Evaluation of the ARP–DRP framework

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Prepared for Energy Network Association's electricity distribution network operator and transmission owner members

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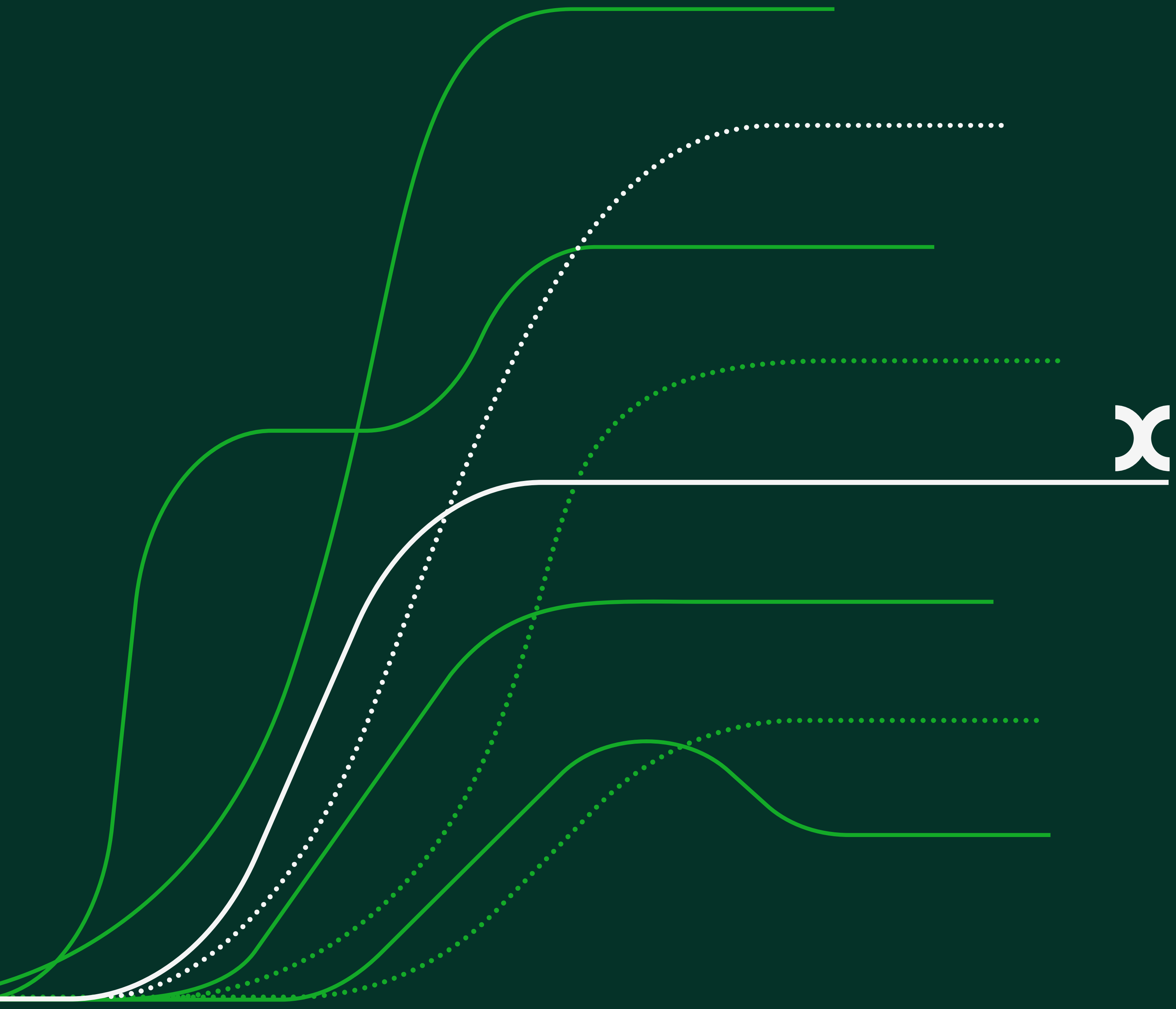

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Executive summary

It is uncontroversial that investors in the equity of a company would expect to earn a higher return than by investing in the debt of that company. The question is, how much higher?

