allow the current cohort of regulatory determinations, with their radically different treatment of risk-free rates, to proceed with indexation mechanisms unchanged, then consider subsequently whether indexation mechanisms were still required at the next set of reviews.

7 Calculating betas for the selected comparators

7.1 How equity betas were calculated in the past

Traditionally, when estimating equity betas, UK regulators have followed the approach recommended by Smithers & Co in 2003.[31] Broadly speaking, this requires estimating an ordinary-least square (OLS) beta on daily data over a rolling window of two years. This approach should ensure the right balance between robustness of the estimates (as two years of daily data guarantee a sufficiently large sample size) and the need of estimating a beta that provides an up-to-date reflection of the company's exposure to systematic risk (bearing in mind that beta changes through time[32]). Furthermore, it is recommended that UK equity betas are estimated against a wide domestic market index (e.g. the FTSE All Share) so as to reflect the behaviour fully diversified UK investor. Typically, as a cross-check, UK regulator have also estimated betas on 1-year, 3-years and 5-years of daily data, and against European and World market indices.

Since there is overwhelming evidence that betas are time-varying[33], Smithers & Co (2003) recommended also estimating rolling betas in order to gain a better understanding of how betas evolved over time. Movements in rolling betas have traditionally been taken into account to inform the judgement on the choice of a point estimate. For example, if the most recent 2-years daily beta is materially low (high) by historical standards, regulators can decide to pick a number which is slightly higher (lower) that the most recent market evidence suggests.

7.2 Methods for calculating debt betas and asset betas

We discuss briefly the main methods used for calculating asset betas and debt betas. More details are provided in the Appendix.

7.2.1 De-levering equity betas into asset betas

When comparing the betas of different firms, one has to take into account the different gearing levels that firms choose since (other things being equal) a firm with higher gearing will exhibit a higher equity beta and there is a difference here between the gearings of the firms we are considering and between their gearing and the notional gearing. Asset betas are calculated in order to control for the effect of differing levels of gearing. An asset beta is a hypothetical measure of the beta that a firm would have if it were financed entirely by equity. By comparing different firms' asset betas it is possible to isolate shareholders' perceptions of underlying systematic risk, and carry out an assessment of the relative riskiness of different companies after controlling for gearing. Another useful concept is the "unlevered beta", which is simply the equity beta multiplied by the portion of total capital that is equity. Asset betas are calculated using the following formula:

$$\beta_A = (1-g)\beta_{E_{raw}} + g\beta_{D,}$$

[31] Smithers & Co Ltd (2003) "A Study into Certain Aspects of the Cost of Capital for Regulated Utilities in the U.K." https://www.ofgem.gov.uk/ofgem-publications/50794/2198-jointregscoc.pdf.

[32] For a discussion of how and why beta changes through time, see Appendix 5, 13.3.

[33] See Appendix 5,13.3. .

where $\beta_{E_{raw}}$ is the "raw" equity beta, $(1-g)\beta_E$ is the "unlevered beta", β_D is the debt beta[34], g is the actual enterprise gearing.

When the debt beta is assumed, for calculation purposes, to be zero, the role of the asset beta is instead played by the unlevered beta, β_U:

$$\beta_U = (1-g)\beta_{E_{raw}}$$

7.2.2 Re-levering asset beta into equity beta

Finally, once a decision is taken on what is the appropriate asset beta value, β_A, this can be expressed back as notional equity beta, β_{EN}, through a re-levering exercise which makes use of a notional gearing level through the following formula:

$$\beta_{EN} = \frac{\beta_A - g_N\beta_D}{(1-g_N)},$$

where g_N is the notional gearing for the regulated entity. The value of debt beta will directly affect the asset betas and the re-levered equity betas.

7.2.3 Calculating debt beta

For most utilities, the cost of new debt is higher than the risk-free rate — there is a "debt premium" that means, by definition, that market participants (rightly or wrongly) believe there is some probability of utility companies defaulting on their debts.[35] Such defaults create a wedge between the risk-free rate and the cost of new debt in two ways. First, a default probability creates a wedge between the promised cost of debt and the expected cost of debt: because the amount promised might sometimes not be paid, the expected cost of debt must (by definition) be lower than the promised cost of debt.

$$\begin{aligned} &expected\ return\ on\ debt \\ &\quad = prob(default) \cdot \%\ loss\ given\ default + \big(1 - prob(default)\big) \\ &\quad \cdot promised\ cost\ of\ debt. \end{aligned}$$

Secondly, if there is a correlation between when defaults are most likely to occur, or the losses on default when defaults occur, and the broader returns cycle, there will be a yield cost reflecting the systematic risk borne — i.e. a debt beta.

The CAPM applies to any asset — an electricity grid, a plastics bottle-making machine, an equity claim on a telecoms firm or a debt claim on a water network. So the expected cost of debt can be expressed, in the CAPM, as

$$expected\ return\ on\ debt = RFR + \beta_D \cdot ERP,$$

It is worth observing the relationship between the probability of default, the loss given default and the debt beta. For any given debt premium, the lower the probability of default and loss given default, the higher the debt beta must be. Conversely, the lower the debt beta, the higher the probability of default and loss given default must be. The assumption of a zero debt beta is equivalent to the assumption that all of the debt premium is to be accounted for by the probability of default and loss given default and that no default risk has a systematic component. That will not typically be correct.

34 For more on debt beta, see Section 7.2.3 and Appendix 2.

35 We note that defaults have been very rare in developed economy utilities sectors. Nonetheless, the market data indicates that market participants do perceive some risk of default.

However, when adjusting for small differences in gearing, it is often mathematically convenient to assume a debt beta of zero because even with a debt beta of 0.1 or 0.2, the mathematical impact would only arise at the second or third significant figure. However, if the enterprise value gearing of listed comparator company differs materially from the notional gearing, then unlevered betas must be re-levered at a materially different gearing. In such a situation it is inappropriate to assume a zero debt beta in order to determine the asset beta. When debt beta cannot be assumed to be equal to zero, UK regulators have typically used debt beta figures in the range of 0.1-0.15.

In practical term, it can be shown that the debt beta can be calculated according to the following mathematical formula (we refer to Appendix 3, Section 10.1.3 for the technical details of how the formula is derived).

$$\beta_D = \frac{\big(1 - prob(default)\big) \cdot \, debt\,premium - prob(default) \cdot \, (RFR \, + \%\, loss\, given\, default)}{ERP}$$

RFR, ERP are not estimated in this report, but a PwC report for CAA has recently estimated them.[36] The mid-points of PwC's range estimates equate, in nominal terms, to[37]: $RFR = 1.6\%$ and $ERP = 8.3\%$.

We can use the PWC risk-free rate, in combination with our estimate of NERL's cost of debt, to obtain a $debt\ premium$. For a risk-free rate of 1.6 per cent our cost of debt recommendation of 3.32 per cent, after deducting 7 basis points for transactions costs[38] implies a debt premium of 1.65 per cent.

With probability of default and percentage loss given default based on external sources (such as credit rating agencies' reports), we can in principle calculate a debt beta. To illustrate the interaction between the debt beta, the probability of default and the loss given default, let us first suppose that $prob(default) = 0.2\%$, and $\%\ loss\ given\ default = 20\%$.[39]

Then, we obtain $\beta_D = 0.19$. If the probability of default is lower, debt beta will be higher. For example, if we assume that $prob(default) = 0.1\%$, $\beta_D = 0.20$.

If, instead of 3.32 per cent for the cost of debt we had used 3.1 per cent (the lower bound of our range), with a 0.2 per cent probability of default, we obtain a debt beta of 0.17, whereas with a cost of debt of 3.53 (the upper bound of our range) the debt beta would have been 0.22.

We can see that the debt beta estimate is relatively invariant to the probability of default when that probability is at such low levels. Indeed, we would obtain roughly the same answer if we ignored the probability of default and simply divided the debt premium by the ERP. So, for example, for a debt premium of 1.65 per cent and an ERP of 8.3 per cent that would produce a debt premium of 0.20.

Overall, these figures suggest a value for the debt beta of 0.19.

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36 https://publicapps.caa.co.uk/docs/33/PwC_H7InitialWACCrange.pdf

37 PwC estimates RPI inflation at 2.8 per cent, the RPI-deflated risk-free rate at -1.0 to -1.4 per cent, implying a nominal risk-free rate of 1.4 to 1.8 per cent. We take the mid-point, 1.6 per cent. PwC estimates the nominal TMR at 8 to 8.6 per cent. We take the mid-point, 8.3 per cent.

38 We note that the Competition Commission's 2008 disaggregation of the debt premium into the debt beta included an allowance for transactions costs, referred to there as "liquidity costs". See paragraphs 4.88-4.90 of CC (2007), "BAA Ltd: A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd)".

39 We have taken the 0.2 per cent as a rounding of the median in Table 19 of S&P Global (2015), "2015 Annual Global Corporate Default Study And Rating Transitions". The 20 per cent is a typical estimate of "costs of bankruptcy" across many sectors. There would be almost no difference to the results if, for example, loss given default were to be 10 per cent.

7.3 Calculation results

Based on the discussion above, our main beta estimation approach relies on the use of OLS and is based on 2 years and 1 year of daily data and with reference to a domestic market index. The gearing has been calculated as a 2-years or 1-year rolling average of the companies' leverage (calculated as net debt over enterprise value).

7.3.1 UK airports

In Section 4 we have argued that the asset beta for NERL should be lower than that of UK airports. In Q6, Gatwick was assigned an asset beta of 0.56. We use that figure here as a proxy value for non-Heathrow airports. In order to obtain an estimate of the plausible beta value for HAL, we rely on market data of two international airports (AdP and Fraport) that the CAA regarded as being the most relevant comparators in Q6. The recent 2-years and 1-year beta estimates obtained with a domestic and European index for AdP and Fraport are summarised in the table below (more details on the analysis underpinning AdP and Fraport betas is provided in Appendix 8) .

Table 7.1: Unlevered betas at 07/08/2018

Index	Airport	2-years beta	1-year beta
Domestic index	AdP	0.53	0.53
	Fraport	0.44	0.50
EU index	AdP	0.56	0.55
	Fraport	0.52	0.58

Based on the figures above the 2-years equally-weighted average beta (in which we give equal weight to the figure obtained with the domestic index and the one obtained with the European index) is 0.55 for AdP, and 0.48 for Fraport. For the purpose of the analysis here — which is that of determining a UK airports-based "ceiling" for ENAV beta — we choose the lower of the two beta values (i.e. the Fraport equally-weighted average beta of 0.48) as a proxy for HAL's beta. With a debt beta of 0.1 and gearing of 60 per cent, these values correspond to a proxy for the asset beta for HAL of 0.54.

We estimate HAL's RAB at £15.8bn and the book value of various other UK airports, falling under NERL's control centres, at £9bn.[40] That implies that the weighted combination of their betas is 0.55. We use that as our airports-based "ceiling". We stress that the UK airports beta estimate we use here does not account for factors such as Heathrow expansion and changes to the regulatory framework for H7.

7.3.2 UK Utilities beta

In Section 4 we have argued that the asset beta for NERL should be no lower than that of UK utillities.

The 1-year and 2-years unlevered betas for a set of UK regulated utilities are reported below. A summary of the beta estimates is then provided in Table 7.2.

[40] Gatwick's RAB is £2.5bn. The book value of the MAG group, including Manchester, Stansted and East Midlands airports, is £2.3bn. The book values of Birmingham and Luton are each about £0.6bn. The book values for Glasgow and Edinburgh are about £1bn each. Other smaller airports constitute the remainer.

Figure 7.1: 2-years unlevered betas of UK utilities

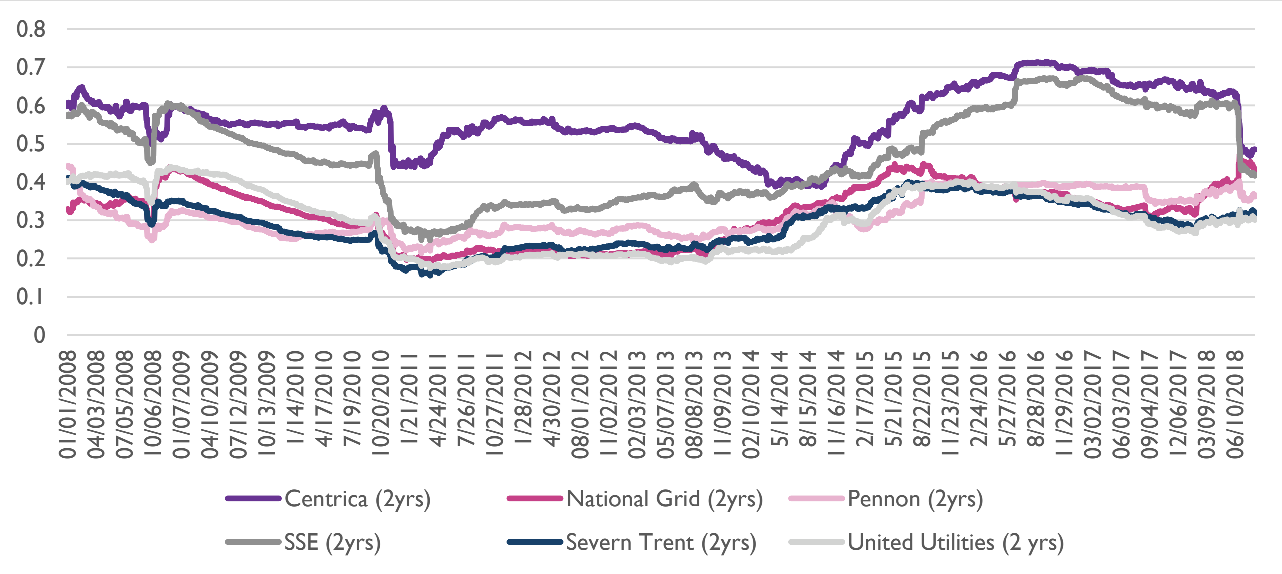


Figure 7.2: 1-year unlevered betas of UK utilities

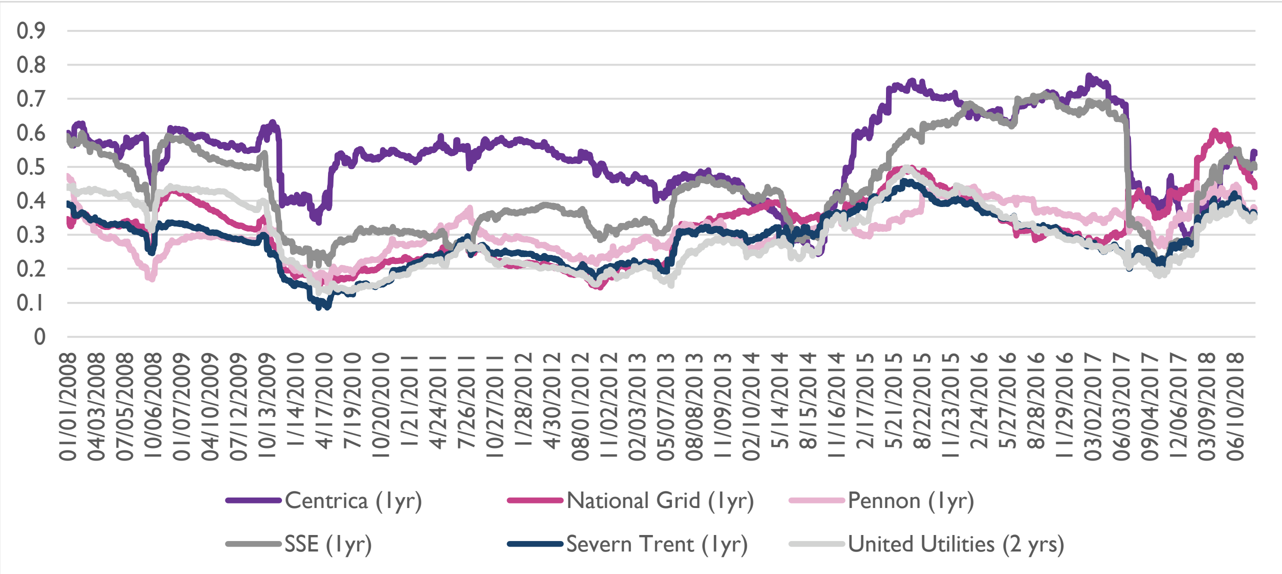


Table 7.2 Summary of beta estimates based for UK utilities

Comparators	2-years unlevered beta (17/08/2018)	1-year unlevered beta (17/08/2018)
Centrica	0.48	0.54
National Grid	0.43	0.44
Pennon	0.36	0.38
SSE	0.42	0.50
Severn Trent	0.32	0.36
United Utilities	0.30	0.35
Average	**0.38**	**0.43**

Focusing on the preferred 2-years beta estimates, for our utilities-based "floor" we shall use a value of 0.38 for the unlevered beta.

