Considerations for UK regulators setting the value of debt beta

Report for the UK Regulators Network

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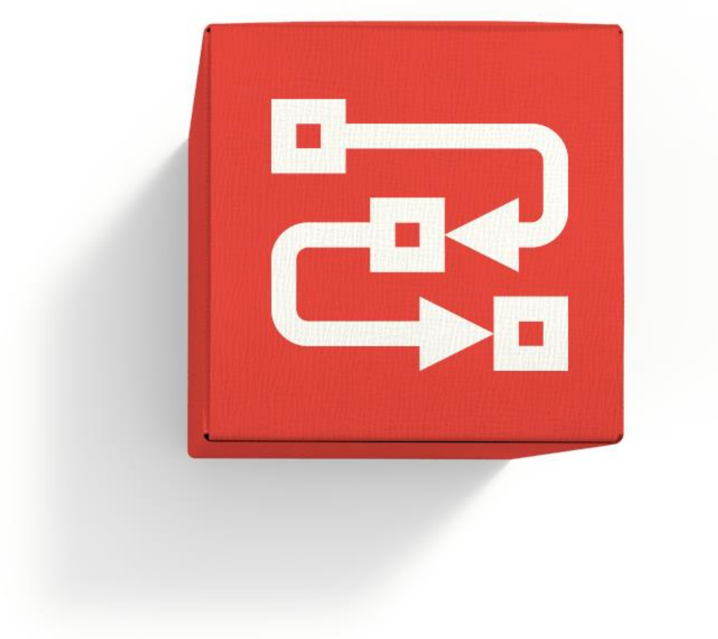

FINAL REPORT

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1. INTRODUCTION[2]

The debt beta is a relatively less researched component of the weighted average cost of capital (WACC) within the general financial economics literature and more specifically in the context of regulatory finance. This report offers a literature review of the methodologies used to estimate the debt beta, and of the ways in which different regulators (including members of the UK Regulators Network, UKRN) have used debt beta in estimating the WACC. It draws on these to identify key insights for future regulatory determinations.

The rest of this section provides context for this paper. Section 2 reviews a number of methodologies that can be used to estimate the debt beta. Section 3 summarises the approaches regulators have taken to the debt beta. Section 4 discusses some of the other practical issues relevant to UK regulators' approach to the debt beta. Section 5 presents key insights for how UK regulators may think about the debt beta in future determinations. Two appendices to the report provide further detail on the 'structural' method for estimating the debt beta and a bibliography of the documents referenced throughout the report.

1.1. THE ROLE OF DEBT BETA IN CALCULATING THE WACC

Within the capital asset pricing model (CAPM), a company's exposure to systematic risk is characterised by its asset beta, which itself comprises of the systematic risk to equity returns (equity beta) and the systematic risk to debt (debt beta):

$$\beta_A = \beta_E \frac{E}{D+E} + \beta_D \frac{D}{D+E}$$

In setting the cost of equity component of the WACC, regulators and their advisors typically:

- collect market data on the 'raw' equity beta;
- de-lever the raw equity beta to derive an asset beta; and
- re-lever the asset beta to get an estimate of the equity beta for the regulated company.

The de-levering and re-levering steps use gearing estimates – typically 'market based' gearing values for de-levering and a 'notional' gearing assumption for re-levering.[3,4] An estimate of the debt beta is also required for both of these two steps, although UK and international regulators have often used a simplifying assumption that the debt beta is zero, for reasons we discuss further below.

[2] This report has been prepared by CEPA together with Professor Robin Mason. Professor Mason is Pro-Vice-Chancellor (International) at the University of Birmingham and a Member of the Competition Appeal Tribunal, having previously been a member of the Competition and Markets Authority (and its predecessor, the Competition Commission). Professor Mason has published extensively on corporate finance issues, including in regulatory contexts, and is a co-author of the 2018 report 'Estimating the cost of capital for implementation of price controls by UK Regulators' for the UKRN. He has acted in a personal capacity in this work.

[3] In this context 'market based' gearing means the gearing of the comparator companies used for the empirical analysis of asset beta. In this de-levering stage, it is sometimes also referred to as 'empirical' or 'actual' gearing.

[4] The de-levering and re-levering process also involves (implicit or explicit) consideration of the debt profile of the actual and notional companies.

It is worth noting that the objectives and the application of a debt beta assumption are different during the de-levering and re-levering steps of regulators' equity beta calculations:

- The de-gearing of comparators is about *measurement* of asset beta – the aim of using the debt beta in this context is to make as accurate as possible an assessment of the asset beta of the target company as part of an empirical exercise of beta estimation. That means it is important that the debt beta is representative of measured debt betas of the comparator companies.
- The re-gearing is to ensure that the calculation of the re-levered equity beta *reflects the notional capital structure* of the target company. In principle, this may require a debt beta assumption higher or lower than that used to measure the asset beta of comparator company(s), as the gearing assumption of the notional company may be higher or lower than the gearing of the comparator company(s).

The impact of using a debt beta in the de-levering and re-levering calculations is low if notional gearing is close to the comparators market-based gearing. However, if the comparators have gearing that is much lower or higher than the notional gearing level, the impact of an assumption of a zero debt beta may be more material. This effect was illustrated in Ofgem's RIIO-2 Sector Specific Decision and is an issue we return to in Section 4.[5]

In addition, the impact of the debt beta in the re-levering calculation may depend on how evidence of comparator companies' gearing is practically used within the re-levering calculation (e.g. to inform the notional gearing assumption) as well as the de-levering step used to measure asset beta. For example, if the equity beta is re-levered using the average gearing of a sample of comparator companies, and the same debt beta is used for all companies, it can be shown that the re-levered equity beta is independent of the debt beta.[6]

Given that the debt beta reflects the systematic (i.e. non-diversifiable) risk borne by debt investors, both in the actual and notional target regulated company, in theory debt beta may also be assumed to vary with the assumed gearing and portfolio of debt of the target company in question (actual and notional). For example, the responsiveness of debt returns to market movements may in principle be influenced by the target company's:

- gearing;
- debt maturity profile;
- share of debt that is inflation-linked; and
- relevant tax regimes.

All of these factors may differ between the comparator companies and the assumptions adopted for the notional target company. How material these issues are in practice to the appropriate debt beta assumption, both in the de-levering and re-levering stages of UK regulators' equity beta calculations, is unclear. As we discuss in later sections of this report, there is little empirical evidence on how gearing levels affect debt betas and even less (or no) evidence of the impact of regulated companies' debt portfolio on the debt beta.

More generally, there are a range of methodological and computational issues with all the approaches that UK regulators have typically used to estimate debt beta. It is generally a challenging parameter to estimate in a statistically robust and accurate as other studies for the UKRN and UK regulators have highlighted.[7]

As we discuss in the next section of the report, some estimation methods often have poor statistical properties, but they may have strong theoretical foundations or benefit from the fact they are consistent with the approach used to estimate other components of the WACC. Other methods may be appealing for their relative simplicity, stability and

[5] See Ofgem (2019), Figure 11.

[6] We understand this is why the New Zealand Commerce Commission (NZCC) choose not to use a debt beta assumption in their Input Methodologies for estimating the WACC (NZCC, 2010).

[7] See Indepen (2018).

clarity, but may be more sensitive than statistical methods to the assumptions used to derive the debt beta estimate.

1.2. Why review the use of debt betas now?

The above discussion illustrates the significant theoretical, empirical and practical issues in accurately estimating debt beta to apply in the de-levering and re-levering stages of regulators' equity beta calculations. Given that debt betas have typically been considered to have a relatively small impact on the overall WACC of regulated businesses – while adding complexity to the WACC calculation – it is understandable that a simplifying assumption that the debt beta is zero has been used in the past, both by regulators and other practitioners commenting on the WACC in UK regulated sectors.

Why then review the use of debt beta now in UK regulatory WACC determinations?

Financial economic theory would suggest that debt beta should typically be (strictly) positive for regulated businesses and recent trends in UK regulatory reviews has increasingly been to use a positive debt beta assumption.[8] There is also a potential practical reason that differences between the gearing of comparator companies and notional gearing may be increasing for the sample of comparator companies typically used by UK regulators to estimate beta, thus increasingly the materiality of the debt beta in the overall calculation of the WACC.