The Asset Risk Premium to Debt Risk Premium (ARP–DRP) framework seeks to answer this question. It builds upon the observation that equity should expect a higher return than a debt claim on the same underlying asset.

There are two steps to the ARP–DRP framework. First, an estimation of the expected returns on debt in excess of the risk-free rate. This is derived from bond yields to maturity using robust estimates of expected loss from default.

The second step is an estimation of the asset risk premium (ARP) using the same asset beta and equity risk premium (ERP) assumptions as used in the Capital Asset Pricing Model (CAPM). This should be higher than the debt risk premium (DRP). A tighter lower bound can be obtained by extrapolating the DRP to 100% gearing.

We demonstrate in this report that for companies with low risk and asset volatility relative to the wider economy, the 'true' ARP should be higher than the ARP implied by extrapolating the DRP.

The ARP–DRP framework provides a powerful tool for evaluating the cost of capital and cross-checking results from the standard CAPM methodology commonly used by regulators to set the allowed returns on equity. The principles of the framework are not disputed.[1] Stakeholders have therefore focused their arguments on claims that measurement error is a reason not to apply the ARP–DRP framework. We disagree. Measurement error is present in the conventional CAPM framework used by regulators, and does not prevent it being applied. The main assumption embedded in the ARP–DRP framework is convexity in the relationship between DRP and gearing. We find empirically that this assumption is likely to hold for regulated network utilities and lead to underestimation of the ARP.

[1] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 24.

The level of the ARP suggested by the framework provides a lower bound rather than a point estimate of required equity returns for a price control. As such, the lower bound of ARP can be applied to narrow the cost of equity range suggested by the CAPM by eliminating parts of the range that provide an inadequate risk premium relative to debt.

For example, when applying the ARP–DRP framework to the Oxera RIIO-3 cost of equity range, we find that the CAPM cost of equity range should be truncated above the low end of the range.[2]

[2] Based on calculating the spot lower bound ARP and the parameters used in Oxera (2024), 'RIIO-3 Cost of Equity—CAPM parameters', 8 November.

1 Introduction

Setting the allowed return on equity is a challenging exercise for regulators, due to the unobservable nature of the cost of equity. In many regulated industries, the cost of equity allowance is based on the Capital Asset Pricing Model (CAPM). As with all asset pricing models, the application of the CAPM is subject to estimation error.

In its 2023 guidance paper, the UKRN recommended that regulators sense-check the point estimate of the CAPM using alternative methodologies. Specifically, the UKRN guidance paper suggests using market benchmarks as a cross-check, as long as the evidence bar for robustness is met.[3]

In this report, we explain the Asset Risk Premium to Debt Risk Premium (ARP–DRP) framework, building upon theoretical foundations, and make a case for how the framework helps to benchmark the regulatory allowed return on capital based on the CAPM as applied by Ofgem and other regulators in the UK. We also address criticisms raised by various stakeholders over the robustness of the framework, and thereby benchmark the level of measurement error in the ARP–DRP framework relative to the CAPM.

The report is structured as below.

- Section 2 explains the ARP–DRP framework and its role as a benchmark for the CAPM cost of equity.
- Section 3 considers application of the ARP–DRP framework ‘through the cycle’.
- Section 4 engages with questions about the degree of measurement error in the framework.
- Section 5 examines the relationship between gearing and debt premium, used to benchmark the asset risk premium (ARP).
- Section 6 concludes.

[3] UK Regulators Network (2023), ‘UKRN guidance for regulators on the methodology for setting the cost of capital’, p. 26, https://ukrn.org.uk/app/uploads/2023/03/CoC-guidance_22.03.23.pdf (accessed 19 January 2024).