We note that the table above includes companies that have a material share of businesses in non-regulated activities (e.g Centrica, SSE, and Pennon) that are presumably riskier than the regulated parts of their operations. In fact, the average beta of Centrica, SSE, and Pennon (i.e. utilities with a material share of businesses in non-regulated activities) is 0.42, whilst the average beta of National Grid, Severn Trent and United Utilities is 0.35. Therefore the use of an average that includes all utilities will produce a result slightly higher than would be obtained by a purer focus upon regulated utilities. That is intentional here — we believe that NERL would be likely to be risker than a typical utility.

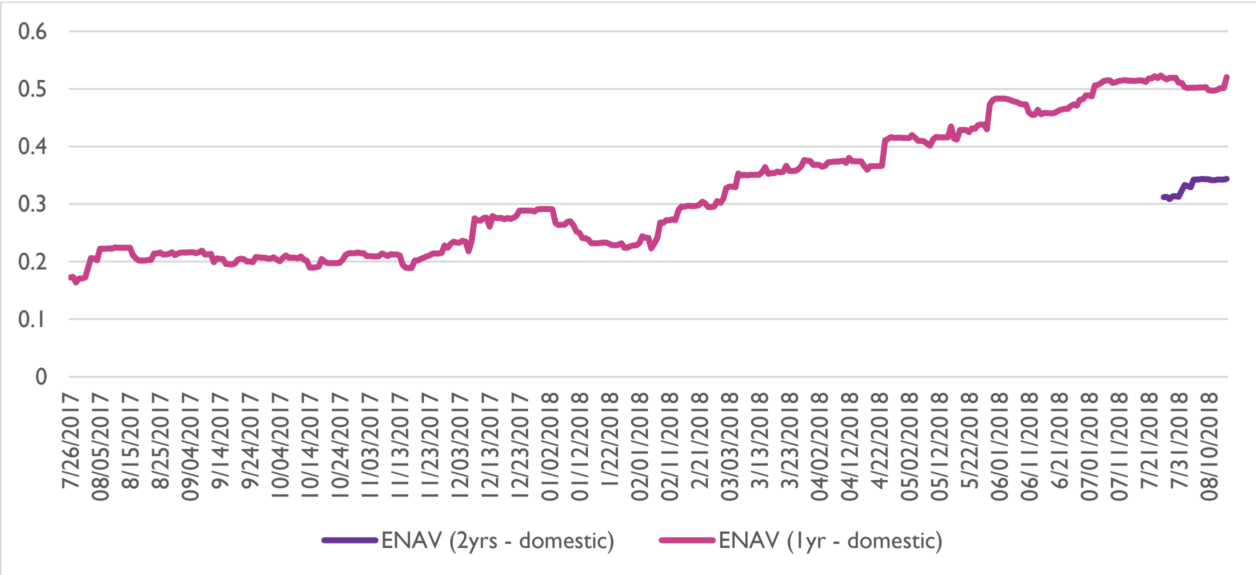
For debt beta, we shall assume UK utilities have the same debt beta as Europe Economics estimated for UK water companies, namely 0.125.[41] At 60 per cent gearing (as per Ofwat[42]), that implies an asset beta "floor", at this stage, of 0.46.

7.3.3 ENAV beta

We next consider whether our "broad" asset beta range can be narrowed by considering the direct comparator, ENAV. Given the high level of integration in European capital markets and the fact that aviation sector investors often hold assets in multiple European jurisdictions[43], we shall place equal weight upon European and domestic betas.

We begin with domestic betas, reporting below 1-year and 2-years unlevered betas for ENAV estimated against the domestic market index.[44]

Figure 7.3: 1-year and 2-years unlevered betas of ENAV (vs domestic index)



We can see that the 1-year asset beta of ENAV has increased steadily since the beginning of 2018 and has reached a value of **0.52** by 17/08/2018. The spot value (at 17/08/2018) of the 2-years asset beta is lower, i.e. **0.34**.

Next we turn to calculations based on European indices. We can see that betas estimated against the European index are higher (the 2-years beta is 0.54, and the 1-year beta is 0.71). This suggests that ENAV's

[41] See https://www.ofwat.gov.uk/wp-content/uploads/2017/12/Europe-Economics-Final-report.pdf, p3, Table 1.1.

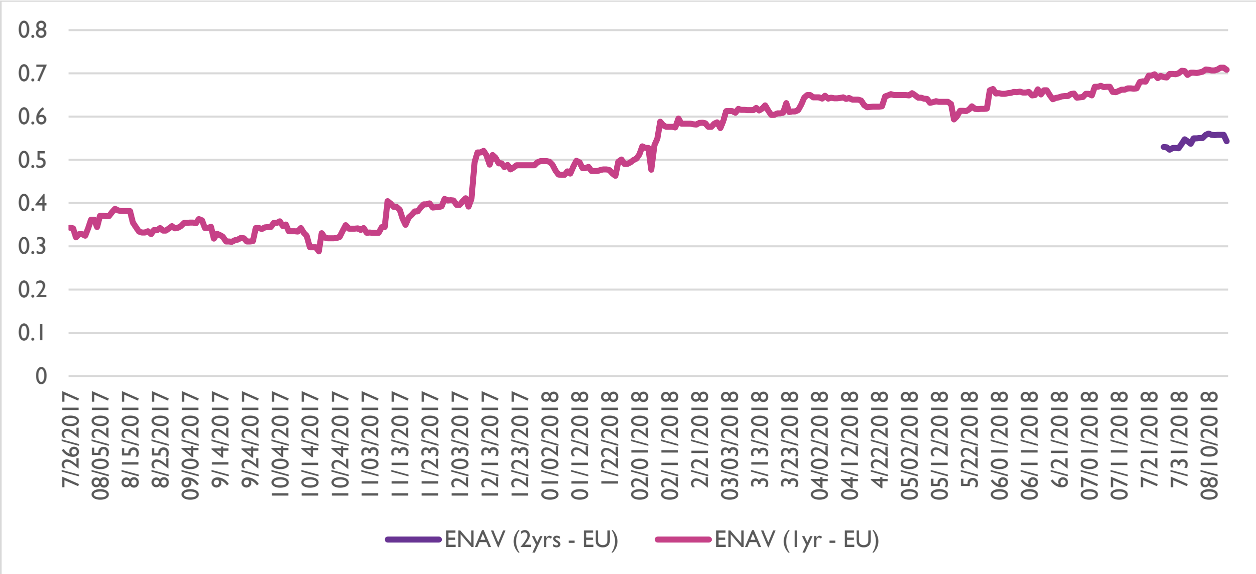
[42] *ibid*.

[43] For example, AdP and Fraport both hold Turkish assets as well as domestic assets.

[44] In Appendix 5, we cross-check the unlevered betas against domestic indices figures for ENAV, along with those for ADP and Fraport, with unlevered betas against the European index.

systematic risk is materially more closely aligned to European market movements than to Italian domestic developments.

Figure 7.4: 1-year and 2-years unlevered betas of ENAV (vs EU index)



A summary of the beta estimates for ENAV is reported in the table bleow.

Table 7.3 Summary of beta estimates for ENAV

Index	2-years unlevered beta (17/08/2018)	1-year unlevered beta (17/08/2018)
Domestic	**0.34**	**0.52**
European	**0.54**	**0.71**

To construct our ENAV range, we use the 2-year domestic unlevered beta of 0.34 as our floor and the 2-year European unlevered beta of 0.54 as our ceiling.

Assigning ENAV a debt beta of 0 (reflecting its extremely low levels of debt, with ENAV's enterprise value gearing being 7 per cent our asset beta range corresponds to our unlevered beta range, at of 0.34-0.54.

7.3.4 NERL beta

In order to determine NERL's beta we start by defining an initial plausible range making use of direct evidence from ENAV. About 80 per cent of ENAV's revenues are attributable to *en route* traffic whist most of the remaining revenue is due to terminal services. Since the systematic risk of terminal services can be proxied by the systematic risk faced by airports, ENAV's beta can be thought of being made up of the following components:

$$\beta_{\text{ENAV}} = 0.8 * \beta_{\text{NERL}} + 0.2 * \beta_{\text{Airports}}$$

From the equation above it follows that NERL unlevered beta can be expressed as follows:

$$\beta_{\text{NERL}} = \frac{\beta_{\text{ENAV}} - 0.2 * \beta_{\text{Airports}}}{0.8}$$

Based on the above we obtain a range of 0.29-0.54 for the asset beta for a notional en route portion of ENAV.[45] This en route portion of ENAV is the direct comparator for NERL.

7.3.5 Impact of changes to risk sharing regulation

As we saw in Section 3.5, changes to NERL's traffic risk sharing mechanism could potentially mean that traffic risk exposure is higher under very extreme scenarios (akin to 2009). That might imply a slight rise in asset betas compared with the past, though that might already be embodied in ENAV's asset beta. Furthermore, the regime might include discretion that would allow the regulator to reduce revenue exposure rather than increase it (via the deadband). Given the uncertainties that remain regarding the final form of the new risk sharing mechanism regulation, we do not believe there is, at this stage, any basis for estimating any clearly material impact, and hence assume the impact is zero.

7.3.6 Impact of changes to performance incentives

Draft RP3 rules could increase the penalty range for delays from +1 to -1 per cent, to +1 to -3 per cent, slightly increasing downside risk. Since this is to a significant extent under the control of the regulated firm, we should not expect any penalties incurred to reflect systematic risk — indeed, if anything it seems plausible that delay targets might be more likely to be missed when demand is higher, so that penalties might offset systematic risk rather than enhance it.

7.4 Interim conclusion on asset beta

We consider the the impacts of changes to risk sharing regulation runs in the opposite direction to the impacts of changes to performance incentives, and both are likely to be small in terms of their impact on unlevered beta, suggesting that their combined effect is likely to be nugatory. Hence we remain of the view that ENAV can, after the adjustments above are applied (i.e. after we derive the notional en route portion of ENAV), be used a a direct comparator for determining NERL's asset beta. Thus what we might term the "Comparator Range" (including adjustments) for the asset beta to be 0.29-0.54. We have also argued that we would expect NERL's beta to be higher than that of UK utilities and to be lower than that of UK airports. We might therefore term the range between our Utilities and Airports estimates as the "Constraint Range", namely 0.46-0.54.

[45] We note that because ENAV is a direct comparator that seems likely to have a fairly similar operating leverage to NERL's, given the structural similarities in the business, the issue of adjusting for operating leverage (as discussed in Section 3.7) does not arise.

8 Asset beta and equity beta for NERL

8.1 Asset beta

Based on the analysis presented in the previous section we find that the "Comparator Range", within which the regulatory determination should lie, is 0.29-0.54. The chosen value within that range should be consistent with the "Constraint Range" of 0.46-0.54. We emphasize that this is not quite the same as recommending a range of 0.46-0.54, because that might make it seem that the centre of the range would be 0.50. In fact, the centre of the range (i.e. the Comparator Range, 0.29-0.54) is 0.42. We are recommending that a value should be chosen that lies above the mid-point of the Comparator Range, at 0.46 or higher.

We note that this shift to a figure of more than 4bps (perhaps up to 12bps) higher than the mid-point of the ENAV range also more-than allows for the impact of any differences that might arise from the effects of differences in operational leverage between NERL and ENAV. As we have set out above in Section 4.3.1, differences in the operational gearings of NERL and ENAV are unclear — on some definitions their operational gearings are the same; on others there is some difference. We believe it is reasonable to take a working assumption that there is some difference, with our best-estimate being that it is equivalent to the average of the three measures.

Table 8.1: Impacts of operational leverage difference on asset betas for NERL and ENAV

	ENAV	NERL	Adjustment ratio
CAPEX/OPEX	16%	40%	1.21
CAPEX/Total Assets	5.50%	12.50%	1.07
OPEX/Total Assets	32.50%	32.50%	1
Average			**1.09**

The mid-point of the ENAV range is 0.42. A 9 per cent rise above 0.42 would be just below 0.46, which is equal to the 0.46 bottom end of our proposed "Constraint Range" (always noting that the Constraint Range has no preference for the mid-point). As regards operational leverage, it is also worth noting that our Constraint Range lower bound is consciously above the level for standard utilities, again to reflect the potential impact of operational leverage differences.

8.2 Equity beta

As set out in Section 7.2.3our estimates of the NERL's cost of debt imply a debt beta of 0.19. In the Competition Commission (CC) hearings on the CAA Q5 review[1], CC's estimate for the debt beta was 0.09-0.19.[1] The CC then argued that because this was the first time a debt beta was being used, it would take a value from the bottom end of the range, and adopted an estimate of 0.1. The same debt beta was used by the CC in Bristol Water review.[1] Moreover, Ofcom used a debt beta of 0.1 in the 2017 Wholesale Local Access Market Review.[1] However, it was not the CC's intention that the 0.1 should be a permanently fixed debt beta result. The debt beta should in principle change as the debt premium change. The 0.19 result we obtain here is within the CC's range and we recommend adopting a range of 0.1-0.19 debt beta for NERL at RP3.

Therefore in our equity beta calculations, we assume two different debt beta values, 0.1 and 0.19. Given the asset beta recommendations provided above, the implications in terms of equity betas are as follows:

- An asset beta of 0.29 and a debt beta of 0.19 imply an equity beta of 0.44 at 60 per cent gearing.

- An asset beta of 0.54 and a debt beta of 0.1 imply an equity beta of 1.20 at 60 per cent gearing.

For reference we also provide the implied equity betas with an asset beta of 0.46 and two different debt beta scenarios (0.1 and 0.19):

- An asset beta of 0.46 and a debt beta of 0.1 imply an equity beta of 1.00 at 60 per cent gearing.
- An asset beta of 0.46 and a debt beta of 0.19 imply an equity beta of 0.87 at 60 per cent gearing.

8.3 Reconciliation with NERA recommendation

As set out in Section 2.1.1, NERA's recommended range for NERL is 0.56-0.66. By contrast, our recommended range is 0.29-0.54 and we recommend a chosen value within that range of at least 0.46. The key differences are as follows.

- NERA uses international airport betas as an upper bound. We consider UK airports a more relevant upper bound than international airports.
- NERA uses its estimate of AdP's asset beta as its lower bound. We consider UK utilities a more relevant lower bound for NERL. AdP is more relevant as a comparator for HAL.
- We use a higher debt beta than NERA, derived from our cost of debt estimate.

The ENAV's beta range recommended by NERA appear to be based on betas estimated against a European market index, and to give weight to 1-year beta estimates. In contrast our range is based on 2-years equity betas estimated against a domestic market index and a European market index. Our preference for 2-year beta estimates is due to the fact that estimates based on a larger sample size tend to be more robust. We acknowledge that the revenues of an ATCO are likely to be affected by the economic conditions beyond the domestic market, and more so than traditional utilities such as, e.g. water companies, but we still consider it appropriate to give weight to correlations with domestic market movements. Therefore we adopt a beta estimation approach which gives weight to both domestic and European market indices.

Appendices

Europe Economics

9 Appendix 1: Comparison of Italian and UK utilities and implications for ENAV

One of the arguments NERA puts forwards against the use of ENAV's asset beta is that that betas for listed Italian regulated companies tend to be lower than betas for equivalent companies in other markets. To corroborate this claim NERA sources Bloomberg evidence showing that the average 10-years asset beta across three Italian utilities (Terna, Acea, and Snam) is 0.23, whilst the average 10-years asset beta across a set of European peers is 0.32.

In the tables below we report the 2-year beta estimates of a set of Italian utilities (ENAV, Acea, Snam, and Terna) and a set of UK regulated utilities. Since the Italian utilities are used as comparators to ENAV, we included a smaller set of them than the UK utility companies. The main point of this section is to support the choice of ENAV as NERL's comparator. We do not find any evidence that Italian betas are materially suppressed.