In the UK, the precedent of accounting for a non-zero debt beta in regulatory decisions can be traced back to the Competition Commission's (CC) Q5 airport review (2007). The CC review was *foundational* in regulators' consideration of debt betas. But the CC itself was clear that further work was required by regulators in future:

> "Because this is the first inquiry in which we have carried out a detailed analysis of the debt beta, we consider it appropriate to choose cautiously from within the range. The subsequent analysis uses a point estimate for the debt beta of 0.1, ie towards the bottom-up end of the range. **We expect that others will want to take forward work on the use of debt betas in regulatory cost of capital decisions and review additional evidence as it becomes available**."[9] (emphasis added)

Both academics and regulators have advanced the debate on debt betas in the 12 years since the CC's determination. With a number of UK regulators either recently making or about to make decisions on the WACC in their periodic reviews, now is an opportune time to survey the landscape and draw lessons for future decisions on the debt beta.

[8] See Indepen (2018).

[9] Competition Commission (2007) Annex F – Cost of capital, para. 106

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2. METHODOLOGICAL CONSIDERATIONS

This section reviews the methodologies that have been used by academics and practitioners to estimate the debt beta. We note the purposes of different methodologies, and their strengths and weaknesses. We also review the literature on the relationship between the debt beta and companies' gearing levels and briefly discuss a range of other factors, related to capital structure, that may impact debt beta estimates for the target company.

2.1. Overview of methodologies

There are broadly four approaches to estimating debt betas:

- Direct
- Indirect
- Structural
- Decomposition.

We will argue that each method has its advantages and disadvantages. As a result, no one method is demonstrably superior to the others. Each has its uses for regulatory decision-making: none can or should be discounted entirely, but none should be relied on exclusively.

How much weight should be given to a particular approach will vary with the regulatory context and specific details. For example, as we will explain below, CAPM–based estimates (which fall under the group "direct methods") often have poor statistical properties but have the benefit of being theoretically well-founded and consistent with other components of the WACC – in particular, the cost of equity. How much weight should be placed on estimates using this direct method will then depend on the exact statistical properties of the estimates (which will vary across companies and sectors), and the importance for consistency with other parts of the WACC.

2.1.1. Direct method

The Direct, or CAPM based, method for estimating debt beta involves regressing observed excess bond returns on the Market Risk Premium (MRP).[10] This has parallels with how the CAPM beta is estimated for equity.[11]

The CAPM is typically used to estimate the cost of equity for regulated firms but is seldom used to estimate the cost of debt. This is because it is usually straightforward to observe market data about the cost of debt, whereas the cost of equity has to be inferred. Specifically, regulators can observe yields to maturity on debt of a similar maturity and risk characteristics to that of regulated companies with leverage at the targeted level. (A caveat will be noted below). A second reason why the CAPM has not been relied on by regulators for estimating the cost of debt is its poor statistical properties. When estimating debt betas, it is often (but not always) the case that estimates have low statistical significance; are volatile over time; take on implausible values (e.g. negative ones); and/or have overall low explanatory power (indicating that the CAPM is a poor model for accounting for the cost of debt); and so on. These problems are usually attributed to the low frequency of debt data – corporate bonds are traded (sometimes far) less often than equity, so there are fewer observations with which to work.

A few caveats to this account are in order.

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[10] For this reason, the direct method is also referred to as the 'regression approach'. See Europe Economics (2019).

[11] Under the CAPM, the expected return on debt is expressed as: $C_D = R_f + \beta_D \times MRP$. For the direct method, this means that the debt beta is the coefficient on the MRP in a linear regression. The debt beta can also be stated and estimated, e.g. using the decomposition method discussed below, as the Market Debt Premium (MDP) divided by the MRP, i.e. $\beta_D = \frac{C_D - R_f}{MRP}$.

See Indepen (2018) for further discussion on the definitional issues associated with the debt beta.

First, while market yields are readily observable, these are not the same as expected returns, since the latter take account of default. As noted in Wright et al. (2018), the yield to maturity is the internal rate of return of the bond (and, for a zero-coupon bond, the expected return to maturity), but calculated on the assumption of no default. Yet default on corporate debt both happens and is quite clearly priced by markets. (We return to this point below, when discussing structural methods). As a result, the true expected return on corporate debt is strictly less than the yield. This point is typically ignored or neglected. In principle, ignoring / neglecting this will tend to give higher debt beta estimates, on the assumption that default is positively correlated with overall market returns. Quite how large an effect this has is an open question. Regulated firms in the UK are, on the most, part required by their licences to retain an investment grade credit rating. This would point towards lower default premia – but not zero, since clearly default risk remains. Wright et al. (2018) report estimates from UK bond yield data, using techniques developed by Afik and Benninga (2010, 2014), indicating default premia of less than 10bps for an A-rated 10-year bond, and around 20bps for a BBB rated bond.

Second, while it is true that CAPM-derived debt betas often do have poor statistical properties, they should not be discounted entirely just for this reason. After all, many of the same criticisms can be levelled at estimates of equity betas: while the statistical significance of individual estimates tends to be good (standard errors are small), the overall explanatory power of CAPM regressions is low.[12] Moreover, equity beta estimates can be unstable, varying considerably over time, with choice of data frequency, and depending on the market index used (among other aspects). Nevertheless, the CAPM is widely used by regulators, and not just in the UK, to estimate the cost of equity because it is theoretically well-founded – and hence less susceptible to *ad hoc* adjustments – and well understood by all stakeholders. These same considerations support at least *some* weight being attached to estimates of debt betas being derived from CAPM regressions.

There then come a range of practical but important matters, many of which are familiar from equity beta estimation:

- Comparators: which companies and debt instruments (see below)?
- Index: which market index should be used?
- Frequency: should daily, weekly or monthly data be used?
- Estimation window: should 2-year, 5-year and 10-year (or some other length) estimation windows be used?
- Estimation method: should ordinary least squares (OLS), (generalized) autoregressive conditional heteroskedasticity (G)ARCH, or some other method (e.g., Kalman, Blume and Vasicek adjustments) be used?

A specific practical consideration, related to the comparator choice question, is the choice of the debt instruments that are used for the regression analysis. We discuss this issue further in Section 2.2 (as we consider it has wider implications beyond the direct method). Relevant questions for the sampling process in the CAPM regressions include:

- What is the appropriate maturity for the debt instrument?
- Should the direct method look only at fixed-coupon ('vanilla') or inflation linked bonds?
- What is the appropriate credit rating for the bond?

Some, but not all, of these considerations were explored in a recent consultancy study by PwC for the Civil Aviation Authority (CAA) into the debt betas for Heathrow Airport Limited (HAL) and for NATS. The findings are summarised in Table 2.1.

[12] Multi-factor models (e.g. Fama and French, 1993 etc.) appear to do a better job.

Table 2.1: PwC's assessment of the impact of different methodological choices on debt beta estimates

Methodological choice	Impact
OLS or GARCH	Both estimation techniques produced very similar results.
Period of estimation	Using data since 2016 produced higher estimates than longer time periods.
Data frequency used for estimation	2-year and 5-year regressions using daily data produced negative debt betas. 5-year regressions using monthly data produces a debt beta estimate of around zero for NATS and in the range of 0.05-0.1 for HAL.
Benchmark equity index as proxy of market portfolio	The three equity indices used give broadly similar results in terms of the profile of debt betas, but FTSE All Share gives slightly higher debt beta estimates, especially for HAL and when using monthly data. The difference is around 0.01 for daily data and up to 0.07 for monthly data.
Company debt or bond index	Debt betas for the iBoxx non-financials 10+ index are higher than for bonds from HAL in more recent years.

Source: PwC (2019b)

Another practical issue arises in using regression-derived debt betas in regulatory decision making: how should they be used when the point estimates are negative, or the relevant confidence interval straddles zero as a result of large standard errors? (As the table above points out, and also confirmed in Europe Economics (EE, 2019), this is not uncommon). Generalising from this particular issue: how much regulatory weight should be placed on evidence that may be unstable (statistically), counter-intuitive, or just implausible? There are a few aspects to this broad question.