2 Benchmarking costs of equity and debt

One approach to cross-checking the allowed return on equity employed both by the regulators and investors is comparison with the cost of debt observed in the market. In its simplest form, debt-based cross-checks compare the allowed return to equity with the allowed return on (new) debt. This builds on the principle that a security with higher risk needs to offer a higher potential return. As debt-holders have a priority claim ahead of equity investors over a company’s cash flow, equity investors are subject to greater risks and expect a higher return. Where this principle is breached by cost of equity estimates being too low relative to the market pricing of debt, this suggests an error in the cost of equity estimate.

A challenge arises when estimating the necessary level of the differential between the cost of equity and the cost of new debt. The ARP–DRP framework seeks to offer a solution. It builds upon the observation that equity and debt are two different classes of security on the same underlying asset.

2.1 Application of the ARP–DRP framework

2.1.1 Estimation methodology

The ARP–DRP framework builds upon the comparison of the cost of equity to the cost of new debt by isolating the risk premia on the asset and the underlying debt required by investors. We estimate the ARP–DRP differential as follows.

$$ARP = asset\ beta * (TMR - RFR)$$

$$DRP = CoND - expected\ loss - RFR$$

The ARP is calculated based on the CAPM parameters used by the regulators or suggested by other stakeholders.

In the debt risk premium (DRP) formula, the cost of new debt (CoND) is measured as the yield to maturity of the relevant iBoxx index. The ‘expected loss’ parameter represents the annualised probability of default multiplied by the losses that a debt investor will suffer if a borrower defaults. For BBB+ rated debt, we have estimated this parameter to be equal to 0.30%.[4] Subtracting the expected loss converts the CoND into an expected return.

To ensure consistent treatment of inflation in the calculation of the DRP, we use a nominal risk-free rate based on nominal zero-coupon gilt yields of maturity matching the modified duration of the specified iBoxx index.

2.1.2 Lower bounds for the ARP

The ARP (i.e. the risk premium on unlevered equity) should always exceed the DRP, because the DRP has a senior claim on the cash flows from the assets. If this was not the case, then investors would sell the equity and purchase the debt until the ARP exceeds the DRP. The question is, how much higher should the ARP be than the DRP?

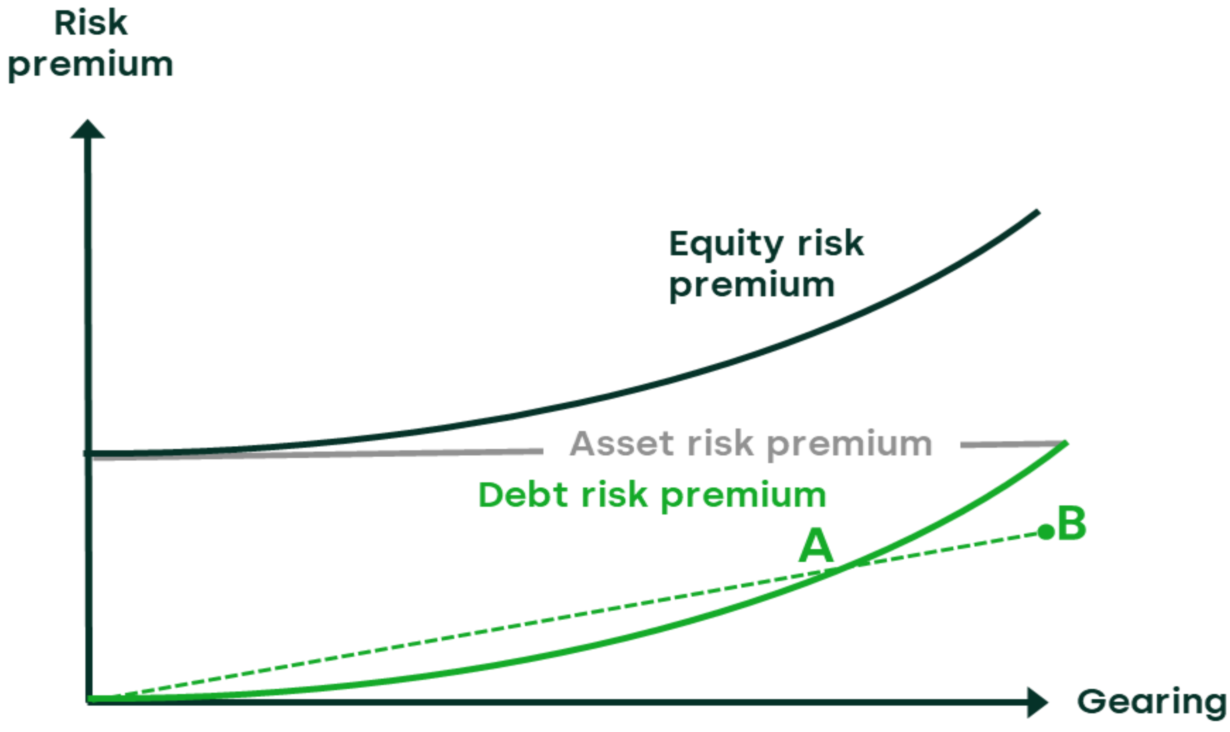
To establish a tighter lower bound on the ARP, we define an 'implied lower bound' by considering the relationship between risk premia and gearing.