Table 9.1: Average 2-years asset betas across UK utilities (estimated against the domestic index)

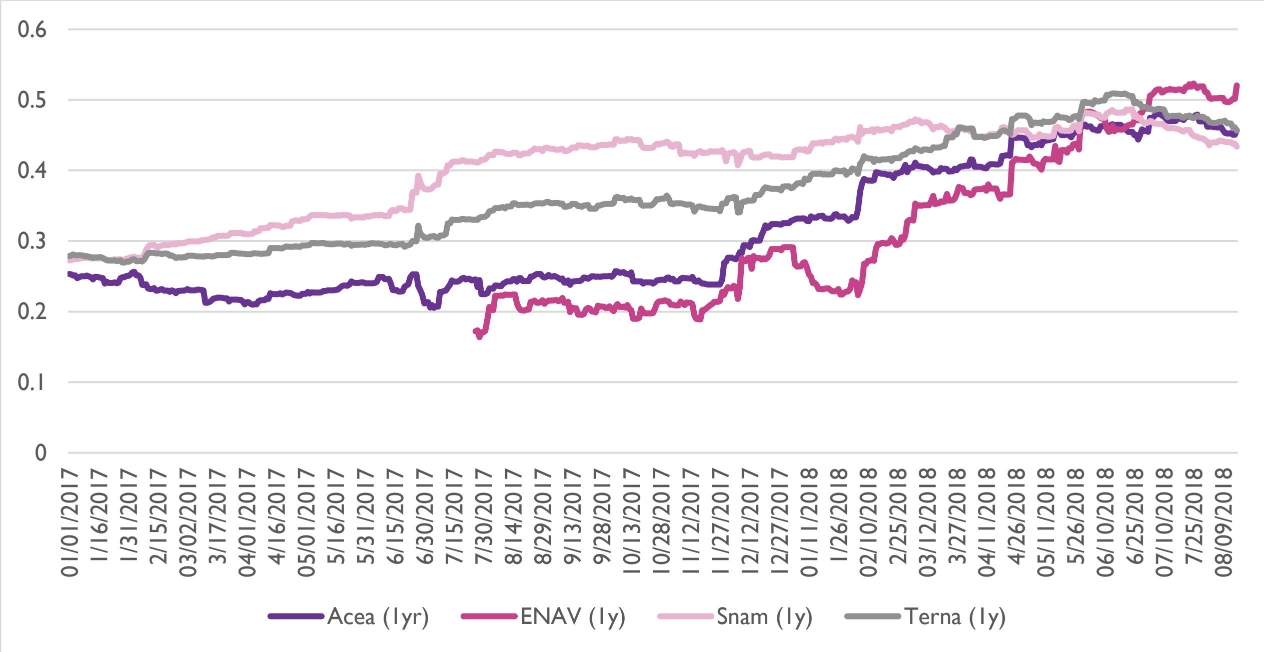
UK utilities	2-years asset beta (at 17/08/2018)
Centrica	0.48
National Grid	0.43
Pennon	0.36
SSE	0.42
Severn Trent	0.32
United Utilities	0.3
Average	**0.38**

Table 9.2: Average 2-years asset betas across Italian utilities (estimated against the domestic index)

Italian utilities	2-years asset beta (at 17/08/2018)
Acea	0.33
ENAV	0.34
Snam	0.43
Terna	0.4
Average	**0.38**

Furthermore, we can see from the chart below the movement of ENAV beta is in line with that of other Italian utilities.

Figure 9.1: 1-year betas of ENAV and other Italian utilities (domestic market index)



This relationship suggests that it would not be surprising if the unlevered beta for NERL moved broadly in line with that of other UK utilities, tending to favour a value for NERL's unlevered beta in the region of 0.4.

10 Appendix 2: Methods for calculating debt betas and asset betas

10.1.1 De-levering equity beta into asset beta

When comparing the betas of different firms, one has to take into account the different gearing levels that firms choose since (other things being equal) a firm with higher gearing will exhibit a higher equity beta and there is a difference here between the gearings of the firms we are considering and between their gearing and the notional gearing.

Asset betas are calculated in order to control for the effect of differing levels of gearing. An asset beta is a hypothetical measure of the beta that a firm would have if it were financed entirely by equity. By comparing different firms' asset betas it is possible to isolate shareholders' perceptions of underlying systematic risk, and carry out an assessment of the relative riskiness of different companies after controlling for gearing. Another useful concept is the "unlevered beta", which is simply the equity beta multiplied by the portion of total capital that is equity.

Asset betas are calculated using the following formula:

$$\beta_A = (1-g)\beta_{E_{raw}} + g\beta_{D,}$$

where $\beta_{E_{raw}}$ is the "raw" equity beta, $(1-g)\beta_E$ is the "unlevered beta", β_D is the debt beta[46], g is the actual enterprise gearing.

When the debt beta is assumed, for calculation purposes, to be zero, the role of the asset beta is instead played by the unlevered beta, β_U:

$$\beta_U = (1-g)\beta_{E_{raw}}$$

Based on the above the relationship between equity beta and asset beta is therefore expressed by the following formula:

$$\beta_{E_{raw}} = \frac{\beta_A - g\beta_D}{(1-g)}$$

or, alternatively:

$$\beta_{E_{raw}} = \beta_A + (\beta_A - \beta_D)\left(\frac{D}{E}\right)$$

where *D* is the company's debt and *E* is the company's equity.[47]

It is important to stress that, since interest payments on debt are tax-deductible, specific assumptions on firms' financing rule can have an implications for the relationship between equity beta and asset beta. The formula commonly used in UK regulatory practice is that proposed by Brealey and Myers.[48] The assumption underlying this formula is that firms rebalance their debt-to-equity ratio continuously, i.e. in each period they

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[46] For more on debt beta, see Section 10.1.3.

[47] It is perhaps worth noting the following definitions. Debt beta: A measure of undiversifiable risk faced by debt investors. "Unlevered beta" is a measure of the undiversifiable risk that investors would face if the assets were 100 per cent equity financed, based on the calculating assumption that the debt beta is zero. Asset beta is a measure of the actual undiversifiable risk faced by investors in an underlying asset, including the true debt beta.

[48] See p. 555 of Brealey and Myers (2000) "Principles of Corporate Finance", *McGraw-Hill,* Sixth Edition.

adjust the debt so as to keep it at a constant fraction of the enterprise value (Brealey and Myers refer to this assumption as "Financing Rule 2").[49] The same formula is proposed by Harris and Pringle (1985)[50] who argue that the systematic risk of the interest rate tax shields is identical to that of the firm's underlying cash flow, and as a result, tax shields should be discounted at the required return to assets.

However, other formulae have been developed to reflect different financing rule assumptions. For example if the amount of debt (rather than the proportion of debt) is kept constant over time (this is referred to as "Financing Rule 1" in Brealy and Myers (2000)), the relationship between equity beta and asset beta (assuming a zero debt beta) follows the Hamada equation[51]:

$$\beta_{E_{raw}} = \beta_A + \beta_A\left(\frac{D}{E}\right)(1-T)$$

In our view, the assumption of a constant capital structure rather than a constant amount of debt is likely to better reflect the situation in a utility with frequent new investments and debt rollover opportunities (though neither assumption is perfect). The Financing Rule 1 assumption seems more naturally applied in a setting where a company raises debt once and self-liquidates at the end of its one-off financed project, when debts are repaid in one go. Furthermore, the assumption that the tax shield is subject to the systematic risk of the company as a whole seems more plausible than alternatives such as its being subject only to the systematic risk of the cost of debt. After all, if the company were not paying tax, it would need to raise less capital overall, not simply less debt (say). Accordingly, we use Financing Rule 2.

10.1.2 Re-levering asset beta into equity beta

Once a decision is taken on what is the appropriate asset beta value, β_A, this can be expressed back as notional equity beta, β_{EN}, through a re-levering exercise which makes use of a notional gearing level through the following formula:

$$\beta_{EN} = \frac{\beta_A - g_N\beta_D}{(1-g_N)},$$

where g_N is the notional gearing for the regulated entity. The value of debt beta will directly affect the asset betas and the re-levered equity betas.

10.1.3 Debt beta

For most utilities, the cost of new debt is higher than the risk-free rate — there is a "debt premium".That means, by definition, that market participants (rightly or wrongly) believe there is some probability of utility companies defaulting on their debts.[52] Such defaults create a wedge between the risk-free rate and the cost of new debt in two ways. First, a default probability creates a wedge between the promised cost of debt and the expected cost of debt: because the amount promised might sometimes not be paid, the expected cost of debt must (by definition) be lower than the promised cost of debt.

$$\begin{aligned} &expected\ return\ on\ debt \\ &\quad = prob(default)\cdot \%\ loss\ given\ default\ + \big(1 - prob(default)\big) \\ &\quad \cdot\ promised\ cost\ of\ debt. \end{aligned}$$

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49 See p. 560 of of Brealey and Myers (2000) "Principles of Corporate Finance", *McGraw-Hill,* Sixth Edition.

50 Harris, R.S. and J.J. Pringle (1985), "Risk-Adjusted Discount Rates Extension from the Average-Risk Case", *Journal of Financial Research*, (Fall), 237-244.

51 Hamada, R.S. (1972), "The Effect of Firms' Capital Structure on the Systematic Risk of Common Stock", *Journal of Finance*, 27: 435-452.

52 We note that defaults have been very rare in developed economy utilities sectors. Nonetheless, the market data indicates that market participants do perceive some risk of default.

Secondly, if there is a correlation between when defaults are most likely to occur, or the losses on default when defaults occur, and the broader returns cycle, there will be a yield cost reflecting the systematic risk borne — i.e. a debt beta.

The CAPM applies to any asset — an electricity grid, a plastics bottle-making machine, an equity claim on a telecoms firm or a debt claim on a water network. So the expected cost of debt can be expressed, in the CAPM, as

$$expected\ return\ on\ debt\ =\ RFR\ +\ \beta_D \cdot\ ERP,$$

It is worth observing the relationship between the probability of default, the loss given default and the debt beta. For any given debt premium, the lower the probability of default and loss given default, the higher the debt beta must be. Conversely, the lower the debt beta, the higher the probability of default and loss given default must be. The assumption of a zero debt beta is equivalent to the assumption that all of the debt premium is to be accounted for by the probability of default and loss given default and that no default risk has a systematic component. That will not typically be correct.

However, when adjusting for small differences in gearing, it is often mathematically convenient to assume a debt beta of zero because even with a debt beta of 0.1 or 0.2, the mathematical impact would only arise at the second or third significant figure. However, if the enterprise value gearing of listed comparator company differs materially from the notional gearing, then unlevered betas must be re-levered at a materially different gearing. In such a situation it is inappropriate to assume a zero debt beta in order to determine the asset beta. When debt beta cannot be assumed to be equal to zero, UK regulators have typically used debt beta figures in the range of 0.1-0.15.[53]

The following table illustrates the mechanisms of debt beta, showing that:

- when debt beta equals zero, unlevered betas are identical with asset betas, and the actual level of gearing has no impact on re-levered betas;
- when actual gearing is the same as notional gearing, then non-zero debt beta will affect asset betas but not re-levered betas;
- when actual gearing differs from notional gearing, this difference has a direct impact on re-levered betas.

Table 10.1: Debt beta mechanics — illustration

Actual gearing	Notional unlevered betas	Debt betas	Notional asset betas	Notional gearing	Re-levered betas
Debt beta equals zero					
	0.46	0	0.46	60%	1.15
Actual gearing equals notional gearing					
60%	0.46	0.1	0.52	60%	1.15
60%	0.46	0.17	0.562	60%	1.15
Actual gearing is different from notional gearing					
50%	0.46	0.1	0.51	60%	1.125

[53] Some examples include:

- Ofwat uses a debt beta of 0.1-0.15 in its December 2017 "Initial View" on the cost of capital for the water sector for PR19 — https://www.ofwat.gov.uk/publication/europe-economics-pr19-initial-assessment-cost-capital/
- In its January 2018 in its report for Ofcom, NERA notes that Ofcom proposed the use of a 0.1 debt beta in its March 2017 WLA consultation and NERA uses 0.1 thereafter — https://www.ofcom.org.uk/__data/assets/pdf_file/0017/111536/Draft-statement-annex-31.pdf
- In its March 2014 report for Ofcom, the Brattle Group considers debt betas of 0.1 and 0.15 — https://www.ofcom.org.uk/__data/assets/pdf_file/0023/77351/15_annex15.pdf

50%	0.46	0.2	0.56	60%	1.1

Source: Europe Economics.

We recall the definition of the expected return on debt.

$$expected\ return\ on\ debt = prob(default) \cdot \%\ loss\ given\ default\ + \left(1 - prob(default)\right) \cdot promised\ cost\ of\ debt.$$

The definition of the debt premium is that

$$debt\ premium = \ promised\ cost\ of\ debt\ -\ RFR,$$

where RFR stands for risk-free rate, and which is equivalent to:

$$promised\ cost\ of\ debt\ =\ RFR\ +\ debt\ premium\ .$$

From those two equations it follows that:

$$expected\ return\ on\ debt = prob(default) \cdot \%\ loss\ given\ default\ + \left(1 - prob(default)\right) \cdot\ (RFR + \ debt\ premium)$$

As noted above, from the CAPM we know that:

$$expected\ return\ on\ debt\ =\ RFR\ +\ \beta_D \cdot\ ERP,$$

and therefore

$$\beta_D\ = \frac{\left(1 - prob(default)\right) \cdot\ debt\ premium - prob(default) \cdot\ (RFR\ + \%\ loss\ given\ default)}{ERP}.$$

As set out in the main text, our estimates of the cost of debt imply, using the formulae above, a debt beta of 0.19 within a broader range of 0.17-0.22. In the Competition Commission (CC) hearings on the CAA Q5 review[54], CC's estimate for the debt beta was 0.09-0.19.[55] The CC then argued that because this was the first time a debt beta was being used, it would take a value from the bottom end of the range, and adopted an estimate of 0.1. The same debt beta was used by the CC in Bristol Water review.[56] Moreover, Ofcom used a debt beta of 0.1 in the 2017 Wholesale Local Access Market Review.[57]

However, it was not the CC's intention that the 0.1 should be a permanently fixed debt beta result. The debt beta should in principle change as the debt premium change. The 0.19 result we obtain here is within the CC's range and we recommend adopting a range of 0.1-0.19 debt beta for NERL at RP3.

54 See paragraphs 4.88-4.90 of CC (2007), "BAA Ltd: A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd)".

55 The lower end estimate included a reduction to take account of a non-CAPM "liquidity" factor.

56 See Appendix N of CC (2010) "Bristol Water Plc price determination". It should also be noted that the CMA (the Competition and Markets Authority) did not use debt beta in the latest 2015 Bristol Water review arguing that the "debt beta has very little impact on the overall cost of capital if Bristol Water's gearing level (and the level of gearing used to calculate the WACC) is similar to the comparators used to estimate the asset beta". See CMA (2015), "Bristol Water plc" final report, paragraph 10.150.