First, if a piece of evidence is simply implausible, then of course no weight should be placed on it. But since implausibility can be in the eye of the beholder, there is a need to give clear reasoning for discarding the evidence. Second, if there is an explicit regulatory view on a matter – for example, that debt betas must be non-negative – then this view should be incorporated in the estimation procedure (this is a standard procedure in econometrics, although not often used in regulatory decisions). Thirdly, there is a question of how point estimates with large standard errors should be used in regulatory decisions. One response to this question is to look to decrease standard errors through the choice of the frequency of data observations. This is a somewhat contested issue when estimating equity betas; for example, the authors of Wright et al. (2018) could not agree on the appropriate frequency. Arguably, it matters even more for debt betas, where thin trading data tend to limit the frequency that can be used. It may be that confidence intervals are irreducibly large. But the size of the standard errors is not the only factor that matters; provided an estimator is not biased, the point estimate is still informative.[13]

To illustrate these points, consider the (not atypical) case, in which the CAPM-based (point) estimate of a debt beta is lower than estimates derived by other methods (see below); but there is a large standard error attached to the CAPM estimate; and suppose that a range of possible values of the debt beta has been arrived at from other methods. In this case, an in-the-round regulatory decision may be to choose a debt beta at a point lower in the range than if the CAPM estimate had not been calculated. How much lower will depend, of course, on a number of factors, such as standard errors, consistency with other pieces of evidence, and regulatory practice and precedent. This helps to highlight the point that in addition to the range of methodological and practical considerations associated with just estimating debt beta, there are wider practical challenges in bringing together the evidence base to reach a balanced regulatory decision. We return to this issue in later sections of the report.

[13] Having a confidence interval that straddles zero introduces the greatest analytical challenge when addressing the question (in statistical language, testing the hypothesis): *does an independent variable have an effect on the dependent variable?*

A regulator is less interested in this hypothesis, and more interested in the size of the effect. In this view, the main concern with a debt beta confidence interval that straddles zero is that it is counter-intuitive: we do not think that the expected return on debt is less than the risk-free rate.

2.1.2. Indirect methods

There are potentially numerous indirect ways of arriving at a debt beta, and we will not attempt to be exhaustive. Instead, we will comment on a particular approach that has recently been advocated by Oxera (2019), based on earlier work by Schaefer and Strebulaev (2008). The approach here is to estimate how sensitive excess debt returns are to excess equity returns; and then multiply equity betas by this elasticity to derive debt betas. Schaefer and Strebulaev (2008) performed this exercise on US corporate bond indices, using indices to avoid the problems noted earlier arising from infrequent bond trades. Oxera, working with Professor Schaefer, has updated this with data on sterling-denominated bonds issued by certain UK regulated companies (National Grid, Severn Trent, United Utilities and Pennon Group) from 1998 to 2018.

The main regression involves (excess) bond returns as the dependent variable against company equity returns and the UK government bond index returns. (The latter is included to overcome an endogeneity problem: both debt and equity returns, left- and right-hand variables in the regression, are correlated with government bond returns. Inclusion of government bond returns on the right-hand side then controls for this fact).

In Schaefer and Strebulaev (2008), and in Oxera's update of this work, the elasticity is small, especially for firms with higher credit ratings. For the four firms in Oxera's study, the elasticities are in the range 0.016-0.042 (although neither the estimates nor the standard errors are reported in Oxera's report – these values are inferred from other figures given). When multiplied by equity betas in the range 0.43-0.61, the resulting debt betas are very low – in the range 0.01-0.04 – and with many of the debt estimates reportedly not statistically significantly different from zero.

It is not possible to give a full assessment of these results without more details than are given. For example, it is not clear whether the low statistical significance of the debt betas comes from low statistical significance of the elasticity estimates, although this seems likely. The general approach can, however, be commented on. The aim of Schaefer and Strebulaev (2008) was to show that so-called structural models (see the next sub-section for further explanation), while generally poor at explaining credit spreads, can nevertheless give a reasonable account of hedge ratios (i.e. the sensitivity of corporate bond returns to changes in the value of equity). Naturally, therefore, Schaefer and Strebulaev estimated this sensitivity, and then matched the estimated sensitivity with values obtained from simulations of structural models. The purpose of the work was not to estimate debt betas (i.e. the sensitivity of corporate bond returns to changes in the value of the market index).

Why, then, use this indirect method – why might it be preferable to a direct, CAPM-based method of estimating debt betas? It does not have a particular theoretical advantage. It is correct that structural models account well for this hedge ratio – this is the point of Schaefer and Strebulaev (2008); and structural models are theoretically well-founded (see the next sub-section). But the implication then is that structural methods should be used directly to calculate debt betas, as is discussed in the next sub-section. Nor does the statistical performance of this indirect method appear to be better. From what Oxera reports, the statistical significance of the debt betas is low; in contrast, it seems that the CAPM-estimated debt beta for National Grid (which is higher: 0.2) is statistically significant.[14]

In summary, there appears to be little reason to place greater weight on this indirect estimate of debt betas than on CAPM-based direct estimates.

2.1.3. Structural methods

So-called structural methods are based on Merton (1974) and others' insight that debt and equity are contingent claims on the assets of a firm, the value of which is uncertain. Contingent claims (i.e. derivatives) pricing can then be used to value the debt and equity. Specifically, equity can be viewed as a call option on the firm's assets, and debt a put option, with a strike price equal to the face value of debt. With particular assumptions made (e.g. that the

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[14] On page 21 of Oxera's (2019) report, it is reported: "If (again for July 2013 – June 2018) we simply regress returns on a portfolio of National Grid debt against the FTSE we obtain a coefficient of 0.20 (t = 2.48)".

value of the assets follows a particular stochastic process over time), the Black-Scholes (1973) formula can be used to value those options. In turn, the debt beta can be calculated from the resulting values.

Cooper and Davydenko (2007) give an account of how this can be done relatively easily, relying on parameter inputs that are (relatively) easy to observe – the gearing level; the volatility of equity returns; and the observed spread (yield to maturity minus the risk-free rate) on debt – or estimate – the equity beta. Appendix A to this report offers further detail on the approach.

There are a few advantages to this approach. The first being that, like the CAPM, a structural model such as this has rigorous theoretical underpinnings. This allows it to be well understood (once understood) by stakeholders, since the underlying assumptions are clear, as are the arguments leading from them to the conclusions drawn. It also insulates the approach from *ad hoc* factors and adjustments that parties on all sides of a regulatory argument may wish to make. The second advantage, discussed further in the next section on debt betas and gearing, is that it allows de-/re-leveraging calculations to be done in a consistent and rigorous way, since the dependence of the debt beta on the level of gearing is explicit in the approach.

In turn, there are a number of disadvantages to the approach. The first – and for practical and regulatory purposes, perhaps the more important – is that it is an approach that is unfamiliar to regulators, regulated firms and other stakeholders. We are not aware of any regulators that currently make use of this approach in calculating or estimating debt betas. This is not an insuperable argument, of course, since regulatory innovation does occur (and indeed, UK regulators have often led in the adoption of new innovations, eventually to become best practice). Nevertheless, it is a factor, and certainly one that means that this approach should not be relied on exclusively.[15]

Secondly, structural approaches are known not to offer a complete account of credit spreads. As noted by Feldhütter and Schaefer (2018):

> "The structural approach to credit risk, pioneered by Merton (1974) and others, represents the leading theoretical framework for studying corporate default risk and pricing corporate debt. While the models are intuitive and simple, many studies find that, once calibrated to match historical default and recovery rates and the equity premium, they fail to explain the level of actual investment-grade credit spreads, a result referred to as the 'credit spread puzzle'."

In a similar vein, Huang and Huang (2012), having assessed a range of structural models, show that "structural models can explain only a small portion of [investment grade] corporate yield spreads once the models are calibrated to be consistent with historical default rates and losses (as well as the equity risk premium)".

More recent studies, however, hold out more hope. For example, Feldhütter and Schaefer (2018) argue that once default probabilities are estimated properly, the credit spread puzzle becomes less puzzling. Du, Elkamhi and Ericsson (2019) find the same if asset volatility is time-varying. Nevertheless, the general view remains that structural approaches provide poor predictions of bond prices. For debt beta purposes, the concern then is that if structural approaches are poor at explaining (expected) debt returns, then there may be bias in the calculations of debt betas based on them. (In a similar but not identical way, CAPM-derived equity betas may suffer from the deficiencies of the CAPM in explaining expected equity returns. Some argue that Fama-French-type models provide a closer match to observed returns. The equity betas from these models typically differ from CAPM-derived beta estimates).