Specifically, the DRP should increase with gearing. This increase in the DRP is driven by greater exposure of the value of debt to changes in the cash flows generated by the assets. In the standard Modigliani–Miller framework it follows that at 100% gearing, the DRP must equal the ARP as then the debt holders are the only claim on the asset.

The relationship between gearing and risk premia is illustrated in Figure 2.1 below. Estimating the exact function of DRP relative to gearing is not straightforward. As an approximation, we use linear extrapolation by the line given by the origin and the DRP at point A. The slope of the line is given by dividing the DRP by gearing (point A). Multiplying the slope by 100% gearing provides the DRP at point B. The DRP at 100% gearing serves as an 'implied' lower bound of the appropriate ARP level. We discuss the potential extent of measurement error implied by the extrapolation process in section 5 of the report.

[4] For the full methodology behind the 0.30% point estimate, see Oxera (2019), 'Risk premium on assets relative to debt', 25 March, p. 11, https://www.northerngasnetworks.co.uk/wp-content/uploads/2020/09/Oxera-2019-%E2%80%98Risk-premium-on-assets-relative-to-debt%E2%80%99-25-March.-1.pdf (accessed 24 September 2024). Our expected loss calculation uses annualised default rates based on Feldhütter and Schaefer (2018) that are higher than those reported by Moody's. Using Moody's reported default rates would produce a lower expected loss assumption, i.e. a higher DRP estimate. See Feldhütter, P. and Schaefer, S.M. (2018), 'The myth of the credit spread puzzle', *The Review of Financial Studies*, **31**:8, pp. 2897–2942; Moody's (2023), 'Annual default study: Corporate default rate will rise in 2023 and peak in early 2024', 13 March, Exhibit 36.

Figure 2.1 Relationship between risk premia and gearing



Source: Oxera based on Berk, J. and DeMarzo, P. (2019), *Corporate Finance*, 5th edition, Pearson, June, p. 536.

2.2 Methodological advantages

The ARP–DRP framework refines the comparison of the cost of equity to the cost of new debt in three significant ways.

First, the ARP and DRP are defined as risk premia on top of the risk-free rate. When the regulator sets the cost of equity in real terms, the ARP can be calculated by subtracting the real risk-free rate assumed by the regulator from the unlevered cost of equity. When the regulator uses nominal data for the cost of debt, the DRP can be calculated by subtracting the nominal risk-free rate. This removes the need to make any assumptions about inflation when calculating ARP and DRP.