57 See Ofcom (2017), "Wholesale Local Access Market Review – Annexes", paragraph A16.101.

11 Appendix 3: Operating leverage

11.1 The impact of operating leverage on asset beta

In order to see how operating leverage relates to beta, first note that the present value of an asset is equal to the present value of revenues, less the present values of fixed and variable costs:

$$NPV(asset) = NPV(revenue) - NPV(fixed\ costs) - NPV(variable\ costs)$$

This can also be expressed with respect to the present value of revenue:

$$NPV(revenue) = NPV(asset) + NPV(fixed\ costs) + NPV(variable\ costs)$$

Given this expression, the beta of the present value of the asset's revenue (as distinct from the beta of the present value of the asset itself) can then be expressed as

$$\beta^{REV} = [NPV(asset) / NPV(revenue)] \cdot \beta^{ASSET} + [NPV(fixed\ costs) / NPV(revenue)] \cdot \beta^{FIXED} + [NPV(variable\ costs) / NPV(revenue)] \cdot \beta^{VARIABLE}$$

By definition, the beta of fixed costs should be approximately zero, while the betas of revenue and variable costs should be approximately equal as they both change in response to output. Noting these, and rearranging the above expression implies

$$\beta^{ASSET} = \beta^{REV} \cdot (1 + [NPV(fixed\ costs) / NPV(asset)])$$

Hence, if we have two comparable firms subject to the same revenue risks but differing only in their operational leverage (i.e. *[NPV(fixed costs) / NPV(asset)]*), the ratio of their asset betas will be the same as the ratio of 1 + their operating leverages.

$$\frac{\beta_{Asset\_1}}{\beta_{Asset\_2}} = \left(\frac{1 + Operationl\ Gearing_1}{1 + Operationl\ Gearing_2}\right)$$

12 Appendix 4: Pros and cons of cost of debt indexation

12.1.1 Pros and cons of indexation

Pros

- Since indexation shifts risk from firms to customers, over time it will mean the cost of capital for firms reduces. Setting aside other effects (discussed below), a lower cost of capital implies lower bills for consumers.
- When there is uncertainty about the future path for the cost of capital, there can be pressure for regulators to "aim up" so as to reduce the risk the cost of capital is set too low. The use of indexation provides insurance for firms instead of "headroom", allowing regulators to resist aiming up pressure (or at least to aim up by less).
- Absent an indexation mechanism, perhaps sufficiently large cost of capital movements might create pressures to re-open a price control, potentially leading to changes in other areas of the price control as well as the cost of capital, undermining the credibility of incentive regulation more generally. (However, it should be noted that there have been relatively large movements in the cost of capital in the past that have not forced re-opening.)
- When potential changes in the cost of capital are asymmetric (i.e. it is more likely the cost of capital rises than that it falls, or vice versa), the expected value of the cost of capital probability distribution might be materially away from the centre-point of the range. In such a case the regulator might come under pressure to choose a value materially away from the centre of the range. That may involve an element of discretion, and the regulator could come under pressure to use that discretion to favour one stakeholder or another — e.g. perhaps firms might argue that, since the expected value for this parameter is obviously above the mid-point of the range (because of asymmetry), the regulator should choose a value towards the top end of the range. If the regulator wishes to use a "follow the data" approach to reduce such pressure to exercise its discretion, there could be advantages in indexation as a way to reflect asymmetry.
- There may be Knightian uncertainty ("unknown unknowns") rather than Bayesian uncertainty ("known unknowns"). Bayesian uncertainty ("risk") allows for an expected value to the risk, whilst under Knightian uncertainty we simply don't know. We can use Bayesian techniques to attempt to model Knightian uncertainty, but in doing so we introduce a speculative element (that assigning of probabilities to different cost of capital scenarios, say, when there is in truth no way to assign them precise probabilities). Indexation may allow us to embrace Knightian uncertainty, allowing the indexation process to shift us between uncertain scenarios without our ever needing to assign them a numerical risk.
- Even when risks are well-understood, sometimes those risks may be bimodal rather than smooth — there could be a 50 per change we are in a type A world or a 50 per cent chance we are in a type B world, but zero change we are half-way between a type A and a type B world (eg perhaps we might be in a Brexit No deal world or a Deal world, but there is no meaningful half-way Deal) — meaning that assigning a cost of capital that is an "average" of plausible scenarios will not be meaningful. Indexation might be a mechanism to allow market data to shift us discontinuously between discrete scenarios.
- Insofar as risk-free rate movements can be seen as entirely exogenous to regulated firms, indexation with respect to the risk-free rate could be seen as reflecting the same rationale as indexation with respect to the price level (just as regulated firms are permitted to adapt to economy-wide shocks to inflation, which competitive firms would be able to adjust their prices to reflect, so, likewise, regulated firms should be,

on this argument, permitted to adapt to economy-wide shocks to the risk-free rate, which, it is claimed, competitive firms would be able to adjust their prices to reflect).

- There was a traditional idea (going back to Dieter Helm's indexation proposals in the mid-2000s) that not indexing may encourage companies to lock their finances in every five years to reduce their risk exposure (though we note that in practice this is not what they do, as shown by the ~15-20 year average tenor for the sector), which may not be the most efficient financing structure, since if they do not lock in financing they are left exposed to (systematic) risks arising from changes in the interest rate, even though these changes are outside their control.[58]
- When firms are exposed to interest rate movements, they should make windfall profits when rates fall and windfall losses when rates rise, but it is questionable how credible it is that firms would be permitted, without limit, to make losses in the event of adverse interest rate movements. For example, there might be huge pressure for a price review re-opener, meaning that risks for firms are asymmetric (they are in practice permitted to make gains but not losses).

Cons

- Since indexation shifts risk from firms to customers, that increases the volatility of bills, reducing the ability of consumers to plan ahead.
- Although indexation should reduce the cost of capital it may be very difficult to estimate by how much it will do so or to produce a credible estimate for such a reduction, with the result being that the cost of capital is not reduced in the same price review and in fact consumers never gain the lower bills their higher bill risk (higher bill volatility) should justify. (Insofar as the beta for firms is based on stock prices for firms that would be subject to indexation, in the following price review, the reduced exposure to systematic risk would be captured in the latest market data on equity betas.)
- When indexation reflects factors partially under the control of central policymakers seeking to affect investment (e.g. the Bank of England or the Treasury), indexation risks offsetting the impacts of macroeconomic policy thereby distorting incentives to invest in regulated utilities versus other assets or other firms. For example, if the Bank of England cuts interest rates, thereby potentially affecting the index used as the proxy indicator for the risk-free rate, one of the things it is seeking to do is to make it more profitable to invest at that time, with the cost of capital falling whilst prices do not (or not by as much). If the regulatory framework means that, say, when Bank of England interest rates drop it becomes more attractive to invest in computer software firms or manufacturing firms but (because of indexation) no more attractive to invest in regulated utilities, that risks creating important distortions to the timing of utilities investment.
- Firms are not only better at diversifying risks than consumers; they are also potentially better at reducing their exposure to such risks over time. Some forms of indexation may blunt incentives to manage risk. For example, indexation on a measure of its own debt premium would mean that if NERL changed its operational methods so as to increase its risk of default, thereby increasing its debt premium, it would automatically increase its cost of capital allowance through the indexation mechanism. For this reason, Ofwat, for example, uses an indexation mechanism that does not depend directly on the yield on UK utilities.
- Cost of capital indexation could distort choices relating to capital-labour trade-offs if wage costs are not also indexed, since firms would be able to reduce their exposure to systematic risk (and thus reduce their financing costs) by substituting capital in place of labour.
- There is a cost to implementation (e.g. the costs of recalculating the index and implications for prices each year).

[58] This is also a criticism levelled against indexation (i.e. that firms will seek to 'shadow' the index).

13 Appendix 5: Technical issues in beta calculation

We discuss here various technical issues concerning beta calculation and our proposed approach to dealing with such issues.

13.1 Returns versus excess returns

It has become standard in the past fifteen years to base beta estimates on models of returns. Such models will only produce a beta equivalent to the CAPM beta if either the risk-free rate is invariant or if other fluctuations (such as movements in the ERP or correlations between movements in the risk-free rate and shocks affecting returns in other ways) net out the impact of risk-free rate movements. One concern is that if risk-free rate movements are large enough, relative to shocks, they could induce systematic biases into beta estimates based on returns data, because when a risk-free rate changes that induces a one-for-one change in both the market's and any specific security's percentage returns, so dragging beta estimates towards 1.

One important reason why returns have been used in preference to excess returns is that there is no straightforward benchmark for the risk-free rate over a short timescale. Measures such as LIBOR or OIS tend to be dominated by policy rates and to be so low and exhibit such low variation over time, in the past nine years, that their use is virtually indistinguishable from the simple use of returns.

A potential alternative might be to use the longer-period risk-free rate benchmark, eg the ten year gilts rate, to estimate excess returns. We have explored this using monthly data, but the impacts appear to be very small and non-systematic — i.e. we do not find that the use of returns tends to upwards-bias beta estimates. Accordingly, we stick with estimates based on returns as our base case, though we cross-check with excess returns estimates.

13.2 Data frequency

The validity of the CAPM framework for estimating the cost of capital, requires that estimations are conducted over time periods at which markets are weakly efficient. If markets exhibit mean reversion or other weak efficiency violations over some short timescale, the timescale needs to be extended to the point at which they become weakly efficient and thus CAPM can be applied. It is likely that markets are not weakly efficient over extremely short timescales (e.g. less than 1 second), since algorithmic high-frequency arbitrage trading systems exist to exploit weak efficiency violations. Extensive studies suggest that, over material timescales all major developed markets become weakly efficient[59]. We consider it rather implausible that systematic weak efficiency violations would endure at a timescale as long as a day without being arbitraged away by algorithmic systems. However, if it could be proven that systematic weak efficiency violations do occur over a longer timescale, it would be appropriate to extend beta windows.

Even if the form of weak efficiency violation were solely mean reversion, that would not necessarily imply betas at timescales shorter than weak efficiency is achieved would be distorted upwards, but a more

[59] See: Malkiel, B. (2003) "The efficient market hypothesis and its critics", Journal of Economic Perspectives, 17(1), pp59-82. Available at: https://eml.berkeley.edu/~craine/EconH195/Fall_14/webpage/Malkiel_Efficient%20Mkts.pdf

fundamental point is that if weak efficiency is violated, there could be all sorts of other patterns in the data, and they would affect the market as a whole as well as utilities stocks, with greatly variable impacts on betas.

We have explored whether UK utilities stocks show evidence of mean reversion, considering Severn Trent (SVT) and United Utilities (UU) stocks. We find that on most tests we can reject the hypothesis that SVT and UU do not follow random walks (i.e. on most tests their pricing evolution appears weakly efficient at day-long scales, which would mean there was no mean-reversion basis for extending windows). However, the random walk tests are not fully decisive in all specifications. Hence we went on to test for lagged impacts on the assumption there is not a random walk (i.e. we assumed markets weren't weakly efficient and went looking for the largest anomaly we could find). Specifically, we searched the UU and SVT total returns series for significant autoregressive lags at different lag lengths (in days).[60]

We found potential lag lengths at various lengths. The models with the highest coefficients were at 9 days for UU and 18 days for SVT. They were both reversing (i.e. partially mean-reverting) impacts. The effects were equivalent to -0.035 per cent and -0.048 per cent of the return 9 and 18 working days earlier. So, if the price of UU went up by 1 per cent on the Monday of one week, we should expect its price to fall by 0.035 per cent on the Thursday of the following week.

We note that this suggests that, if an algorithm could predict the impact perfectly (which a risk-averse agent could not, since the 0.035 coefficient is only an average, and trading on it would sometimes induce losses) and could trade with transactions costs of less than 0.035 per cent, it could make indefinite sums of money.

Assuming that these markets do indeed exhibit mean reversion on the scale we identified, we explored what impact that would have upon betas and whether the distortion was eliminated by using a weekly beta instead of a daily beta. We simulated the effect in a stylised model with an anomaly-free beta of 0.5, a six-day mean-reversion anomaly of 0.035 per cent, daily shocks that, on standard days, were +/-2 per cent and one in every 20 days were +/-4 per cent, and a trend annual rise of 7 per cent. We simulated over 4,000 days. We found that the anomaly induced an error in beta of of order 0.00001, i.e. of order one one thousandth of a percent. This is much less than the accuracy with which betas are determined anyway, and much less than plausible losses in accuracy from lower data frequency owing to having fewer data points.

If instead we took the sum of all lags from 1 to 20 days, the coefficients would rise by around one order of magnitude — so we should expect the impacts on betas would rise only to of order 0.0001, still well below the accuracy with which betas are determined.

One long-standing issue regarding beta estimation windows concerned low-liquidity stocks. If a stock does not trade every day, then daily windows will tend to under-state the beta for that stock. For example, suppose there were a stock that had a true beta of 1, but only traded each Friday. Then on Monday through Thursday, there would be market movements but no change in the last-traded price of the stock. Then on the Friday the stock price would change to reflect that entire week's market movements. So although the true beta is 1, the observed beta from daily data would be well below 1.

There is a standard test and adjustment made for low-liquidity stock betas, called the "Dimson adjustment". A Dimson-adjusted beta is calculated as the sum of coefficients from the regression

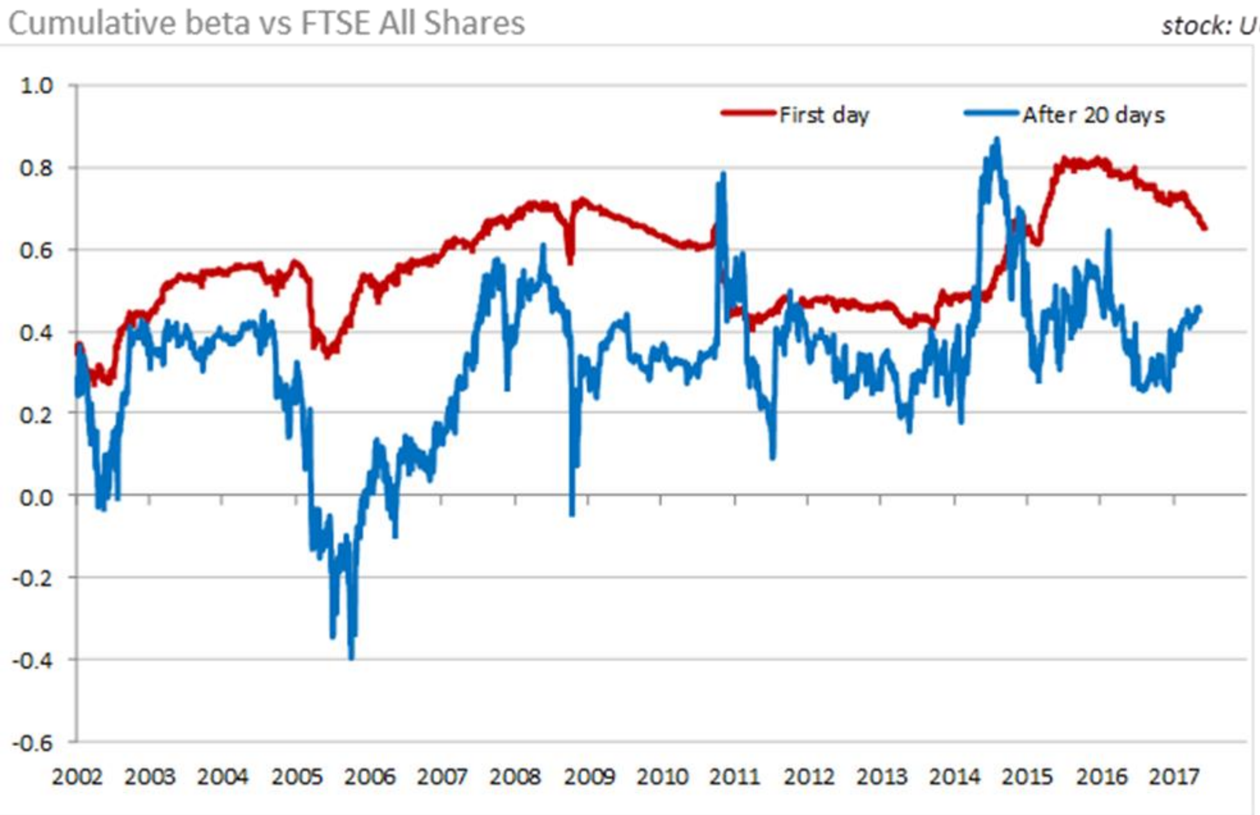
$R_{j,} = \alpha + \sum_{k=-n}^{n} \beta_k M_{t+k} + \varepsilon_{j,}$
$\beta_j^{DIM} = \sum_{k=-n}^{n} \beta_k$

Where is the number of periods (e.g. days) before and after the date at which beta is being calculated.

[60] We note that, absent a robust basis for believing that data patterns exist, the process we undertake here of searching for anomalies is subject to the standard datamining criticism that patterns of this sort will always be identifiable in large datasets even when entirely spurious.

Recent analysis from Ofgem has raised the thought that betas may be over-stated because of a tendency for covariant movements on one day to be reversed up to 20 days later. The following graph is frequently quoted.

Figure 13.1: Ofgem graph on impacts of considering lagged betas



The graph compares a two-year daily beta calculated in the standard way ("First day") with a daily beta that sums all the lagged betas for the subsequent 19 days. This is closely akin to the Dimson adjustment, but using only the upper half of the calculation — i.e.

$R_{j,} = \alpha + \sum_{k=0}^{19} \beta_k M_{t+k} + \varepsilon_{j,}$

$\beta_j^{\text{Ofgem}} = \sum_{k=0}^{19} \beta_k$

The Ofgem graph reports the sum across all lagged coefficients, even though in Ofgem's analysis none of them is statistically significant. When we have reproduced the calculation ourselves, using our preferred measure of returns, we find that of the 19 lagged variables, 7 are positive and 12 negative, and all are statistically insignificant at the 95 per cent level. If we sum them, we obtain the following graph, which we can see is qualitatively similar to the Ofgem graph, albeit with some differences. In particular, the after 20 days beta is materially lower than the spot estimate. For example, the 20 July 2018 "beta" for the cumulative series is 0.50 versus 0.64 for the standard beta.

Figure 13.2: Betas versus lagged betas for UU

If instead of only the lagged half of the Dimson adjustment calculation, we were to focus solely on lead variables, again summing coefficients whether they are statistically significant or not, we would obtain the following result. It is worth observing that with lead-only variables, two are statistically significant, those for 14 and 15 days, both positive coefficients (i.e. raising beta). The lead series cumulative beta for 20 July 2018 is 1.22, considerably higher than the standard beta of 0.64. In this case we can see clearly from the graph that summing lead coefficients would usually add to beta.