To illustrate the method outlined in Appendix A, consider the following parameter values:

- Gearing: 40%
- Equity volatility: 30% (per annum)

[15] The Brattle Group (2016) argue that structural methods are complex, particularly for "[National Regulatory Authorities] with more limited resources". We disagree: the approach is relatively simple, requiring just a few lines of e.g. Matlab code and a runtime of a few seconds to solve; but it is unfamiliar.

- Debt spread (yield to maturity minus the risk-free rate): 100 basis points
- Equity beta: 0.7

The resulting debt beta is 0.16. Since the debt beta depends linearly on the equity beta, it moves in step with this: an equity beta of 0.6 results in a debt beta of 0.14, for example.

The example helps to highlight a third potential disadvantage with this method: that it is sensitive to the parameters used within the calculation, including gearing, the equity beta and equity volatility.[16] The result of the worked example above is most sensitive to the equity volatility parameter used: if this is 50% rather than 30%, then the resulting beta is instead 0.05. Since equity volatility can change quite significantly, this may present a challenge in deciding on the appropriate estimation period. The dependence of the debt beta on the level of gearing under this method is discussed in the next section.

The sensitivity of the approach to particular parameters is compounded by the fact that this method has to date not been used in UK regulatory proceedings. As a result, there is also no precedent of how the assumptions that it requires should be applied and justified in practice to reach a judgement on the cost of capital. While we have set out above the potential advantages of the structural method in that it has a theoretically sound foundation and would require regulators to be clear on their underlying assumptions (e.g. on the relationship between gearing and debt beta), within the context of a regulatory proceeding and decision-making process it is currently untested. However, past regulatory practice should not in itself prevent from UK regulators considering alternative methods where they offer positive insights, and as discussed above, UK regulators have in the past adopted new and innovative approaches that have over time become best practice.

2.1.4. The decomposition approach

The decomposition is a form of indirect approach but is sufficiently well-known that it merits a separate discussion. This approach was first used by UK regulators in the CC (2007) airports review. In this approach, various deductions are made from the observed market debt premium to leave the component of the premium attributable to systematic market risk; the debt beta is then this component divided by (an estimate of) the MRP.

EE (2019) use the following decomposition formula referencing the CC (2007) decision:

$$\beta_D = \frac{(1 - P_D) \times (DP - LP) - P_D \times (R_f + L)}{MRP}$$

where DP is the debt premium, LP is liquidity risk premium, R_f is the risk free-rate, P_D is the probability of default and L is the percentage loss given default.

During its 2007 airports review, the CC favoured the decomposition approach on the basis that it was a well-established method and had recently been used by leading academic researchers to estimate the systematic risk of debt securities. The CC also favoured the decomposition approach compared to other approaches it considered at the time (specifically, the direct method), because it considered it could be more confident that it was observing how much compensation lenders were asking for in exchange for bearing systematic risk.[17] One of the other advantages often cited with the decomposition approach, is that it can be less volatile than the other statistical approaches that have been used in UK regulatory proceedings to estimate debt beta.[18]

However, the formula above also shows there are a number of practical issues to address in this approach. How many components are included, and how large they are, will vary and, accordingly, so will the resulting debt beta.

[16] These parameters in turn affect the maturity profile of debt, which is imputed in this approach.

[17] CC (2007), p. F24. The CC's comparison was with the direct/CAPM-based method and assumes that the input assumptions to the decomposition method can be estimated appropriately.

[18] PwC (2019)

Indepen (2018) notes that the quality of the derived debt beta under the decomposition approach depends on the quality of the risk premia estimates that are used in the decomposition formula.

It is commonly agreed and uncontroversial that an estimate of a premium relating to default risk should be deducted. In EE (2017), this is the only deduction that is made. In a number of other approaches, including the CC (2007), deductions are also made for an estimate of a premium relating to liquidity risk.

Arriving at definitive estimates of each of the components is far from straightforward. We have commented already on the likely size of the default premium for regulated utilities in the UK: it is probably quite small, although larger than zero: Wright et al. (2018) estimated these to be of the order of 10bps for an A-rated 10-year bond, and around 20bps for a BBB rated bond. By way of comparison, the first regulatory use of the decomposition approach, CC (2007), took the default premium to be in the range 14-38bps. More recently, EE (2018) has argued for a default premium of 4bps (the product of a default probability of 0.2 per cent and a percentage loss given default of 20 per cent). But estimating default probabilities is itself not a straightforward task: Feldhütter and Schaefer (2018), for example, argue that defaults are highly skewed: there are periods with few defaults, and periods with many defaults. As a consequence, historical default rates are poor predictors of *ex ante* default probabilities. This skewness in the distribution of defaults presents a challenge in estimating a time-invariant, forward-looking default premium. There appears to be broad consensus that recovery rates for regulated networks in the UK should be higher than for other corporates (as reflected, for example, in credit ratings for regulated networks), so that default premia are likely to be at the lower end of estimated ranges.

In terms of the liquidity premium, it should be noted first that there is no single accepted approach to the estimation. Most authors find evidence of a liquidity premium. Hibbert et al. (2009) provide a good summary of the theory and empirical practice up to 2009; Schestag et al. (2016) assess a range of liquidity measures. The CC (2007) concluded, following a review of a number of academic studies, that the premium lay in the range 30-41bps. Aquilina and Suntheim (2016) look at the liquidity premium for UK corporate bonds over the period 2008–2014, using a range of liquidity measures. They estimate that, on average, the liquidity premium for investment grade bonds is around 0.01bps (0.01% of the overall spread, but not statistically significant at the 95% level). For speculative bonds, they estimate the liquidity premium to be 13.5bps, or 3.35% of the total spread. These estimates are, however, not very stable across different measures of liquidity and they vary considerably over time. Bongaerts, de Jong and Driessen (2017) find considerably larger effects of liquidity – 55bps or more (they consider different notions of liquidity) – but for US corporate bonds over the period 2002-2013. This latter point is also found by van Loon et al. (2015), who look at GBP-denominated investment-grade corporate bonds over the period 2003-2014. They estimate that just before the start of the credit crunch, in 2006-2007, average liquidity premia were near zero; during the crunch, the liquidity premium rose to almost 250bps (approximately 50% of credit spreads), even on A-rated bonds; but had fallen back to less than 30bps for A-rated bonds by the end of their study period. They also find that, in general, bonds with a lower credit rating have higher liquidity premia.

Others argue for yet further deductions: for example, a tax premium (Elton et al., 2001); or Fama-French factors; or some other component that has yet to feature but can be argued to affect debt premia.

As well as these practical considerations, the decomposition approach also has a few conceptual challenges. It is not clear in this approach that the various components deducted are independent of systematic market risk. For example, it is plausible that default risk is negatively correlated with overall market returns. As Chen et al. (2019) observe: "It is common practice in the empirical literature to decompose credit spreads into a liquidity and a default component, with the interpretation that these components are independent of each other. Our model suggests that both liquidity and default are inextricably linked". To date, it appears that decomposition approaches used in UK regulatory processes have either ignored correlations between the components or implicitly assumed it to be absent. We consider this issue merits closer attention if used in future regulatory reviews.

Another conceptual consideration is that the decomposition approach does not give a sense of the statistical significance of the beta estimates. The typical means of addressing this is to calculate a range of values – high and low, say – and then choose judiciously within the range.

Despite various challenges, the decomposition approach is still a useful source of evidence for regulatory decisions, all the more so since it is now familiar and has established UK regulatory precedent. It should be viewed, however, alongside other methods and not as the sole approach. In that regard, we consider the decomposition approach particularly helpful in helping to interpret estimates from different methods – what does a low debt beta estimate based on the direct or other methods imply for the assumption one has to make about the decomposition of the debt premium? This, in turn, would support careful consideration of how the different components of the WACC are set.

2.1.5. Summary

We have reviewed four approaches to estimating debt betas, noting the advantages and disadvantages of each. Our overall conclusion is that there is no one approach to estimating debt betas that dominates all others. Rather than a single source of truth, there is instead a body of evidence that regulators should draw upon.