Second, the ARP–DRP framework accounts for expected loss by a debt investor, therefore, better reflecting the expected return on debt than a direct read-across of the cost of new debt based on the market data. Any re-gearing is undertaken within a Modigliani–Miller framework.

Third, the ARP–DRP differential enables the estimation of a tighter lower bound for the cost of equity than simpler debt-based cross-checks. The ARP estimated by de-gearing equity risk premium (ERP) to 0% can be compared against the ARP implied by re-gearing the risk premium on debt to 100% gearing. The lower bound suggested by the ARP–DRP framework does not provide a point estimate for the return on equity, but rather allows to narrow the cost of equity range estimated by the CAPM and other indicators.

3 ARP–DRP 'through the cycle'

An overarching objection that has been raised against cost of equity estimates generated by the ARP–DRP framework and debt-based cross-checks more generally is that the results of these methodologies vary over the macroeconomic cycle.

Specifically, if regulators choose to set equity return based on a 'through the cycle' approach such that a stable total market return (TMR) is assumed, the ERP falls when the risk-free rate rises. Therefore, ARP will tend to be lower in a high interest rate environment. Conversely, in a low interest rate environment, ERP would tend to be higher leading to a higher ARP. Reflecting the results of debt-based cross-checks in the cost of equity determination therefore creates tension with a 'through the cycle' approach.

Ofgem, Ofwat, the CMA and their respective advisors have all questioned the use of ARP–DRP and debt-based cross-checks more generally, in the context of a 'through the cycle' approach to setting the allowed return on equity.[5] Their position can be summarised as follows.

Regulators have not historically used cross-checks to revise the allowed returns downward when the implied differentials were high—hence, it would be wrong to start applying these cross-checks when the differentials are low. The mechanics of the 'through the cycle' approach to setting the TMR for the cost of equity result in cost of equity being smoothed out over the long run. Therefore, regulators claim that adjusting the return on equity only when the premium relative to debt is low may lead to overcompensation of equity returns over the long term.

3.1 Response to the 'through the cycle' critique

It is correct to describe the debt-based cross-checks as reflecting current market conditions rather than a 'through the cycle' approach. Estimating the cost of equity from a spot, forward, or short-term average of the cost of debt will, by definition, reflect today's interest rates and risk premia.

[5] Competition and Markets Authority (2023), 'H7 Heathrow Airport licence modification appeals. Final Determination', 17 October, p. 215; CEPA (2024), 'PR24 Cost of equity', 11 July, p. 143.
[5] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 6; Ofgem (2024), 'RIIO-3 Sector Specific Methodology Decision - Finance Annex', July, pp. 107–109.

A ‘through the cycle’ approach to TMR is a regulatory policy choice that increases the stability of the return on equity. The downside of this approach is that it increases the probability that at any particular point in time the cost of equity allowance will be lower or higher than what the market requires.

The problem faced by regulators is that while companies and investors may also use a cost of capital that is smoothed over time within a regulatory period, they are likely to adjust the cost of capital across regulatory cycles to reflect the market conditions at the time. If the allowed return for any given price control is below the cost of capital, there is significant risk of under-investment. This is notwithstanding that actual returns in a previous price control may have been higher than the required return. When regulators set the price control they must be concerned that investors will always have the choice of investing in other industries and/or geographies that provide at least a return equal to their cost of capital.

On balance, a ‘through the cycle’ approach to setting the allowed return on equity is a policy choice that requires careful calibration to maintain investability. The ARP–DRP framework provides an important cross-check that will ensure a more realistic range for the cost of equity and thereby reduce the probability of underinvestment.

4 Addressing measurement issues of ARP–DRP

The ARP–DRP framework presents a robust way for evaluating the cost of capital and cross-checking the allowed return on equity set by the regulators. Stakeholders have therefore focused on identifying areas where there is scope for measurement error.