Figure 13.3: Standard beta versus sum of lead coefficients

If we combine the above two, we obtain the following. In this case the summed lags and leads estimate as at 20 July 2018 is 1.14. If we sum only statistically significant variables, conducting the Dimson adjustment in the orthodox manner, the summed lags and leads estimate as at 20 July 2018 is 1.14 — i.e. the analysis suggests, if anything, that the standard beta estimate is too low. However, we should also note that in this case there is no clear systematic tendency for the effect of summing. For most of the past five years, summing lead and lagged coefficients would result in an adjusted beta higher than the standard beta. But for the five years previous to that summing lead and lagged coefficients would result in an adjusted beta lower than the standard beta.

Figure 13.4: Standard betas versus summed lead and lagged coefficients

These results suggest that there is no robust basis in lead/lagged analysis for claiming that a daily window introduces a systematic upwards (or downwards) bias.

The use of longer data windows, switching from daily to weekly, monthly or quarterly data, involves a material loss in the number of datapoints used in statistical models.[61] There is a consequent loss of precision in models, with an almost inevitable broadening of confidence intervals. That could easily mean, for example, that at the same time a monthly beta has a lower central estimate than a daily beta, the upper bound of the monthly data confidence interval is higher than that of the daily data estimate.

For example if we estimate United Utilities' equity betas using 5 years of daily and monthly covering the period 01/Jan/2010—31/Dec/2014 we obtain the following results:

- The central beta estimate using monthly data (0.323) is lower than the central estimate based on daily data (0.501).
- The upper bound of the beta estimate based on monthly data is higher (at the 90%, 95%, and 99% confidence intervals) than the upper bound of the beta estimate obtained using daily data (see Table below).

[61] For example, if we use a two-year rolling window of weekly data, we have only of order one fifth as many datapoints as if we use a two-year rolling window of daily data.

		90% CI		*95% CI*		*99% CI*	
Beta	*Central estimate*	*Low*	*High*	*Low*	*High*	*Low*	*High*
Monthly	0.323	0.059	0.587	0.007	0.639	-0.097	0.743
Daily	0.501	0.452	0.549	0.443	0.559	0.425	0.577

One standard way to construct a range for betas is to use the low and high points of the 95th percentile confidence intervals. So in this case the daily range would be 0.443 to 0.559, whilst the monthly range would be 0.007 to 0.639. In the past it has not been unusual for regulators to be conservative by choosing figures in the upper part of a beta range. Therefore, a consequence of using monthly instead of daily data could often be to produce higher determinations for beta, than would have been the case had they focused more on daily data, even in cases where the central estimate is lower (which is not systematically so).Thus, we do *not* believe there is, as yet, robust evidence that the use of daily data will induce a systematic upwards bias in betas even if weak efficiency is sometimes violated at day-long timescales. Accordingly we believe it is potentially useful to consider betas calculated at longer timescales as well as daily data, but recommend continuing to use daily data as the base case, pending any proof of enduring material systematic weak efficiency violations over timescales longer than one day.

13.3 Evidence beta changes through time

Betas could be calculated on a backwards-looking basis, using the entire available set of historic data to construct a single beta estimate. This would maximise the statistical significance of estimates and limit the impact of possibilities such as that forwards-looking estimates (e.g. those based on the most recent two years of data) are temporarily distorted away from a underlying long-term beta value to which beta will revert over the period of a price control.

However, Donald Robertson points out in his report for Ofgem[62], after setting out a series of empirical evidence that beta changes through time[63], "With such evidence of persistent time variation in the variances of these series it is extremely difficult to argue that β should be treated as a constant, except perhaps in the very short run."

[62] Robertson, D. "Estimating β", April 19, 2018

[63] The evidence that the beta of UK regulated utilities change over time is supported by both a simple inspection of the data, and more formal statistical tests. A chart displaying 2-years rolling betas (based on daily data) for Severn Trent, National Grid, and United Utilities clearly indicates that the betas are not constant over time. For example, over the period Jan-2000 to August 2017, the beta of National Grid fluctuates between 0.4 and 0.8, whilst the beta od Severn Trent display even wider movements (e.g. between 0.05 and 0.8). Rolling betas based on 5 years of monthly data appear to move in a slightly narrower range, but they still display a significant variations.

Since beta is formally defined as the ratio of the covariance between an asset returns and the market returns — Cov(Ri,Rm) — over the variance of the market — Var(Rm)—, in order for a beta to be stable over time it must be the case that:

- Either Var(Rm) and Cov(Ri,Rm) are both constant in time (i.e. they are both homoscedastic); or
- The time variation in Cov(Ri,Rm) mimics very closely that of Var(Rm).

The use of a Chi-squared test leads to a clear rejection of the hypothesis of homoscedasticity for, both, the market returns, (i.e. Var(Rm) is time-varying), and the returns of all three assets (i.e. for each of the three assets, V(Ri) is also time-varying). Therefore, in order to have constant betas it would be necessary for time variation in the covariances to mimic that precisely that of Var(Rm), which is unlikely.

A firm's beta reflects the ever-evolving relative riskiness of its future cashflows. A firm's asset beta need not change because of any change in the firm's own business. As was argued before the Competition Commission in the BT Appeal of 2012[64], there is no reason a regulator must identify a way that a firm's risks have changed in order to justify a change in asset betas. BT argued that Ofcom's asset beta analysis included an unjustified change because "Ofcom had not provided evidence to show that BT's business risks had in fact moved in the manner implied by such asset betas".[65] The Competition Commission's Assessment was that "The CAPM approach adopted by Ofcom relies on financial market data to provide evidence of investors' pricing of the systematic risks of a company. As such it does not require wider evidence of a company's business risks or explanations of how risks have changed."

It is sometimes suggested that observed fluctuations in betas for utilities (which can be of the order of a doubling in only two to four years) are implausible, given that utility risks change only modestly, if at all. But if an asset beta begins at a very low level, such as 0.2, it is by no means obvious that the correct way to think about the issue is the asset beta doubling as opposed to the asset beta, say, recovering 0.2 of systematic risk that was lost in the previous period — e.g. asset betas of some utilities could have become temporarily depressed because of greatly increased perceived risk in other sectors of the economy (e.g. finance, construction, sectors exposed to EU trade). Furthermore, in the case of some utilities – e.g. firms exposed to the electricity sector — there are quite straightforward reasons to believe their risks may have increased materially in recent years (specifically, large rises in wholesale price volatility, which rough calculations suggest could in principle justify up to between a 50 and 80 per cent increase in beta by themselves).[66]

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[64] https://assets.publishing.service.gov.uk/media/55194c5fed915d1424000380/wba_determination.pdf
[65] *ibid*. paragraph 3.63.
[66] The table below shows the ratio of volatility in 2017 to volatility in 2014 (the last full year supporting the data underpinning the 2015 results). The volatility measure we are using is based on the standard deviation, and we express it here in percentage terms, for ease of comparison between years.

Change in volatility of electricity and gas prices

	Average volatility for months in year	
	Electricity (baseload)	**Electricity (peakload)**
2014	19%	73%
2017	29%	133%
Ratio of 2017 volatility to 2014 volatility	**1.54**	**1.81**

Source: Ofgem, Own calculations.

It can be proved that, subject to certain (fairly strong) assumptions, the ratio of the standard deviations of returns (above the risk-free rate) should be equal to the ratio of the asset betas. At a given point in time, the relationship between the asset beta in year 1 and average market returns can be written as:

$$R_1 = \alpha_1 + \beta_1 R_m + e_1 \qquad (1)$$

Where R_1 is the excess return for year 1, R_m is the excess return on the market, β_1 is year 1's beta coefficient and α_1 is its alpha coefficient. e_1 is the non-systematic component of the return in year 1.

Our modelling is intended to incorporate only systematic components of risk. Provided this is fully achieved, $e_1 = 0$ and the above equation becomes:

$$R_1 = \alpha_1 + \beta_1 R_m \qquad (2)$$

Using the mathematical properties of variance, we can write the variance of R_1 as follows:

$$\text{var}(R_1) = \text{var}(\alpha_1 + \beta_1 R_m) = \beta_1^{\,2}\ \text{var}(R_m) \qquad (3)$$

In the same way, we can derive an equivalent statement for year 2:

On the other hand, it may be worth observing that movements in a firm's unlevered beta (the equity beta unlevered as if the debt beta were zero[67]) may give an exaggerated picture of movements in that firm's asset beta if the debt beta moves in the opposite direction to the unlevered beta — which might occur if risks driving the debt premiums of utilities up also tend to drive asset betas down.[68]

For example, suppose that a firm had a constant gearing of 50 per cent and its equity beta varied between 0.6 and 0.8 and back to 0.7 over a two-year period, in the way illustrated in the figure below. Then the unlevered beta would rise from 0.3 to 0.4 and then back to 0.35. But if the debt beta started at 0.25, then fell to 0.2 and rose back to 0.225, the asset beta would start at 0.425, rise to 0.5 and fall back to 0.4625, as we see in the figure. If we normalise the unlevered and asset betas to a start-value of 100, we can see that the movements in the asset beta are notably less pronounced than those in the unlevered beta. It is perhaps worth remarking that only part of this effect arises from the variation in the debt beta. Simply having a larger debt beta results in lower volatility in the asset beta, for any given shifts in the equity beta, other things being equal, even if the debt beta does not change.

$$\text{var}(R_2) = \beta_2^{\;2}\,\text{var}(R_m) \qquad (4)$$

Dividing equation 4 by equation 3, we obtain the following relationship:

$$\frac{\text{var}(R_2)}{\text{var}(R_1)} = \frac{\beta_2^{\;2}\,\text{var}(R_m)}{\beta_1^{\;2}\,\text{var}(R_m)} = \frac{\beta_2^{\;2}}{\beta_1^{\;2}} \qquad (5)$$

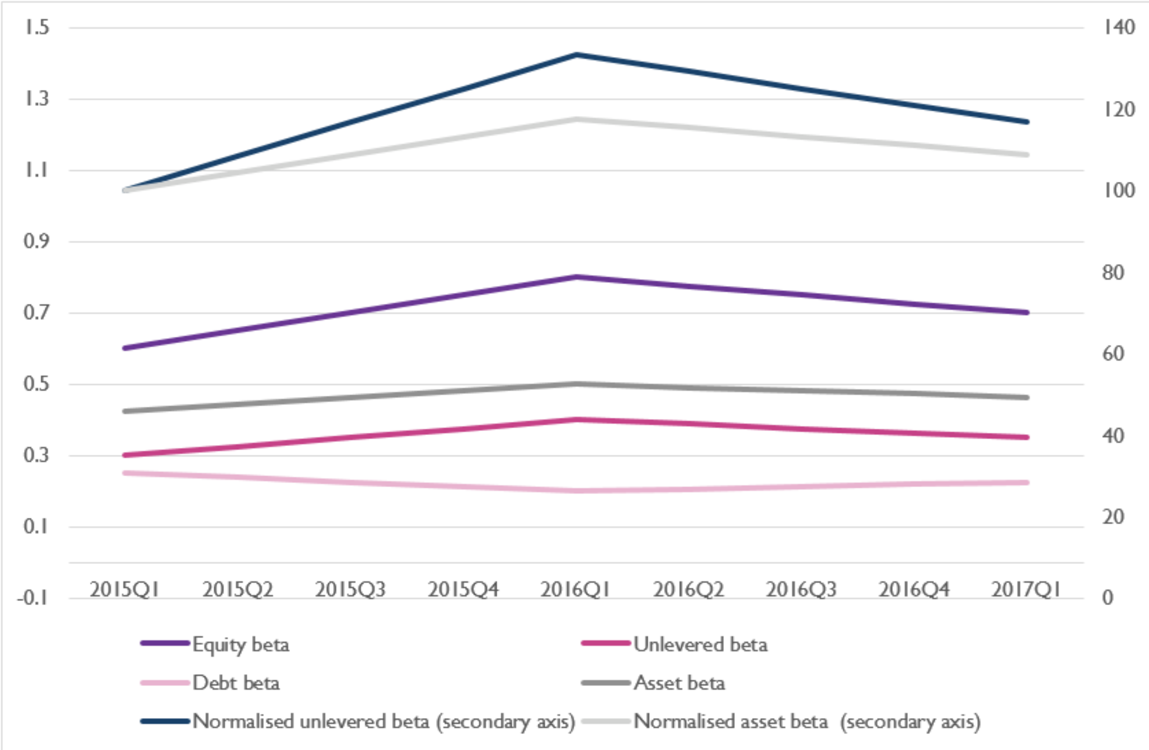
The standard deviation σ of the excess return for each year is simply the square root of the relevant variance. Hence, we can take the square root of equation (5) to give:

$$\frac{\sigma_2}{\sigma_1} = \frac{\beta_2}{\beta_1}$$ Q.E.D.

67 The term "unlevered beta" is often used as a synonym for asset beta in contexts in which it is assumed that the debt beta is zero (in which case unlevered beta and asset beta are the same). Here we use the term "unlevered beta" as it was used in Europe Economics' December 2017 cost of capital report to Ofwat, to refer to the equity beta unlevered without any adjustment for debt beta (i.e. as if the debt beta were zero).

68 This was explored in the BT 2012 Appeal at *ibid*. paragraph 3.84 and commented upon in the Competition Commission's Assessment at 3.104.

Figure 13.5: Movements in unlevered versus asset beta when debt beta moves contrariwise



This could be an argument for using a more dynamic and elaborate debt beta methodology than has been used to date.

The UKRN recommends a highly forwards-looking approach to risk-free rate. Regulators such as Ofwat have attempted to apply a similarly forwards-looking approach to Total Market Return estimation. The natural complement to a forwards-looking approach in these areas is a fully forwards-looking approach to beta. It would be paradoxical to use fully up-to-date spot estimates of, say, the risk-free rate but base the beta on data that was 20 or more years old and reflecting both technologies and the general state of the economy from decades in the past to assess the cost of capital over the next five years.

It is not very plausible that a "long-run beta" really exists. Over the decades since privatisation, the roles of the finance sector and of assets such as housing have changed dramatically, affecting the riskiness of regulated utilities relative to the wider economy. The role of energy in the economy and the risks from geopolitics and from factors such as climate change regulation or energy taxation have changed dramatically, affecting the riskiness of utilities relative to each other. The utilities themselves have changed, as new methods and technologies have evolved, new runways have been built, new IT systems installed, as firms have merged and restructured, and as regulation has evolved. There is little to no reason to believe that these factors have, in sum, left the relative riskinesses of regulated utilities the same as they were two and more decades ago.

Furthermore, even if betas moved cyclically around some long-term mean, the correct approach would be to use that evidence to assess how betas would evolve over the forthcoming price control period, rather than to use a long-term beta. To some (limited) extent that is what is already done by taking account of 1 year daily betas as well as 2 year daily betas (since the 1 year betas provide a signal about how the 2 year beta should be expected to move over the next year).

To use a long-run beta, based on obsolete historic data, would risk either material over-remunerating or under-remunerating regulated firms for their investments, distorting incentives and undermining the objectives of economic regulation.

14 Appendix 6: alternative approaches to beta estimation

14.1 Introduction

There does appear to be variation in beta variance over time, i.e. betas can remain relatively stable for some time (fluctuating within a narrow band) and display much wider variations in other periods. This might to some extent reflect the fact that the CAPM model is conceptually incomplete. According to microeconomic theory, agents should care about skewness, kurtosis and other moments of the returns distribution as well as variance. Beta variance over time might be a symptom of the impacts these other factors would be having upon returns if they were used in the model (e.g. in a third moment CAPM model) and that those other factors evolve non-randomly. Therefore, to certain extent beta variation might be due to uninformative volatility (i.e. measured betas changing more than actual betas do).

The traditional way to deal with this potential issue is by using two-year daily betas whilst also taking into account beta estimates based on windows of different length (e.g. 5-years, and 1-year) and to exert some form of judgment. A potential drawback with this approach is that it introduces judgement into the process of beta estimation instead of a straightforward "let the data speak" approach. That could subject regulators to pressure to use the discretion the process offers them to justify accepting systematically materially higher beta numbers than the data imply — for example, the UKRN study authors claim that this has happened, over a number of price controls in succession since the mid-2000s, with Ofgem and Ofwat. That risks meaning that the exercise of judgement introduces far larger distortions than any distortions there are in the data that the judgement is attempting to correct for. If this reasoning is correct, it could therefore imply there is some advantage in a more mechanical, less judgement-based approach, even if in principle judgement-based adjustments could be adequate or superior.

One potential class of more mechanical ways to address the issue of time-varying variance has been the proposals to move away from the traditional OLS estimation approach to make more use of the ARCH/GARCH framework. This alternative approach has two main potential benefits over OLS:

- First, it allows an adjustment for variance variation through time that does not require the use of such long backwards-looking data windows;
- Second, it reduced the role for regulatory judgments in interpreting beta data.