As a result, regulators have to exercise their judgement in weighing up that body of evidence before determining the debt beta. In this regard, the debt beta is very similar to its equity counterpart: regulators look at a range of evidence and approaches when estimating the equity beta; the same should be true of the debt beta. Another similarity should be the judicious use of the CAPM: it is an imperfect model for both equity and debt betas (admittedly worse for the latter) but has the great benefit of being well understood and theoretically founded. For this reason, if seeking to apply a debt beta assumption within the cost of capital calculations, at least some weight should be attached to CAPM-derived estimates of debt betas.

We summarise the key points on each methodology in Table 2.2.

Table 2.2: Summary of the different estimation methodologies

Methodology	Strengths	Weaknesses
Direct (CAPM)	Theoretically sound foundation, making it less susceptible to *ad hoc* adjustments	Sensitive to the data used (i.e. poor statistical robustness)
Indirect	Offer an alternative perspective that is linked to theoretically sound structural models	Not specifically intended to use for estimating the debt beta, and potentially has poor statistical robustness
Structural	Theoretically sound foundation, providing a clear link between the assumptions and conclusions, including on the relationship between gearing and the debt beta	Not currently used by regulators. Appears not to fully explain the level of investment grade credit spreads Potentially sensitive to the assumptions made of parameter values (especially equity volatility)
Decomposition	Produces more stable estimates over time, subject to the values used in the decomposition	Sensitive to the choices made for the components used and their values

Source: CEPA and Mason

2.2. Debt beta and the capital structure

2.2.1. Impact of gearing levels

There is relatively little empirical evidence about how gearing levels affect debt betas. This is not surprising, given the general paucity of data. (This may explain in part why the issue has not featured previously in regulatory decisions). Schwert and Strebulaev (2014), however, provide some evidence based on Schaefer and Strebulaev's (2008) results. They take the debt betas estimated by Schaefer and Strebulaev for seven credit rating categories, and the average gearing level for observations in each category. The results are shown in Table 2.3.

Table 2.3: Debt beta and gearing for different credit ratings

Rating	AAA	AA	A	BBB	BB	B	CCC
Gearing	0.10	0.21	0.32	0.37	0.50	0.66	0.74
Debt beta	0.04	0.05	0.05	0.10	0.24	0.31	0.43

Source: Schwert and Strebulaev (2014)

They then regress debt beta on mean leverage by rating category. The resulting estimated equation is:

$$\beta_D = -0.09 + 0.63\,g;$$

where β_D is the debt beta, and g is the level of gearing. (Both coefficient estimates are statistically significant at the 95% level; the R-squared is 0.91).

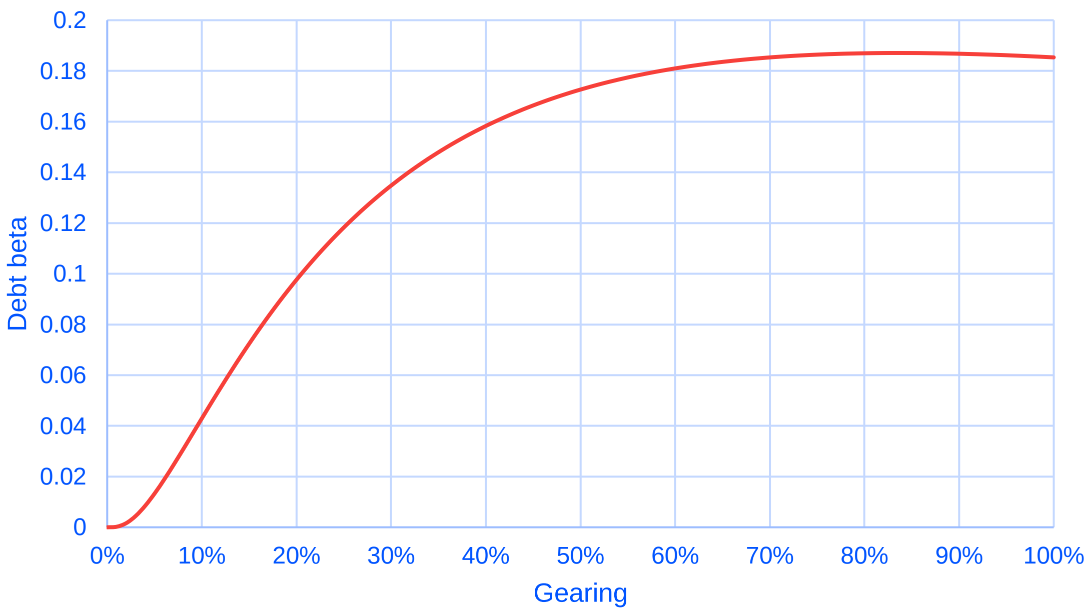
Evidently from this equation, a 10% increase in gearing leads to a rise in the debt beta (on average) of 0.063. Put differently, at 40% gearing, the average debt beta from this equation is 0.162; at 50%, 0.225; at 60%, 0.288.

Only limited weight should be placed on this evidence, however: it is clearly a partial exercise (Schwert and Strebulaev, 2014 have other objectives, and this part of the analysis is not a major focus for them) with a small number of observations. Moreover, it is not clear whether it is the level of gearing that is responsible for the variation in the debt beta, or whether it is instead the credit rating – the two are evidently correlated.

A related set of results is given by Schaefer and Strebulaev (2006) who, in addition to estimating debt betas by credit rating, also investigate their dependence on time to maturity. They find that as maturity increases, so do debt betas: in moving from 1-5 year maturity to 15+ years, the average debt beta increases by a factor of 4.[19]

All these empirical results are consistent with theory. In particular, debt betas should rise as gearing increases, as debt bears more non-diversifiable risk. The question is the extent of this effect. The structural approach described previously has the advantage that the dependence of the debt beta on gearing can be calculated explicitly. Figure 2.1 shows the outcome, using the same illustrative parameter values as in section 2.1.3.

Figure 2.1: Illustration of the debt beta against gearing using the Cooper and Davydenko (2007) method



Source: CEPA and Mason

[19] See their table XII, for example.

In this example, when gearing is 40%, the debt beta is calculated to be 0.16 given the input assumptions used. When gearing rises to 60%, the debt beta also rises, to 0.18, levelling off at around 0.19 for gearing levels above 70%. However, clearly different parameter values would result in different values, although the nature of the relationship between the debt beta and gearing would remain (Figure 2.1 should not, therefore, be interpreted to mean that for any company with gearing of 60% the debt beta is 0.18). Note also that the relationship is not linear, in contrast to the simple regression performed by Schwert and Strebulaev (2014). The debt beta rises from 0 when gearing is 0, and increases initially fairly steeply. However, for the levels of gearing typically observed for regulated firms and used by regulators, the debt beta is likely to be fairly stable.[20]

Overall, our view is that it is probably more important for regulators to get the overall level of the debt beta right: this is the more important factor, with the effect of gearing likely to be of second-order importance. This can be readily verified if needed, however, using the approach outlined in this section.

2.2.2. Debt maturity profiles

A related issue to the impact of gearing levels on debt beta, is the assumed debt maturity profile of the target company when estimating debt beta.[21]

In all of the estimation methods that are discussed above, an assumption of the target company's debt maturity profile is explicitly or implicitly used when estimating the debt beta, whether in selecting the relevant debt instruments in the regressions under the direct or indirect methods, or in deriving an estimate of the debt premium in the structural method or decomposition method.

When estimating the debt beta in the *de-levering* stage of the equity beta calculation, ideally we believe regulators should be seeking to estimate the responsiveness of debt returns to market returns for the actual debt portfolio of those comparator companies, as this would aid in more accurately measuring asset betas. We found relatively limited discussion of this issue within the recent UK regulatory literature, although found that regulators and their consultants have tended to consider debt beta estimates that derive from a range of evidence of UK corporate debt and company or sector specific debt at different maturities.

The same issue is also relevant to the *re-levering* calculation. Regulators typically assume (or their cost of debt calculations implicitly reflect) a notional debt maturity profile for the notional regulated company. Debt beta should, in theory, reflect this rather than a debt beta that happens to be measured. In principle, this might be higher than market (i.e. relevant comparator) debt betas as notional gearing might be higher, or it might be lower, because the expected debt maturity profile of the notional regulated company might be of shorter (or lower) duration than average profiles used to estimate debt beta one of the methods discussed above.