In particular, Ofwat's advisors have raised points around:[6]

- accuracy of parameter estimation;
- DRP estimate reflecting other risk factors such as beta risk;
- impact of inflation on the measurement of the DRP;
- estimate of the DRP at zero gearing;
- level of gearing of the benchmark index.

We will address these points in this section.

As an overarching point, all models of the cost of capital are subject to measurement error. While there may be some measurement challenges in estimating parameters in the ARP–DRP framework, similar or equivalent challenges are present in the CAPM estimation. For ARP–DRP to be a valid and useful cross-check, it only needs to improve on the measurement issues faced by CAPM, rather than be free of any measurement issues altogether. Therefore, the criticisms levied against the ARP–DRP framework are insufficient to dismiss its validity as a cross-check.

The ARP–DRP framework uses CAPM parameters as determined by the regulator to ensure that its results are internally consistent for a notional company. In addition to introducing information from the debt markets into the estimation framework, the 'rearrangement' properties of ARP–DRP relative to the CAPM reduce measurement error and provide new tests to improve comparability over time and across companies.

- The ARP–DRP framework configuration allows us to test the internal consistency of the parameters set by the regulator for the efficient notional company by providing an explicit link

[6] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February; CEPA (2024), 'PR24 Cost of equity', 11 July, p. 143.

between the allowed return on equity and the prevailing cost of debt.

- The transformation of the required return into asset and debt premia in the ARP–DRP framework provides an improved comparability of the resulting differential over time and across companies with similar asset risk through removing the risk-free rate to consider the relevant asset and debt risk premia.

4.1 Benchmarking measurement uncertainty relative to CAPM

It is intrinsic to setting the allowance for the cost of equity to estimate parameters that are not directly observable in the market and to exercise judgement in selecting the precise methodology for their estimation. There are numerous valid alternative assumptions and specifications of the CAPM cost of equity estimation used by regulators in the UK and internationally—for example, regulators have to make a decision on the preferred tenor of the risk-free rate, specification of the inflation wedge, methodology for the TMR estimation, as well as the selection of the appropriate beta windows.

The need to make these assumptions, as well as the availability of other academically accepted approaches for estimating the cost of equity, does not by itself make the approach to setting the cost of equity through the CAPM inappropriate. In comparison, the ARP–DRP framework requires relatively fewer assumptions. In particular, the key assumptions are the estimation of the expected loss and the necessary conditions for extrapolation of DRP to a 100% gearing level.

In comparison, the standard CAPM estimation has significant uncertainty in the estimation of most parameters.

- **Risk-free rate** requires definition of appropriate tenor (same as ARP–DRP), as well as consideration of appropriate premia and the inflation wedge (which does not affect DRP).
- **TMR** has a wide range of academically established estimation methodologies that lead to considerably different results (ARP–DRP allows to cross-check the appropriateness of the selected TMR assumption).
- **Beta** estimation requires exercise of judgement in selecting an appropriate sample of companies and window of estimation (ARP–DRP allows to cross-check the appropriateness of the selected beta).

In addition, the ARP–DRP framework presents a clear benefit relative to the CAPM estimation as it is not affected by the attenuation bias—a tendency of regression estimates of beta to be downward biased due to measurement error in the independent variable (market returns).

Therefore, our central benchmark is a consideration of the measurement uncertainty of the ARP–DRP parameters relative to the CAPM parameters.

The Ofgem 'early view' of the cost of equity published in the RIIO-3 Sector Specific Methodology Decision (SSMD) shows a range that spans from 4.57% to 6.35% from the low point to the high point. This implies a potential measurement error of up to 0.89% assuming the allowed return is set at the midpoint and the 'true' cost of equity lies within the defined range. This may be a significant underestimation of measurement error if credible ranges presented by other stakeholders were to be considered—for example, Oxera has estimated the CAPM range for RIIO-3 to be 5.70–6.83% (at 60% gearing).[7] SSMD cost of equity parameters are summarised in Table 4.1 below.