Whist we agree that the use of a GARCH approach can be used as a useful cross-check to traditional OLS estimates, we noted that GARCH methods so far have not tended to produce greatly different betas from non-GARCH methods. Furthermore, there is as yet not a consensus on which GARCH methods are to be preferred. Consequently, at this stage we believe GARCH estimates are best used as a cross-check, to help inform the use of judgement in interpreting the OLS-based estimates.

Accordingly, in this we first provide the technical details of these beta estimation techniques, i.e. traditional OLS approach and the ARCH/GARCH approach. We then compare the results we obtain with the two different estimation methods.

14.2 Traditional OLS

Theoretically, the CAPM framework characterises the following relationship between the expected return of a company (stock), $E(r_i)$, and the expected return of the market, $E(r_M)$:

$$E(r_i) = \alpha + \beta E(r_M)$$

where the beta coefficient is equal to the ratio between the covariance of the stock with the market, over the variance of the market, i.e.:

$$\beta = \frac{Cov(r_i, r_M)}{Var(r_M)}$$

Empirically, the beta can be calculated by estimating the following OLS regression:

$$r_{i,t} = \alpha + \beta r_{M,t} + \epsilon_{i,t}$$

where $r_{i,t}$ are the returns of company i at time t, and $r_{M,t}$ are the return of the market at time t, α is the constant of the regression, β is the estimation coefficient of interest (i.e. the *beta*) and $\epsilon_{i,t}$ is the error term of the regressions. When betas are estimated on daily data the returns are based on daily closing prices and include also including dividends. More specifically, daily returns are defined as follows:

$$r_{i,t} = \frac{p_{i,t} - p_{i,t-1} + d_{i,t}}{p_{i,t-1}}$$

where $p_{i,t}$ is the closing price of stock i on day t, $p_{i,t-1}$ is the closing price of stock i on the previous day $t-1$ and $d_{i,t}$ is any dividend that stock i pays on day *t*. It is also common to express returns in log-format in which case the beta is estimated through the following equation:

$$log(1 + r_{i,t}) = \alpha + \beta\ log(1 + r_{M,t}) + \epsilon_{i,t}$$

Since beta vary over time it is also common to estimate the OLS regression on a sample (for example a rolling window containing 2 years of daily data).

14.3 ARCH/GARCH estimation

One ARCH/GARCH approach that has been proposed[69] to estimate beta consist in using the entire set of data available to estimate a BEKK[70] multivariate GARCH mode in which the stock's return and the market return are explained by two constant, i.e.:

$$\begin{pmatrix} r_{i,t} \\ r_{M,t} \end{pmatrix} = \begin{pmatrix} c_1 \\ c_2 \end{pmatrix} + \begin{pmatrix} u_{i,t} \\ u_{M,t} \end{pmatrix}$$

and where the variance-covariance of the system's residuals (i.e. $u_{i,t}$ and $u_{m,t}$) is time varying

$$Cov\begin{pmatrix} u_{i,t} \\ u_{M,t} \end{pmatrix} = \begin{pmatrix} Var(u_{i,t}) & Cov(u_{i,t}, u_{M,t}) \\ Cov(u_{i,t}, u_{M,t}) & Var(u_{M,t}) \end{pmatrix}$$

The time-varying variance-covariance matrix can be used to calculate an "instantaneous beta" for each data point as follows:

$$\beta_t = \frac{Cov(u_{i,t}, u_{M,t})}{Var(u_{M,t})}$$

A rolling average of the instantaneous betas can then be used to calculate time-varying betas defined on different time horizons.

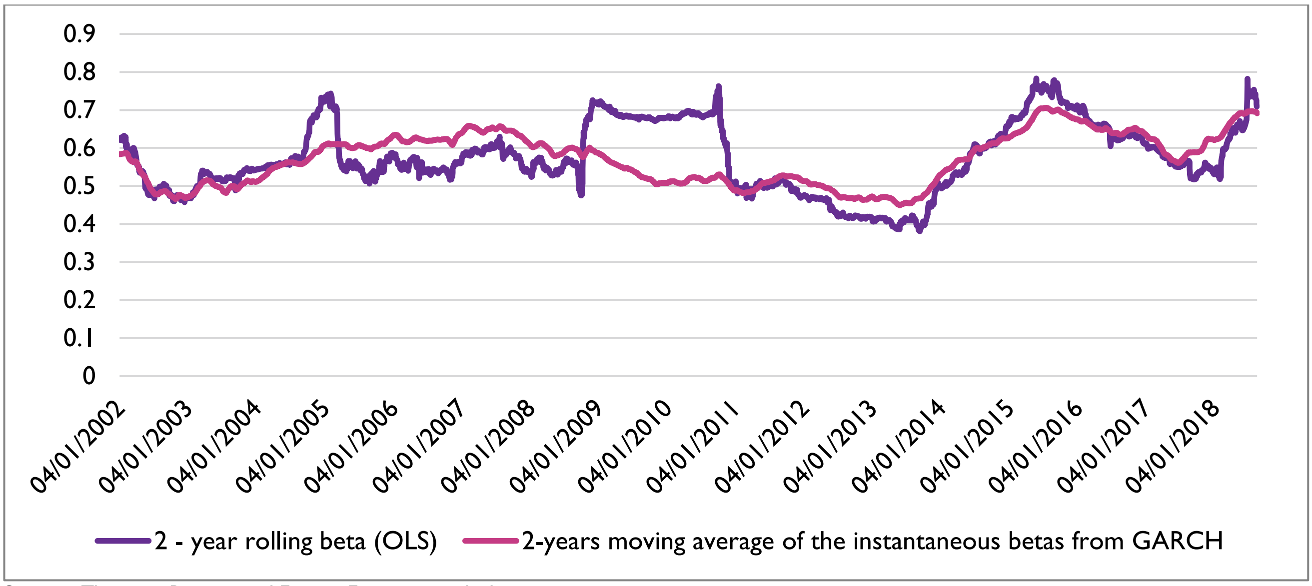
[69] See, e.g. D. Robertson (April 19, 2018), "Estimating β"

[70] See Baba, Engle, Kraft and Kroner (1990) published as "Multivariate Simultaneous Generalised ARCH" by Engle and Kroner, Econometric Theory, Vol. 11, Issue 1, Feb 1995, pp 122-150.

14.4 Comparison between OLS and ARCH/GARCH betas

In this section we cross-checked our core OLS beta estimates with GARCH estimates. The GARCH estimates provided here are based on a 2-years rolling windows of high frequency (daily) data. This is also the GARCH approach preferred by NERA.[71] As such it differs from the estimation approach proposed by Mason, Pickford, and Wrigth[72] who advocate the use of long time horizon and low frequency (i.e. quarterly data). For National Grid, Pennon, SSE, and Severn Trent, and United Utilties, we report below the 2-years rolling equity betas obtained with a standard OLS estimate, and the 2-years moving average of the instantaneous equity betas obtained from a GARCH estimate of the full sample of data available up to the cut-off date 17 August 2018.[73]

Figure 14.1: OLS and GARCH equity betas for National Grid



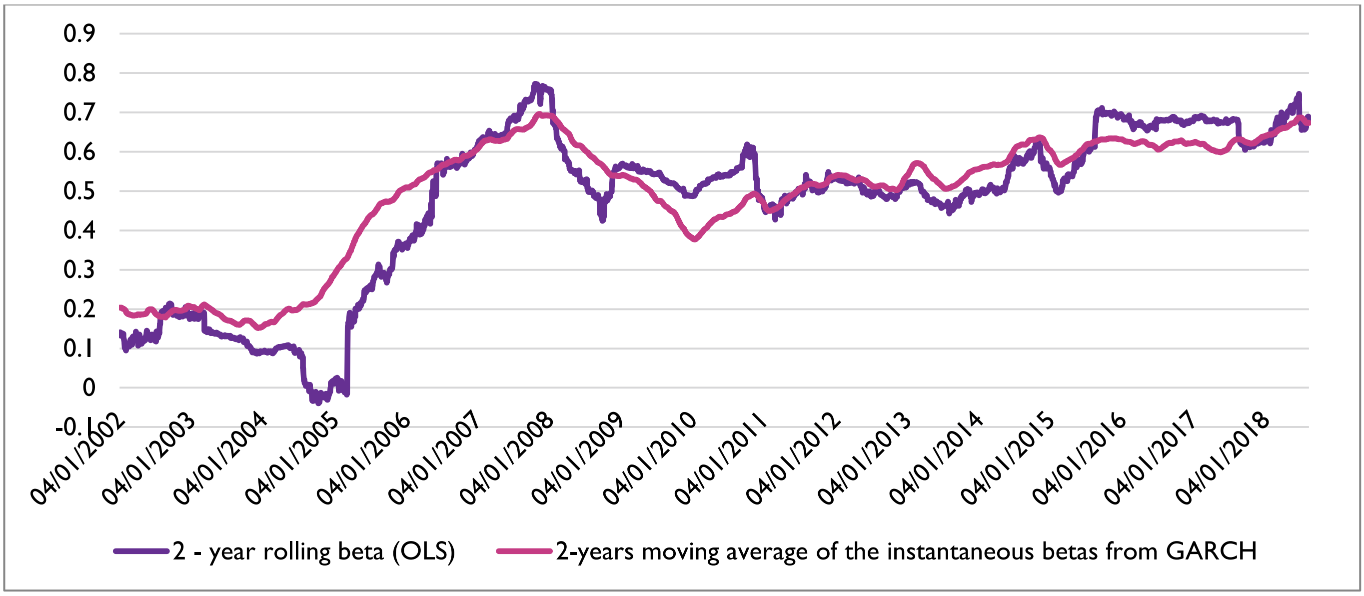
Source: Thomson Reuters and Europe Economics calculations

71 NERA (June 2018), "Review of UKRN report recommendations on beta estimation"

72 Wright, S, Burns, P, Mason, R, and Pickford, D (2018), Estimating the cost of capital for implementation of price controls by UK Regulators, An update of Mason, Miles and Wright (2003).

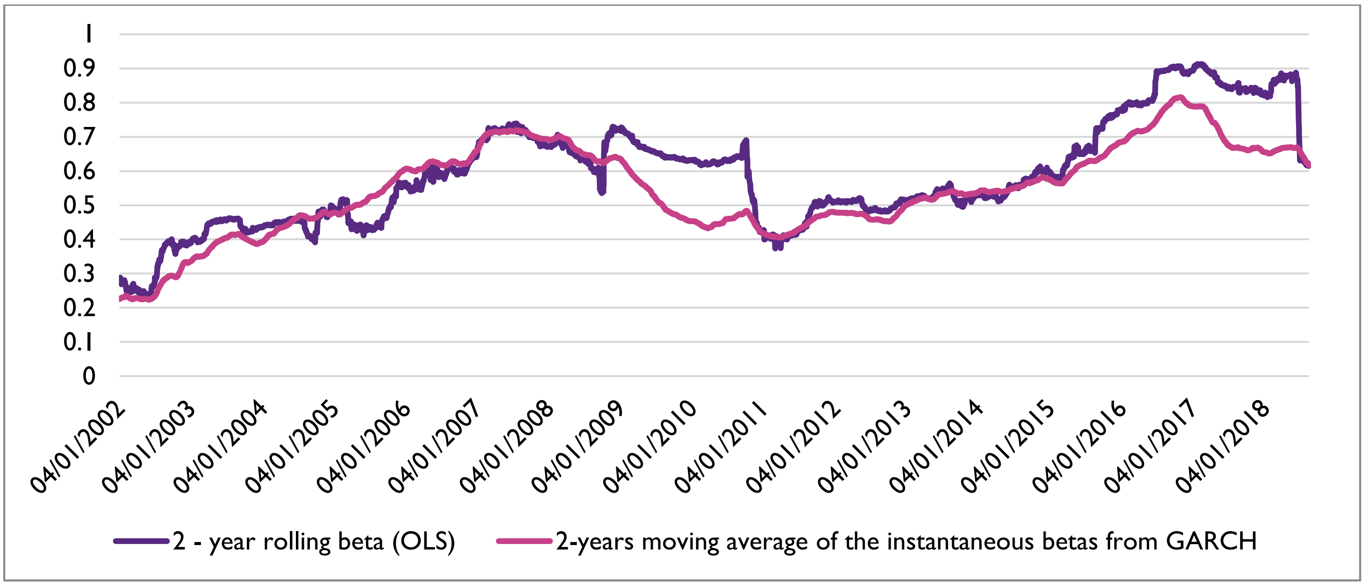
73 The method for calculating the moving average of instantaneous betas is described in Roberson, D. (April 2018), "Estimating β "

Figure 14.2: OLS and GARCH equity betas for Pennon



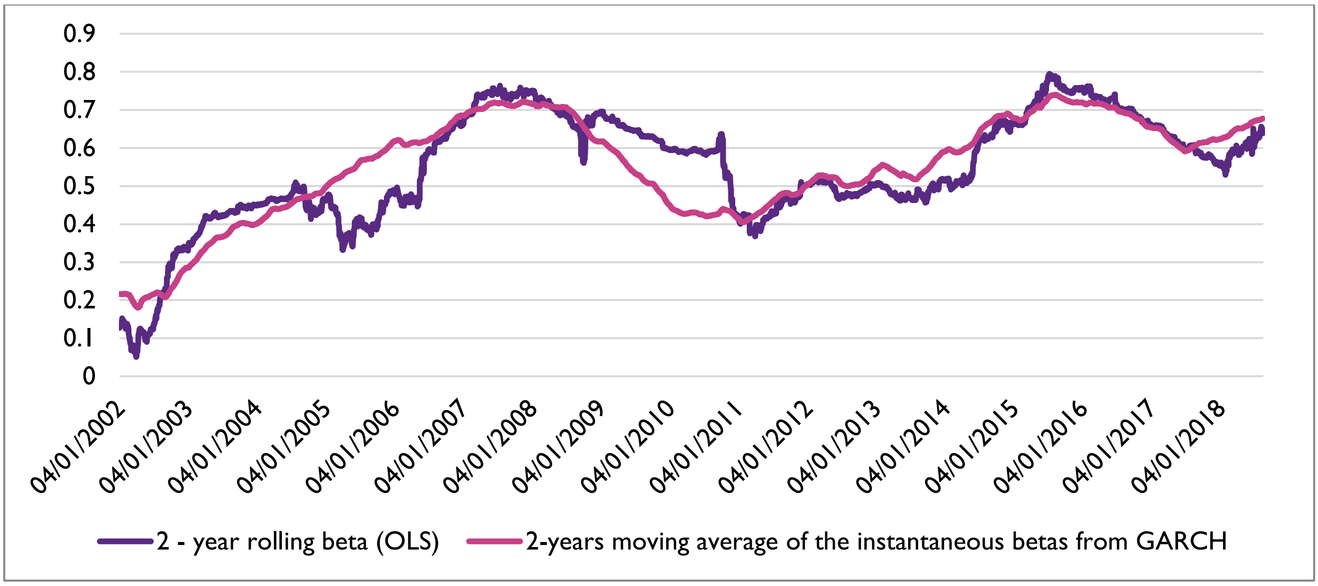
Source: Thomson Reuters and Europe Economics calculations

Figure 14.3: OLS and GARCH equity betas for SSE



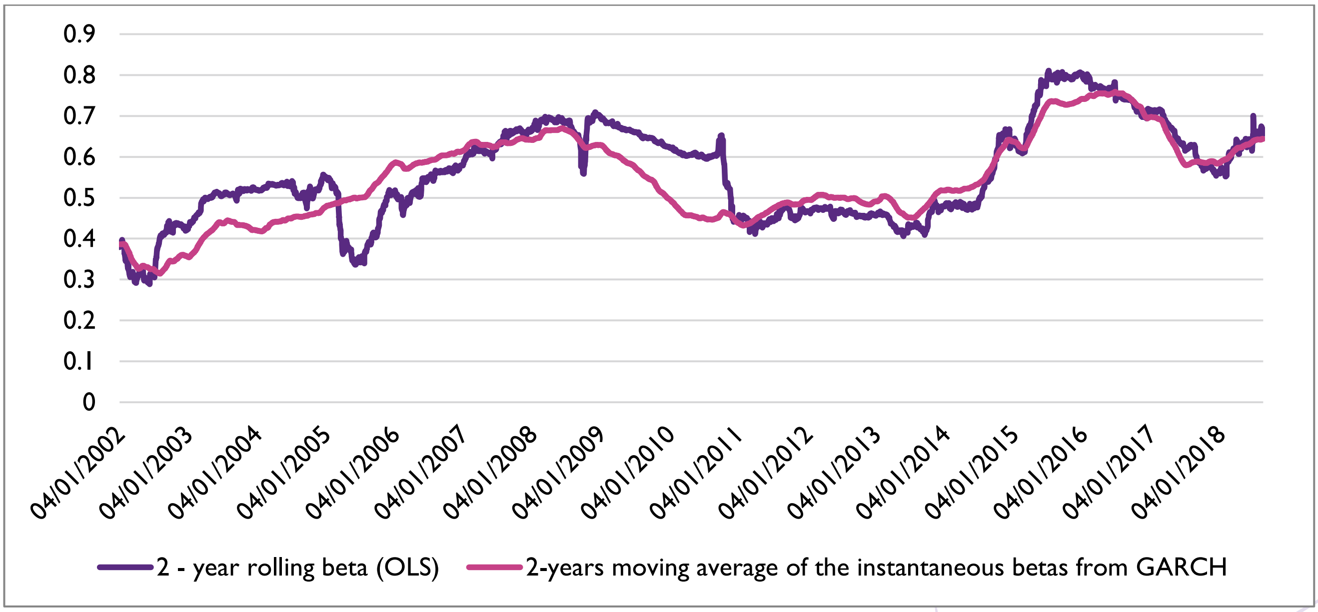
Source: Thomson Reuters and Europe Economics calculations

Figure 14.4: OLS and GARCH equity betas for Severn Trent



Source: Thomson Reuters and Europe Economics calculations

Figure 14.5: OLS and GARCH equity betas for UU



Source: Thomson Reuters and Europe Economics calculations

In the tables below we also report the estimation outputs for the GARCH (BEKK) models estimated.