There are two issues here: consistency and materiality. As with the impact of gearing on debt beta, how material this issue is in practice to the appropriate debt beta assumption (both in the de-levering and the re-levering stages of beta calculations) is unclear, and may depend on how the evidence is brought together to reach overall regulatory judgements on debt beta. Further empirical work would need to be undertaken to test what is the responsiveness of the returns of the actual debt portfolio of target companies as compared to the maturity profile of the bonds and indices (e.g. the iBoxx 10-year+) that UK regulators have used to estimate debt beta.

The point on consistency is a broader issue, although highlighted by the maturity profile assumptions that may be made when measuring debt beta. In reaching overall judgements on the equity beta for notional regulated companies, if applying debt betas in this calculation, then UK regulators should as a principle, be seeking to ensure consistency throughout their WACC calculations. This means that the assumptions and estimates of debt beta should, as far as possible, be consistent with the purpose for which it is being applied in that particular stage of the

[20] The same structural approach indicates that debt betas also depend on: time to maturity, negatively; volatility of assets/equity, negatively; and the yield to maturity, positively.

[21] Debt betas may also be affected by the type of debt the actual / notional company holds. For example, index-linked bonds may have a different (likely lower) debt beta than nominal bonds of comparable maturity and rating. A number of UK regulated companies hold index-linked debt, but these are less common in other jurisdictions.

WACC calculation. We suggest that one of the implications of this is that UK regulators should not assume that the same debt beta assumption should necessarily be used in both the de-levering and re-levering stages of their equity beta calculations for UK regulated business.

3. REGULATORY PRECEDENT

In addition to theoretical considerations, regulators often place some emphasis on the precedents set by their past decisions and by other regulators' decisions. This section explains why regulatory precedent may be important in setting the value of debt beta and reviews the approaches and decisions UK regulators have used.

3.1. THE ROLE OF REGULATORY PRECEDENT

An important role of economic regulation, in the UK and elsewhere, is to facilitate investment in essential infrastructure. Since such investment is typically recouped over a long time period, consistency and predictability of regulatory decisions over time is important.

One of the ways in which regulators provide such stability and predictability is by balancing empirical evidence against the precedent set by their past decisions and other regulators' past decisions. This is true for decisions on the components of the WACC, but also on other regulatory decisions such as the methodology used to set operating and capital expenditure allowances.

Accounting for past precedent is increasingly important for decisions where the empirical evidence may still leave room for judgement. As the previous section has shown, that applies to the debt beta. As we show in the next sub-section, UK regulators that have set a non-zero debt beta have placed weight on similar precedents. Implicitly, regulators who have assumed that the debt beta is zero have also relied on their own precedent and the general tendency to make this simplifying assumption.

3.2. PAST REGULATORY DECISIONS

The majority of evidence on the use non-zero debt betas that we have found is from the UK. Internationally, there is some evidence of telecoms regulators setting non-zero debt betas – a report by the Body of European Regulators for Electronic Communications (BEREC, 2018) shows that three European regulators have used a non-zero debt beta, with values ranging from 0.1 to 0.22 and a mean of 0.14 in the fixed lines market and 0.16 in the mobile market. The European Commission (2019) has suggested that an estimate of 0.1 would be reasonable for European telecoms regulators to use.

In the energy sector there is less evidence of non-zero debt betas being assumed outside the UK. The Australian Energy Regulator (2018) considered the use of non-zero debt betas in its Rate of Return Guideline, but rejected the approach.[22] Likewise, the New Zealand Commerce Commission (NZCC), in its 2010 and 2016 reviews of its approach to price controls (the 'Input Methodology Review') also considered but rejected the use of non-zero debt betas. The NZCC considers that while the use of non-zero debt betas is more theoretically sound than using a zero debt beta, it deliberately uses a notional gearing that reflects the average gearing of the comparator sample and thus the cost of capital estimate is independent of the debt beta (NZCC, 2010). The Council of European Energy Regulators' (CEER, 2019) annual summary of price control decisions does not report values for debt betas, although this does not mean that some European energy regulators do not use a non-zero debt beta.

Looking at UK regulatory decisions, as discussed in the introduction, the CC (2007) airport review was foundational in framing how the debt beta should be considered. The CC looked at both the direct (CAPM regression) approach and the decomposition approach. It favoured the latter, stating that it was more difficult to rely on the direct method because of estimation problems relating to:

[22] "Our view is that the debt beta should continue to be zero. It appears market practice to assume a debt beta of zero and Damodaran has made the same assumption in his works. Further, the debt beta of businesses in the provision of regulated energy network services are likely to be low due to the relatively low risk of supplying regulated energy network services" (Australian Energy Regulator Office, 2018).

- the relatively poor quality of the data on returns to debt holders;
- the poor statistical properties of the regressions; and
- the difference between historical and notional gearing levels.

Using the decomposition approach, and different estimates of the liquidity premium and default premium, and a mid-point assumption of market risk premium of 3.5%, the CC estimated a range of 0.09-0.19 for the debt beta. It noted that the range would widen to 0.07-0.26 if the full range of the market risk premium (2.5-4.5%) was used in the calculation. The CC decided to use the analysis cautiously as it was its first attempt at this estimation, and set a point estimate of 0.10 for the debt beta.

Regulators and regulated companies have advanced the debate on debt beta since the CC's determination. Table 3.1 summarises recent decisions on the debt beta by UK regulators.

Table 3.1: Recent UK regulatory decisions on the debt beta

Regulatory review	Review stage	Year	Debt beta used
CMA (Bristol Water)	Decision	2015	0
Ofcom (MCT)	Decision	2015	0.10
Ofcom (BCMR)	Decision	2016	0.10
NI Utility Regulator (GD17)[23]	Decision	2016	0.10
NI Utility Regulator (RP6)	Decision	2017	0.10
Ofwat (PR19)	Methodology decision	2017	0.10
Ofcom (WLA)	Decision	2018	0.10
Ofgem (RIIO-2)	Methodology decision	2019	0.10-0.15
CAA (NERL)	Decision	2019	0.10
Ofwat (PR19)	Draft Decision	2019	0.125
Ofcom (LLCC)	Decision	2019	0.10

Source: CEPA review of regulatory determinations, supplemented by UKRN (2019) and NERA (2018)

Different regulators have taken different approaches to inform the value of the debt beta that they set. For example, Ofcom appears to have relied on its own regulatory precedent, while also considering a range of third-party estimates and/or precedents.

A number of Ofcom determinations also explore the relationship between debt beta and gearing. We note that Ofcom has typically set a debt beta of 0.10 or greater, while applying a notional gearing assumption that is typically in the range of 30-40%. This compares to typically around 60% (or higher) notional gearing used in the energy and water sectors.

The relationship between gearing and debt beta was also raised in the Competition and Markets Authority (CMA, 2017) appeal by Firmus Energy, with the CMA noting that it was within the Utility Regulator's judgement to assume that the debt beta need not be changed for modest changes in gearing. The CMA also emphasised that it is reasonable for the Utility Regulator to make different decisions on the debt beta based on the range of evidence available to it at different regulatory determinations.

In the box that follows we present a short case study summarising the methodologies and considerations that went into Ofwat's PR19 draft determination. Further detail on the consultancy studies that regulators have relied on when considering the debt beta is provided in the next sub-section.

[23] Firmus Energy appealed the Utility Regulator's decision to the CMA, with the debt beta being raised as an issue under one of the grounds for appeal. The CMA upheld the Utility Regulator's decision.

Case study: Evidence used for Ofwat's PR19 Draft Determination

Ofwat's approach to PR19 was grounded in a view that it is highly probable that the absences of defaults on debt in the water sector since privatisation provides support for a positive debt beta, as concluding otherwise implies that systematic risks such as recessions do not increase the probability of default.

Ofwat commissioned a study from Europe Economics (EE, 2019a) to inform its views on the WACC in general, including on debt beta. EE considered two empirical methodologies for estimating the debt beta:

- the CAPM approach; and
- the decomposition approach.

Europe Economics CAPM approach

In its CAPM approach, EE regressed the returns of both iBoxx Non-financial 10-year + A/BBB indices and returns on selected water bonds against the FTSE All-Share index. EE used 1-, 2- and 5-year trailing windows with daily, weekly and monthly data frequencies in the regression.