Table 4.1 'Early View' RIIO-3 cost of equity at 60% gearing

Parameter	Low	High
Risk-free rate	1.18%	1.18%
Total market return	6.5%	7.0%
Equity beta	0.64	0.89
Cost of equity	4.57%	6.35%

Source: Ofgem (2024), 'RIIO-3 SSMD Finance Annex', July, p. 99.

4.2 Consistency of the DRP parameter estimation

Ofwat's advisors have raised concerns over the inclusion of a forward premium in the cost of new debt calculation.[8] These criticisms are not a relevant issue for the ARP–DRP framework.

The ARP–DRP framework allows us to cross-check parameters that the regulator deems appropriate for the respective price control. Whether the regulator includes a forward premium, or other premia in their

[7] Oxera (2024), 'RIIO-3 Cost of Equity—CAPM parameters', 8 November.
[8] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 20.

allowed return methodology for any of the parameters, does not limit the validity of the ARP–DRP as a cross-check.

Forward premium adjustment does not have an impact on the DRP calculation, as any forward premium should be applied to both risk-free rate and cost of new debt—therefore, the forward premium is cancelled out when calculating the DRP.

4.3 Risk factors reflected in the DRP estimation

Another measurement concern that has been raised around the ARP–DRP methodology is the possibility that debt yields reflect a range of premia and risks, such as beta risk or inflation risk.[9] In addition, Mason and Wright have claimed that the observed debt spreads do not map clearly to combinations of observed frequency of default and plausible risk premia.[10] Following from this, Mason and Wright have suggested that the observed credit spreads are 'too high'.

The criticism that the debt yields reflect a wide range of risk factors is misplaced, as by definition the DRP captures a combination of risk factors faced by the business and priced by debt investors. For example, beta risk (and volatility) is one of the key factors affecting the pricing of the DRP within a Merton model framework. Moreover, beta risk is also a significant driver of the cost of equity. Hence, any beta risk present in the DRP should be strictly less than in the cost of equity.

The claim that the observed debt premia are not well explained by empirical models is not supported by recent academic literature. Research by Feldhütter and Schaefer has found that, on average, investment grade bond spreads predicted by structural models[11] have no statistical difference with actual spreads observed in the market.[12] In other words, structural models can effectively explain observed credit spreads of investment grade debt on average—there is insufficient evidence to claim that the credit spreads are 'too high' for investment grade debt. Therefore, the DRP is an informative data point for evaluating the cost of capital for utility companies.

[9] CEPA (2024), 'PR24 Cost of equity', 11 July, p. 143.
[10] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 3.
[11] In particular, structural models that include adjustments for more realistic loss given default and default boundaries seem to perform well in empirical testing.
[12] Feldhütter, P. and Schaefer, S.M. (2018), 'The Myth of the Credit Spread Puzzle', 14 January.

4.4 Inflation neutrality of ARP–DRP

Ofwat's advisors, Mason and Wright, have raised concerns over inconsistent treatment of inflation within the ARP–DRP framework.[13] It is unclear how this criticism applies to the framework, as in fact, inflation neutrality is an advantage of the ARP–DRP framework. As explained in section 2.1.1, estimates of ARP and DRP are internally consistent with respect to inflation, as the parameters are defined in terms of a risk premium that can be added on top of either nominal or real risk-free rates. This property avoids the need to make an inflation assumption for the calculation of the DRP, while at the same time maintaining consistency with the regulatory regime. Avoiding the need to make an inflation assumption for the cost of new debt is a direct improvement on comparing the cost of equity (levered or unlevered), adjusted for inflation, with the cost of new debt.

We calculate the ARP, based on the parameters specified by the regulator, i.e. CPIH-real risk-free rate and CPIH-real TMR. Thus, the implied benchmark level of ARP is directly comparable to the CAPM cost of equity estimates produced by the regulator. It is invariant to inflation assumptions.