Table 14.1: GARCH estimates for National Grid

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Sample: 1/04/2000 8/17/2018
Included observations: 4690
Total system (balanced) observations 9380
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 15 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000550	0.000115	4.768202	0.0000
C(2)	0.000772	0.000159	4.868295	0.0000
	Variance Equation Coefficients			
C(3)	1.38E-06	1.83E-07	7.523629	0.0000
C(4)	1.04E-06	1.27E-07	8.189864	0.0000
C(5)	3.78E-06	2.91E-07	13.00660	0.0000
C(6)	0.293014	0.008747	33.49983	0.0000
C(7)	0.253607	0.006177	41.05741	0.0000
C(8)	0.950241	0.002999	316.8628	0.0000
C(9)	0.955379	0.002068	462.0425	0.0000

Log likelihood	30014.91	Schwarz criterion	-12.78331
Avg. log likelihood	3.199883	Hannan-Quinn criter.	-12.79134
Akaike info criterion	-12.79570		

Equation: R_INDEX_UK = C(1)

R-squared	-0.000587	Mean dependent var	0.000272
Adjusted R-squared	-0.000587	S.D. dependent var	0.011449
S.E. of regression	0.011452	Sum squared resid	0.614981
Durbin-Watson stat	2.062268		

Equation: R_NG = C(2)

R-squared	-0.000559	Mean dependent var	0.000454
Adjusted R-squared	-0.000559	S.D. dependent var	0.013449
S.E. of regression	0.013452	Sum squared resid	0.848542
Durbin-Watson stat	2.111525		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

	Transformed Variance Coefficients			
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	1.38E-06	1.83E-07	7.523629	0.0000
M(1,2)	1.04E-06	1.27E-07	8.189864	0.0000
M(2,2)	3.78E-06	2.91E-07	13.00660	0.0000
A1(1,1)	0.293014	0.008747	33.49983	0.0000
A1(2,2)	0.253607	0.006177	41.05741	0.0000
B1(1,1)	0.950241	0.002999	316.8628	0.0000
B1(2,2)	0.955379	0.002068	462.0425	0.0000

Table 14.2 GARCH estimates for Pennon

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Sample: 1/04/2000 8/17/2018
Included observations: 4690
Total system (balanced) observations 9380
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 12 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000891	0.000183	4.870977	0.0000
C(2)	0.000541	0.000114	4.752959	0.0000
	Variance Equation Coefficients			
C(3)	1.27E-06	1.37E-07	9.228879	0.0000
C(4)	8.13E-07	1.14E-07	7.151815	0.0000
C(5)	1.32E-06	1.79E-07	7.381737	0.0000
C(6)	0.162421	0.005191	31.28676	0.0000
C(7)	0.294877	0.009086	32.45308	0.0000
C(8)	0.983451	0.000888	1107.613	0.0000
C(9)	0.949508	0.003052	311.0858	0.0000

Log likelihood	29168.93	Schwarz criterion	-12.42256
Avg. log likelihood	3.109694	Hannan-Quinn criter.	-12.43058
Akaike info criterion	-12.43494		

Equation: R_PNN = C(1)

R-squared	-0.000316	Mean dependent var	0.000625
Adjusted R-squared	-0.000316	S.D. dependent var	0.014989
S.E. of regression	0.014992	Sum squared resid	1.053864
Durbin-Watson stat	2.080224		

Equation: R_INDEX_UK = C(2)

R-squared	-0.000549	Mean dependent var	0.000272
Adjusted R-squared	-0.000549	S.D. dependent var	0.011449
S.E. of regression	0.011452	Sum squared resid	0.614958
Durbin-Watson stat	2.062346		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

Transformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	1.27E-06	1.37E-07	9.228879	0.0000
M(1,2)	8.13E-07	1.14E-07	7.151815	0.0000
M(2,2)	1.32E-06	1.79E-07	7.381737	0.0000
A1(1,1)	0.162421	0.005191	31.28676	0.0000
A1(2,2)	0.294877	0.009086	32.45308	0.0000
B1(1,1)	0.983451	0.000888	1107.613	0.0000
B1(2,2)	0.949508	0.003052	311.0858	0.0000

Table 14.3 GARCH estimates for SSE

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Included observations: 4690
Total system (balanced) observations 9380
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 18 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000732	0.000154	4.747615	0.0000
C(2)	0.000547	0.000115	4.744405	0.0000
	Variance Equation Coefficients			
C(3)	3.13E-06	3.14E-07	9.949147	0.0000
C(4)	8.26E-07	1.07E-07	7.714439	0.0000
C(5)	1.09E-06	1.46E-07	7.418346	0.0000
C(6)	0.238022	0.006122	38.88081	0.0000
C(7)	0.273328	0.007967	34.30721	0.0000
C(8)	0.961261	0.002280	421.5464	0.0000
C(9)	0.957044	0.002447	391.0491	0.0000

Log likelihood	29933.99	Schwarz criterion	-12.74881
Avg. log likelihood	3.191257	Hannan-Quinn criter.	-12.75684
Akaike info criterion	-12.76119		

Equation: R_SSE = C(1)

R-squared	-0.000244	Mean dependent var	0.000518
Adjusted R-squared	-0.000244	S.D. dependent var	0.013653
S.E. of regression	0.013655	Sum squared resid	0.874297
Durbin-Watson stat	2.177615		

Equation: R_INDEX_UK = C(2)

R-squared	-0.000575	Mean dependent var	0.000272
Adjusted R-squared	-0.000575	S.D. dependent var	0.011449
S.E. of regression	0.011452	Sum squared resid	0.614974
Durbin-Watson stat	2.062293		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

Transformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	3.13E-06	3.14E-07	9.949147	0.0000
M(1,2)	8.26E-07	1.07E-07	7.714439	0.0000
M(2,2)	1.09E-06	1.46E-07	7.418346	0.0000
A1(1,1)	0.238022	0.006122	38.88081	0.0000
A1(2,2)	0.273328	0.007967	34.30721	0.0000
B1(1,1)	0.961261	0.002280	421.5464	0.0000
B1(2,2)	0.957044	0.002447	391.0491	0.0000

Table 14.4 GARCH estimates for Severn Trent

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Sample: 1/04/2000 8/17/2018
Included observations: 4690
Total system (balanced) observations 9380
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 17 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000867	0.000186	4.653129	0.0000
C(2)	0.000538	0.000116	4.635183	0.0000
	Variance Equation Coefficients			
C(3)	1.94E-06	1.50E-07	12.94651	0.0000
C(4)	8.76E-07	1.02E-07	8.553408	0.0000
C(5)	1.17E-06	1.59E-07	7.377552	0.0000
C(6)	0.151684	0.003553	42.69653	0.0000
C(7)	0.273322	0.008037	34.00623	0.0000
C(8)	0.982903	0.000852	1153.075	0.0000
C(9)	0.955898	0.002569	372.0279	0.0000

Log likelihood	29372.27	Schwarz criterion	-12.50927
Avg. log likelihood	3.131372	Hannan-Quinn criter.	-12.51729
Akaike info criterion	-12.52165		

Equation: R_SVT = C(1)

R-squared	-0.000429	Mean dependent var	0.000568
Adjusted R-squared	-0.000429	S.D. dependent var	0.014400
S.E. of regression	0.014403	Sum squared resid	0.972689
Durbin-Watson stat	2.048244		

Equation: R_INDEX_UK = C(2)

R-squared	-0.000536	Mean dependent var	0.000272
Adjusted R-squared	-0.000536	S.D. dependent var	0.011449
S.E. of regression	0.011452	Sum squared resid	0.614950
Durbin-Watson stat	2.062372		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

Transformed Variance Coefficients

	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	1.94E-06	1.50E-07	12.94651	0.0000
M(1,2)	8.76E-07	1.02E-07	8.553408	0.0000
M(2,2)	1.17E-06	1.59E-07	7.377552	0.0000
A1(1,1)	0.151684	0.003553	42.69653	0.0000
A1(2,2)	0.273322	0.008037	34.00623	0.0000
B1(1,1)	0.982903	0.000852	1153.075	0.0000
B1(2,2)	0.955898	0.002569	372.0279	0.0000

Table 14.5 GARCH estimates for UU

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Sample: 1/04/2000 8/17/2018
Included observations: 4690
Total system (balanced) observations 9380
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 15 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000693	0.000165	4.196090	0.0000
C(2)	0.000536	0.000115	4.656836	0.0000
	Variance Equation Coefficients			
C(3)	1.33E-06	1.83E-07	7.257858	0.0000
C(4)	7.23E-07	9.96E-08	7.260185	0.0000
C(5)	1.16E-06	1.59E-07	7.299368	0.0000
C(6)	0.173479	0.004561	38.03134	0.0000
C(7)	0.277135	0.007871	35.20775	0.0000
C(8)	0.980584	0.001025	956.2746	0.0000
C(9)	0.955202	0.002555	373.8791	0.0000

Log likelihood	29792.96	Schwarz criterion	-12.68867
Avg. log likelihood	3.176222	Hannan-Quinn criter.	-12.69669
Akaike info criterion	-12.70105		

Equation: R_UU = C(1)

R-squared	-0.000530	Mean dependent var	0.000382
Adjusted R-squared	-0.000530	S.D. dependent var	0.013540
S.E. of regression	0.013544	Sum squared resid	0.860149
Durbin-Watson stat	2.097109		

Equation: R_INDEX_UK = C(2)

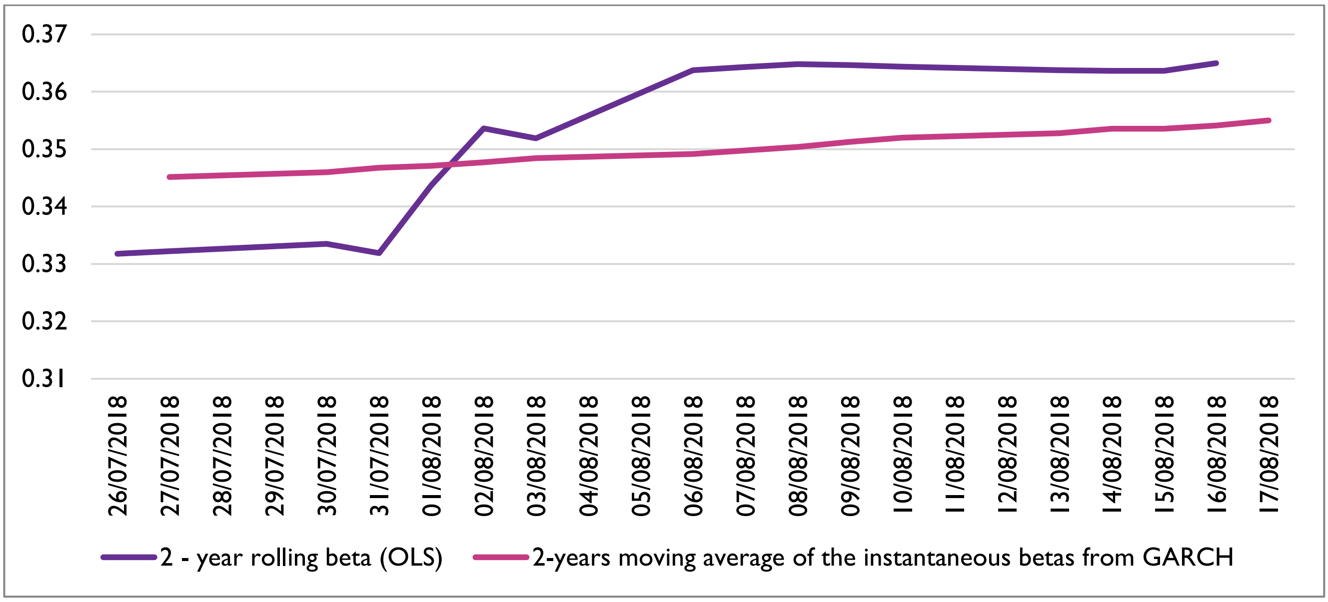
R-squared	-0.000531	Mean dependent var	0.000272
Adjusted R-squared	-0.000531	S.D. dependent var	0.011449
S.E. of regression	0.011452	Sum squared resid	0.614947
Durbin-Watson stat	2.062382		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

	Transformed Variance Coefficients			
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	1.33E-06	1.83E-07	7.257858	0.0000
M(1,2)	7.23E-07	9.96E-08	7.260185	0.0000
M(2,2)	1.16E-06	1.59E-07	7.299368	0.0000
A1(1,1)	0.173479	0.004561	38.03134	0.0000
A1(2,2)	0.277135	0.007871	35.20775	0.0000
B1(1,1)	0.980584	0.001025	956.2746	0.0000
B1(2,2)	0.955202	0.002555	373.8791	0.0000

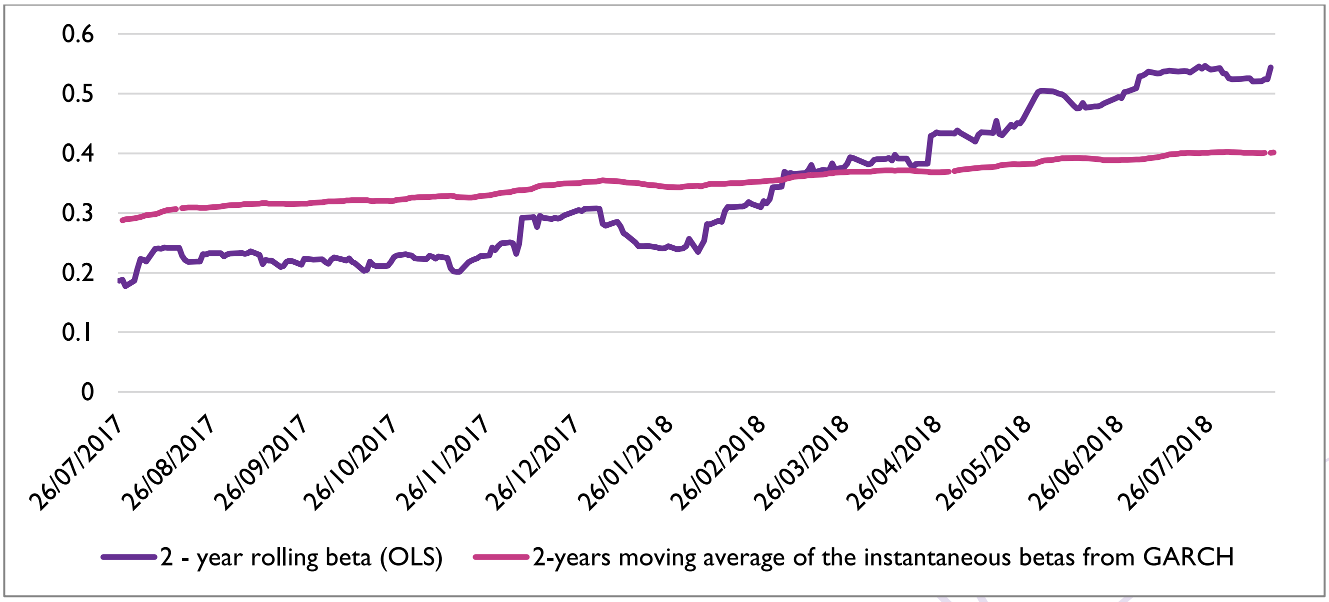
We also provide the 2-years and 1-years OLS and GARCH estimates for ENAV. We note that, because of the smaller sample of data available, the GARCH estimates for ENAV are less reliable than those we obtained for other utilities. This is confirmed by the estimation output of Table 14.6 that indicates that the GARCH coefficients C(1) and C(2) are not statistically significant.