EE found the debt beta estimate to vary considerably across different data frequencies and time horizons, with estimates often negative. The approach suggested that the debt beta estimate ranges between 0.04 (average across all estimates) and 0.16 (average across non-negative estimates). EE concluded that estimates of the debt beta with the CAPM approach:

- are volatile and lie within a wide range;
- are often measured as being negative for periods of time; and
- are often not statistically significantly different from zero.

EE concluded that the CAPM approach does not provide conclusive results.

Europe Economics decomposition approach

In its decomposition approach, EE looked at the two-year trailing average value of the debt beta using data from 2010 onwards. The results yielded a debt beta range of 0.10 – 0.25 with a February 2019 value of 0.18. For the two-year trailing average debt beta, EE arrived at a range of 0.125 – 0.175 with a February 2019 value of 0.15. Overall, EE recommended a debt beta value in the range of 0.10 – 0.17, with a central estimate of 0.15.

Ofwat's decision

Ofwat concluded that the CAPM approach does not provide conclusive results, whilst nothing that the decomposition approach provides support for a debt beta higher than the 0.10 estimate used in its PR19 Methodology Decision in 2017. Ofwat stated that its position is supported by the CC (2007) favouring the decomposition approach over the CAPM approach.

At the same time, Ofwat acknowledge the possibility that high debt beta estimates may not be sustained into 2020-25. On the weight of evidence, Ofwat adopted for its draft determination a debt beta estimate of 0.125 for the 2020-25 period.

Source: CEPA review of Ofwat's Draft Determination and supporting publications

3.3. Consultancy studies informing regulators' decisions

As with other components of the WACC, regulators' decisions have been informed by consultancy studies that have deployed different methodologies. CEPA, typically in advising regulators, has tended to consider evidence on empirical beta estimates in the round when reaching overall views of the range for beta and cost of equity.[24] Other consultancies have taken more specific approaches to the debt beta in calculating the cost of equity – these are discussed below.

Europe Economics (EE) has advised the CAA and Ofwat on their most recent price control reviews – respectively, of NATS and of water companies in England and Wales – which cover the period 2020-24/25. EE has stated a preference for the decomposition approach over the direct CAPM approach. This is because of the sensitivity of the

[24] We have also tended to implicitly assume a zero debt beta given the various complexities and issues associated with its estimation that have been discussed in previous sections of the report.

CAPM approach to the data and time period used – as discussed in the previous section. EE's recommendations were:

- For Ofwat (EE, 2019a), a range of 0.1-0.17 and a point estimate of 0.15. This was based on: the CAPM approach estimates ranging from 0.04 (average across all estimates) to 0.16 (average excluding negative estimates); the decomposition approach range of 0.1-0.25 using daily estimates and of 0.125-0.175 using 2-year trailing averages; and the 28 February 2019 decomposition estimates of 0.18 (daily) and 0.15 (2-year trailing average) (see earlier text box).
- For the CAA (EE, 2018 and 2019b), EE focused primarily on the decomposition approach, and tested the sensitivity of results to different estimates of the cost of debt, the probability of default and liquidity premiums. EE initially estimated a debt beta of 0.19 for NATS in 2018, then updated the estimate to a range of 0.19-0.25 (with a central estimate of 0.22) in 2019.

PwC has advised the CAA on different topics related to the WACC for the NATS 2020-24 price control, as well as for the upcoming price control of HAL. PwC recommends taking a balanced approach to debt beta that is informed by a range of sources, including the CAPM method, decomposition method, and regulatory precedents.

PwC's own estimates using the CAPM approach (PwC, 2019a), use the iBoxx non-financials A and BBB 10+ year indices between 2006 and 2018 to produce a range of -0.09 to 0.26 for the debt beta. It recommended a spot value of 0.10 to reflect upward market trends in the preceding 18 months, and in light of past regulatory decisions.

Subsequently (PwC, 2019b), PwC critiqued a study by Zalewska (2019) that concluded that the debt beta on bonds issues by NATS were statistically significantly negative for most of the period investigated and statistically insignificantly different from zero in the last few years. PwC replicated Zalewska's analysis and produced similar results, but also found a persistent difference between debt beta estimates for HAL and for NATS, with the latter being lower. PwC suggest that the difference could be because NATS:

- has significantly lower gearing than HAL;
- has a higher credit rating (AA) than HAL (mostly A-); and
- NATS is a critical national asset with regulatory protections and government support.

NERA has advised Ofcom on the WACC for a number of recent reviews (including Mobile Call Termination (MCT); Business Connectivity Market Review (BCMR); and Wholesale Local Access (WLA)). NERA's (2015, 2018 and 2019) approach was to primarily rely on academic and regulatory evidence. In addition to insight from the likes of Shaefer and Strebulaev (2008) – as discussed in Section 2 – NERA notes the relationship between credit rating and debt beta found in previous studies, for example:

- Fama and French (1993) estimate debt betas of 0.22 for BBB-rated bonds, 0.21 for A-rated, and 0.20 for AA-rated.
- The Brattle Group (2016) estimates debt betas of 0.10 for the BBB- to BBB+ rating category, and 0.05 for the rating categories A- to AAA.

Regulated companies have also commissioned consultancy studies into the debt beta. These have typically tended to argue for a zero or low debt beta. One such recent example is the study by Oxera (2019) for the Energy Networks Association, which uses the indirect estimation method described in Section 2.

4. THE IMPACT OF DEBT BETA IN REGULATORY DECISIONS

The previous section presented recent regulatory precedent on debt beta in UK regulatory reviews. A question that arises from that is how material these assumptions have been to the estimate of the WACC and, ultimately, the level of prices that UK consumers pay for the services provided by UK regulated businesses.

As we discussed in Section 1, one of the reasons why a number of regulators and practitioners have sometimes used a zero debt beta as a simplifying assumption is because, under certain conditions, it has a relatively limited impact on the cost of capital estimate. However, its estimation in the context of regulatory proceedings can add computational complexity.

We suggest that UK regulators need to ask themselves two questions:

- First, what factors will influence the materiality of the impact of debt beta in their cost of capital calculations?
- Second, what level of materiality justifies the additional complexity involved in estimating debt beta, given the significant uncertainties and challenges in estimating other parameters of the WACC?

Within the time period for this assignment, we have not been able to test the materiality of the impact of regulators debt beta assumptions within each regulatory review. However, in Table 4.1 we have illustrated how the assumption on debt beta impacts the notional equity beta of the regulated business under different assumptions of actual company gearing, notional gearing and unlevered beta.[25] A number of practical implications potentially arise from this analysis in considering the use of debt beta in future regulatory reviews.

First, although highly stylised, this analysis illustrates quantitively the point made earlier in the report that as the difference between the actual enterprise value gearing of listed comparator companies and UK regulators assumptions of notional gearing increases, then the asset beta will be re-levered at a materially different gearing and the impact of regulators' assumptions on debt beta increases. Therefore, as the extent of the difference between the actual gearing of listed comparator companies and notional gearing increases, the simplifying assumption of using a zero debt beta arguably becomes less sustainable.[26]

Second, while under certain conditions debt beta can have a relatively small (e.g. second decimal place) impact on the notional equity beta calculation, there is a strong theoretical and intellectual case for not ignoring debt beta. It is theoretically reasonable for regulators to assume a non-zero debt beta and we note that even relatively small changes in the notional equity beta assumption will have some impact on the revenues / prices set for regulated companies, which UK consumers ultimately pay. Therefore, while the impact of the use of a debt beta may be small, it is for the regulators to determine what, in their view, is and is not economically significant and material in fulfilling their statutory duties. Should a regulator decide to use a non-zero debt beta, there is then a responsibility on it to ensure that the debt beta estimate used is well-evidenced and is applied consistently in the WACC calculation.

[25] The relationship between notional equity beta, gearing and debt beta is more generally illustrated by Ofgem in its RIIO-2 Sector Methodology Decision paper. See Figure 11 in Ofgem (2019).

[26] Europe Economics make the same point in their report for Ofwat's PR19 draft determinations.

Table 4.1: Stylised analysis of the relationship between debt beta, gearing and notional equity beta

Notional vs. Actual Gearing difference of 10%	Raw equity beta = 0.7				Raw equity beta = 0.6			
Debt beta	0	0.05	0.1	0.15	0	0.05	0.1	0.15
Raw beta	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Actual comparator gearing	50%	50%	50%	50%	50%	50%	50%	50%
Notional gearing	60%	60%	60%	60%	60%	60%	60%	60%
Asset beta	0.35	0.38	0.40	0.43	0.30	0.33	0.35	0.38
Re-levered equity beta	0.88	0.86	0.85	0.84	0.75	0.74	0.73	0.71
% change in re-levered equity beta [1]	0.0%	-1.4%	-2.9%	-4.3%	0.0%	-1.7%	-3.3%	-5.0%

Notional vs. Actual Gearing difference of 5%	Raw equity beta = 0.7				Raw equity beta = 0.6			
Debt beta	0	0.05	0.1	0.15	0	0.05	0.1	0.15
Raw beta	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Actual comparator gearing	55%	55%	55%	55%	55%	55%	55%	55%
Notional gearing	60%	60%	60%	60%	60%	60%	60%	60%
Asset beta	0.32	0.34	0.37	0.40	0.27	0.30	0.33	0.35
Re-levered equity beta	0.79	0.78	0.78	0.77	0.68	0.67	0.66	0.66
% change in re-levered equity beta [1]	0.0%	-0.8%	-1.6%	-2.4%	0.0%	-0.9%	-1.9%	-2.8%

Notional vs. Actual Gearing difference of 0%	Raw equity beta = 0.7				Raw equity beta = 0.6			
Debt beta	0	0.05	0.1	0.15	0	0.05	0.1	0.15
Raw beta	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
Actual comparator gearing	60%	60%	60%	60%	60%	60%	60%	60%
Notional gearing	60%	60%	60%	60%	60%	60%	60%	60%
Asset beta	0.28	0.31	0.34	0.37	0.24	0.27	0.30	0.33
Re-levered equity beta	0.70	0.70	0.70	0.70	0.60	0.60	0.60	0.60
% change in re-levered equity beta [1]	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Source: CEPA analysis

Note 1 – change in re-levered equity beta relative to zero debt beta assumption

Finally, we note that the stylised analysis illustrated above assumes a constant debt beta assumption on the de-levering and re-levering stages of the analysis. We discussed in Section 2 why it may not be appropriate to assume that is the case. Where that is the case, then clearly the impact of the debt beta assumptions used in the separate de-levering and re-levering stages of the notional equity beta calculation may differ compared to the illustrations we provide above.

CEPA economics matters

5. INSIGHTS FOR REGULATORS

In this section we draw out the key lessons from the academic and consultancy studies, and from past regulatory precedents, for how regulators may think about the debt beta in future determinations.

5.1. KEY TAKEAWAYS

Both empirically and theoretically, it is reasonable to assume that debt betas are typically positive for regulated companies. This is likely to hold after accounting for regulated companies' investment grade credit ratings, and the levels of gearing typically seen in these sectors.

Our review suggests that no one method for estimating debt beta is clearly superior in estimating how far away from zero the debt beta is likely to be:

- CAPM-based regression estimates generally have poor statistical properties, but have the advantage of theoretical foundations and consistency.
- Structural models offer a potentially useful method of estimating debt betas, but they are open to criticism about how well they match market data.
- Indirect estimation gives another perspective, but has a lack of theoretical basis and (potentially) has poor statistical properties.
- The decomposition method avoids some statistical problems but encounters others. It provides a clear and generally less volatile result, but also relies on various assumptions and decisions of what should and should not be included in the decomposition formula – e.g. inclusion of default and/or liquidity premiums.

All methods involve some choices familiar from equity beta exercises: estimation technique; data frequency; period for estimation; choice of portfolios; etc. Over time, regulators have honed in on the choices that they consider are best suited to their sectors. So, as regulators investigate debt betas further, it is reasonable that they will similarly develop an evidence base for how to make those choices with regard to the debt beta. In doing so, **it is important that a consistent approach is applied to the debt beta and to other components of the WACC**. This includes consistency when de-levering and re-levering, taking into account how debt betas may vary with gearing levels.

We note that UK regulators should not necessarily use the same debt beta values in both the de-levering and re-levering stages of their equity beta calculations for UK regulated business. Indeed, there may be good reasons to believe that the estimates that are used should not be the same, depending on (explicit or implicit) assumptions about other components of the WACC. This has implications for how debt beta is both estimated and calculated in regulatory proceedings.

When it comes to the specific issue of the relationship between debt beta and gearing there is generally less information in the public domain. Nevertheless, there is empirical evidence, with theoretical backing, that debt beta increases with gearing. However, our view is that the effect of gearing on debt beta is likely to be of second-order importance, and that it is probably more important for regulators to get the overall level of the debt beta right.[27]

5.2. IMPLICATIONS FOR REGULATORY DECISIONS

As we have discussed throughout this report, there are a range of computational challenges in estimating debt beta. While UK regulatory reviews have increasingly applied debt beta assumptions in their WACC calculations, we would suggest that it is still possible to make good judgements on the cost of capital even in their absence. In certain circumstances, debt beta can have a relatively small impact on the cost of capital, but adds complexity to

[27] We suggest this is consistent with the position the CMA has taken in the Firmus Energy appeal (CMA, 2017).

the WACC calculation. There are, however, good theoretical reasons to assume that the debt beta is greater than zero and practical reasons to do so in the context of the comparator company evidence base used to estimate beta in the UK.

This study suggests that there is no one approach to estimating debt betas that dominates all others, as evidenced by the different methods used in studies and the different weights regulators have given to different evidence sources. This means that it is not possible to be prescriptive at a general level about what weights to attach to the different approaches – regulators have to exercise their judgement, and their decisions will depend on the details of each case. However, where UK regulators are applying debt beta assumptions, then similar principles to those that apply to the estimation of other components of the WACC can also be applied to the debt beta:

- **Consider methods with theoretical underpinning.** We believe regulators should at least give some consideration and weight to models with firm theoretical foundations such as CAPM-based regressions, while acknowledging the limitations of such methods.[28]
- **Consider a range of empirical evidence.** This also requires thinking about what evidence from one model might be saying about how a different model should be interpreted.
- **Draw on regulatory precedent to inform judgement.** This can be helpful in meeting broader regulatory objectives such as consistency of decisions. But, in doing so, it is important to consider the context in which past regulatory decisions were made, and their relevance for the decision at hand.

Lastly, we reiterate the need for consistency in the approach used to the debt beta and to other components of the WACC.

[28] The weight a regulator should place on debt beta estimates from CAPM-based regressions would depend on how sensitive the estimates derived are to the assumptions used and views on the overall statistical properties of the regressions. This will vary from case to case.

Appendix A THEORY BEHIND THE STRUCTURAL METHOD

Following Merton (1974), suppose that the value V of a firm's assets over time follows a geometric Brownian motion:

$$dV = \mu V\,dt + \sigma V\,dz$$

where μ and σ are parameters (the latter being volatility of the firm's asset value) and dz is an increment of a standard Wiener process. The firm is assumed to have a single class of zero-coupon risky debt of maturity T. In addition, there is a constant interest rate and a simple bankruptcy procedure: if at maturity the value of the assets is lower than the liability, the assets are handed over to the bondholders without any costs being incurred.

Equity can be viewed as a call option, and debt as a put option, on a firm's assets. With this, the Black-Scholes option pricing formula can be used to value these claims. Cooper and Davydenko (2007) show that Merton's formula can be written in the following form

$$1 - g = N(d_1) - g\,e^{yT}N(d_2) \quad (1)$$

where g is the gearing level, y is the promised yield spread,

$$d_1 = \frac{-\ln(g) - \left(y - \frac{\sigma^2}{2}\right)T}{\sigma\sqrt{T}}$$
$$d_2 = d_1 - \sigma\sqrt{T}.$$

Equation (1) has two unknowns: σ and T. The asset value volatility σ is difficult to observe. It is more straightforward to observe equity volatility σ_E. The two are related:

$$\sigma_E = \frac{\sigma N(d_1)}{1-g}. \quad (2)$$

We now have two equations in two unknowns, σ_E and T. These non-linear equations can be solved numerically, with the inputs being the gearing level g, the equity volatility σE, and the yield spread y. (Matlab code doing this is available on request.)

Berz and DeMarzo (2007) then show that the debt beta β_D is given by

$$\beta_D = \frac{(1 - N(d_1))}{g}\beta_E$$

where β_E is the equity beta.

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