Figure 14.6: OLS and GARCH 2 – years equity betas for Enav



Source: Thomson Reuters and Europe Economics calculations

Figure 14.7: OLS and GARCH 1 year equity betas for Enav



Source: Thomson Reuters and Europe Economics calculations

Table 14.6: GARCH estimates for ENAV

System: SYS01
Estimation Method: ARCH Maximum Likelihood (Marquardt)
Covariance specification: Diagonal BEKK
Sample: 7/27/2016 8/17/2018
Included observations: 524
Total system (balanced) observations 1048
Presample covariance: backcast (parameter =0.7)
Convergence achieved after 25 iterations

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000658	0.000529	1.245270	0.2130
C(2)	0.000610	0.000433	1.408045	0.1591
	Variance Equation Coefficients			
C(3)	3.02E-05	1.21E-05	2.488322	0.0128
C(4)	5.09E-06	2.15E-06	2.367393	0.0179
C(5)	6.29E-06	2.59E-06	2.431029	0.0151
C(6)	0.318173	0.054138	5.877090	0.0000
C(7)	0.234329	0.043391	5.400348	0.0000
C(8)	0.828543	0.063616	13.02409	0.0000
C(9)	0.938007	0.020431	45.91062	0.0000

Log likelihood	3290.166	Schwarz criterion	-12.45034
Avg. log likelihood	3.139471	Hannan-Quinn criter.	-12.49487
Akaike info criterion	-12.52353		

Equation: R_ENAV = C(1)

R-squared	-0.000176	Mean dependent var	0.000500
Adjusted R-squared	-0.000176	S.D. dependent var	0.011941
S.E. of regression	0.011942	Sum squared resid	0.074586
Durbin-Watson stat	2.101833		

Equation: R_INDEX_IT = C(2)

R-squared	-0.000053	Mean dependent var	0.000537
Adjusted R-squared	-0.000053	S.D. dependent var	0.010006
S.E. of regression	0.010006	Sum squared resid	0.052364
Durbin-Watson stat	2.050319		

Covariance specification: Diagonal BEKK
GARCH = M + A1*RESID(-1)*RESID(-1)'*A1 + B1*GARCH(-1)*B1
M is an indefinite matrix
A1 is a diagonal matrix
B1 is a diagonal matrix

Transformed Variance Coefficients				
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	3.02E-05	1.21E-05	2.488322	0.0128
M(1,2)	5.09E-06	2.15E-06	2.367393	0.0179
M(2,2)	6.29E-06	2.59E-06	2.431029	0.0151
A1(1,1)	0.318173	0.054138	5.877090	0.0000
A1(2,2)	0.234329	0.043391	5.400348	0.0000
B1(1,1)	0.828543	0.063616	13.02409	0.0000
B1(2,2)	0.938007	0.020431	45.91062	0.0000

From the analysis presented above we can conclude that there differeces in estimation results between the two method are somewhat small. This point if further reinforced by the following table where we compare the asset betas obtained with the two different estimation methods.

Table 14.7: Comparison of OLS and GARCH asset betas at 17 August 2018

	OLS (2 years daily)	GARCH (2 years moving average of daily instantaneous beta)
National Grid	0.43	0.42
Pennon	0.36	0.36
SSE	0.42	0.42
Severn Trent	0.32	0.34
Enav	0.34	0.33
United Utilities	0.30	0.30

Source: Thomson Reuters and Europe Economics calculations

15 Apppendix 7: Debt issuance and liquidity costs

Table 15.1 shows the estimated debt issuance costs. The average based on all the issues in 1993-2017 period is 5bps, and the average based on issues since 2000 is 3bps. Taking also into account PwC's estimate of 6bps issuance cost for Artesian debt,[1] the Ofwat report used an issuance cost range of 3-6 bps.

Table 15.1 Debt issuance costs

Company	Overall number of issues	Average issuance cost — overall (bps)	Average issuance cost — after 2000 (bps)
AFW	2	3.22	3.22
ANH	11	12.18	3.25
NWL	4	4.65	2.87
SVT	7	3.60	4.12
SEW	1	1.50	1.50
SSC	2	3.26	3.26
TWUL	15	3.43	3.28
UU	18	3.70	3.18
WSX	6	2.42	2.21
YKY	6	2.20	1.97
Average	**72**	**4.68**	**3.05**

Note: The averages here are defined with respect to all debt issues rather than being an average of company averages.
Source: Bloomberg, LSE, ICE, Europe Economics' calculations.

In addition to issuance costs, companies also bear a cost of maintaining financial liquidity. Companies have different approaches to ensuring liquidity, but among the common ones are revolving credit facilities — for the purpose of this report we assume that the cost of such facilities is a good approximation of liquidity costs in general. There is a cost associated with revolving facilities even if — as often is the case — they are not drawn upon.

According to the Ofwat analysis the cost of undrawn credit facilities is around 35-45 bps and on average firms were assumed to have the credit facilities for the amount of around 10 per cent of the value of their debt. This implies the liquidity cost of around 3.5-4.5 bps.

Combining debt issuance and liquidity cost gave a range of 6.5-10.5 bps.

We assume that differences in the nature of the business means that NERL would have less need of revolving credit facilities than water companies do, so we take the lower end of the 3.5-4.5bps liquidity cost range. Given that NERL's debt is assumed to be A+ and hence relatively less complex to find buyers for, we assume that issuance costs are at the lower end of the 3-6bps range. That gives us an overall combination of 6.5bps, which we round to 7bps.

[1] PwC (2017), "Company specific adjustments to the WACC", page 23.

16 Apppendix 8: Analysis of HAL's beta

At Q6 Fraport and AdP were considered the most relevant comparators for HAL. We shall take as a working assumption, for the purposes of estimating NERL's asset beta, that that continues to be the case.

16.1 Beta of AdP and Fraport

In the chart below we report the evolution of AdP and Fraport unlevered betas based on 2-years and 1-years of daily data, estimated against both domestic and European indices.

Figure 16.1: 2-year unlevered betas of AdP and Fraport (vs domestic index)

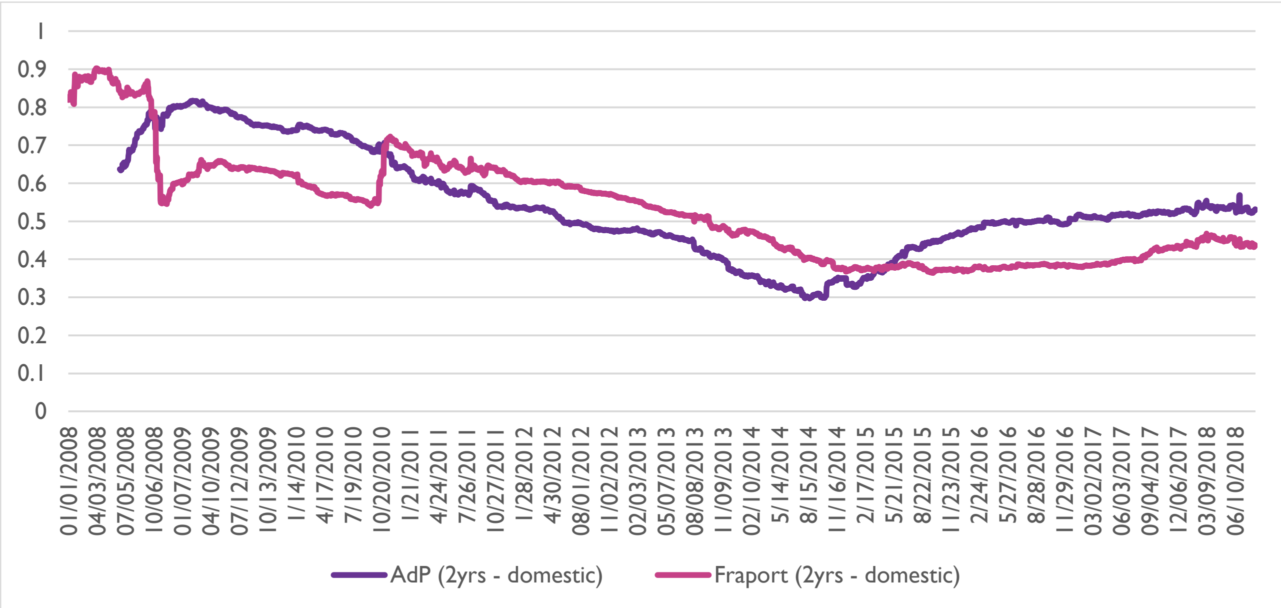


Figure 16.2: 1-year unlevered betas of AdP and Fraport (vs domestic index)

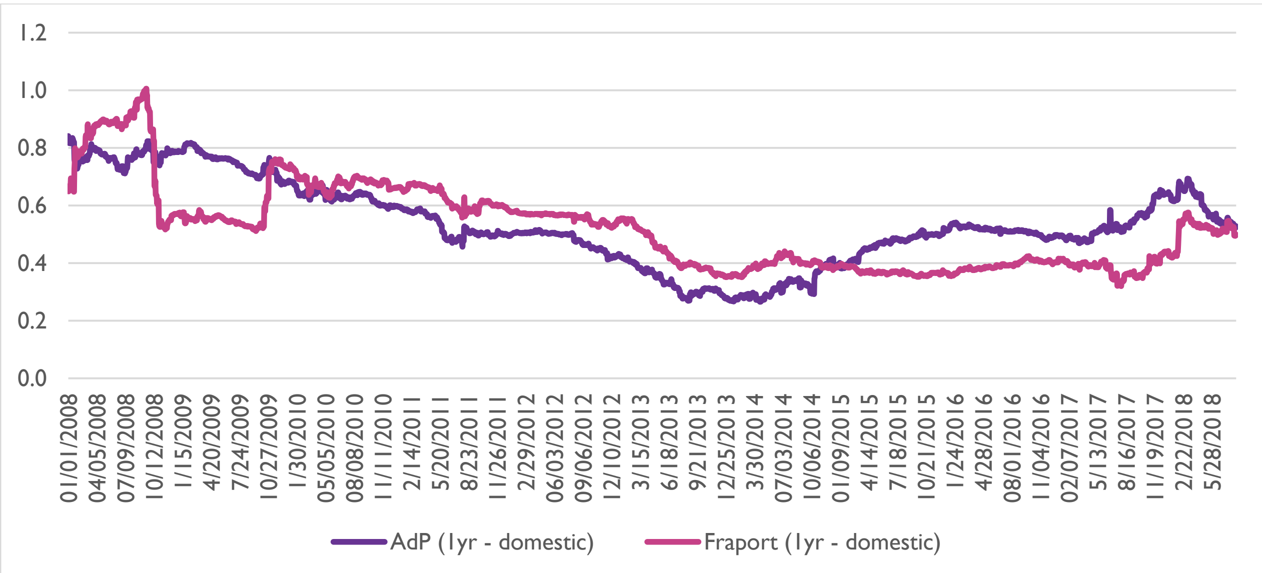


Figure 16.3: 2-year unlevered betas of AdP and Fraport (vs European index)

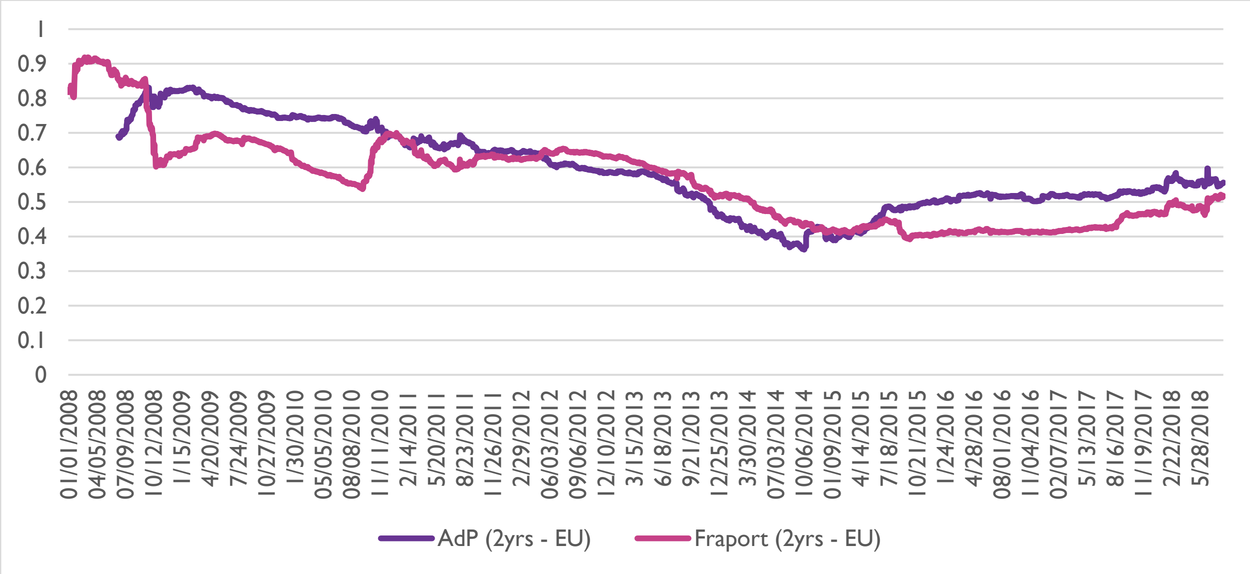
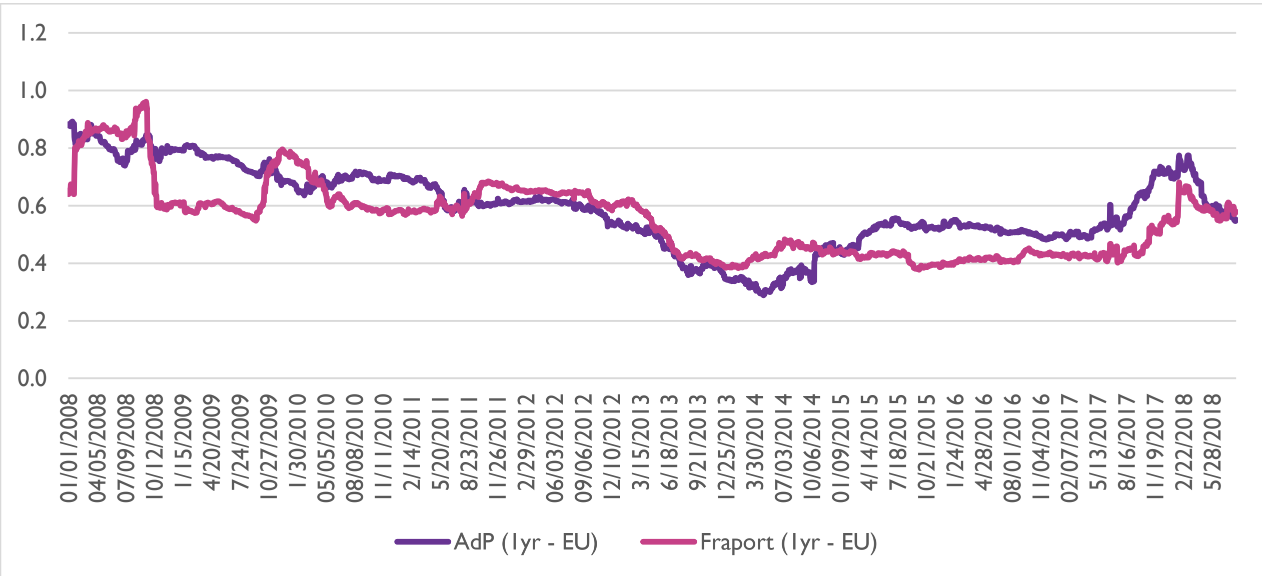


Figure 16.4: 2-year unlevered betas of AdP and Fraport (vs European index)



Our spot estimates for 2-years and 1-year beta estimates, based on our data cut-off date, obtained with a domestic and European index for AdP and Fraport, are summarised in the table below.

Table 16.1: Unlevered betas at 07/08/2018

Index	Airport	2-years beta	1-year beta
Domestic index	AdP	0.53	0.53
	Fraport	0.44	0.50
EU index	AdP	0.56	0.55
	Fraport	0.52	0.58

Based on the figures of Table 16.1, the 2-years equally-weighted average beta (in which we give equal weight to the figure obtained with the domestic index and that obtained with the European index) is 0.55 for AdP, and 0.48 for Fraport.