We calculate the DRP based on nominal yields of the relevant iBoxx index—in the case of RIIO-3, iBoxx Utilities index, and yields of nominal zero-coupon gilts with maturity matching the modified duration of the index. By keeping the cost of new debt index and risk-free rate in nominal terms, we avoid the need to make an additional inflation assumption. Nominal bond index yields incorporate expected inflation and inflation risk based on the market expectations over the tenor of the bond. Gilts matched to the modified duration of the bond index should incorporate the same level of inflation expectations and risk. Therefore, through subtracting the risk-free rate from the debt index yields, we arrive at an inflation neutral DRP estimate. It follows, that the inflation measurement error of the DRP should be lower than its CAPM cost of equity counterpart.

4.5 DRP at zero gearing

In the Heathrow CMA appeal process, one of the parties questioned the assumption that the DRP curve starts at the origin.[14] The same question

[13] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 20.
[14] Competition and Markets Authority (2023), 'H7 Heathrow Airport licence modification appeals. Final Determination', 17 October, p. 216.

has also been raised by Ofwat's advisers.[15] The suggested implication of the DRP curve not starting at the origin is that the linear extrapolation—illustrated in Figure 2.1—would tend to overestimate the DRP at 100% gearing.

It is difficult to assess empirically the exact DRP level at 0% for an individual firm, as by definition a firm with 0% gearing does not have observable debt yields. For construction of a general DRP curve for a given industry at a single point in time, it is reasonable to assume that a firm with no debt faces zero DRP. This is consistent with the implications of 'structural' models of debt such as the Merton model. These models estimate probability of default and the associated risk premium as the probability that the value of a company's debt exceeds the value of the company. When the value of debt is zero this probability is therefore also zero, resulting in the DRP curve starting at the origin.

4.6 DRP at notional gearing (gearing of the benchmark index)

Another measurement issue raised both by the CMA[16] and Ofwat's advisors[17] is the level of gearing at point A in Figure 2.1 above, i.e. the point of the observed level of DRP used in the extrapolation. The criticism suggests that the level of gearing at point A, defined by the observed yields of the relevant iBoxx index, should also correspond to the gearing level of the index. Stakeholders correctly note that measuring the gearing of each constituent issuer of the iBoxx index is not a simple task, albeit not impossible.

However, this criticism is less relevant in the context of the ARP–DRP framework being used to cross-check the allowed returns in a regulated industry. Regulators use the iBoxx index to determine cost of debt for an efficient notional company. By doing so, they explicitly make an assumption that the index yields—and, by extension, the DRP implied by the index yields—are achievable by the regulated companies at the notional gearing level (e.g. 55% for Transmission Operators; 60% for Distribution Network Operators). Hence, dividing the DRP implied by yields on the index by notional gearing is equivalent to dividing the DRP of a regulated company by its notional gearing to get an ARP.

[15] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 20.
[16] Competition and Markets Authority (2023), 'H7 Heathrow Airport licence modification appeals. Final Determination', 17 October, p. 216.
[17] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 20.

In fact, not needing to measure the gearing of the benchmark index contributes to the strength of the ARP–DRP framework as a cross-check of the internal consistency of the regulatory parameters, including cost of equity, cost of debt and notional gearing. The framework checks whether the allowed return on equity is commensurate with the allowed return on debt for a notional company.

5 The relationship of the debt premium and gearing

Mason and Wright have challenged the assumption of convexity of the DRP curve necessary to prove that linear extrapolation results in an underestimate of the DRP at 100% gearing. To illustrate the point, they have provided results of two specifications of Merton models.

- Standard Merton model—which showed a convex DRP curve.
- Merton with jumps model—which showed a DRP curve which is partly concave.

We agree that one can create model specifications that produce a non-convex DRP curve. We also agree that the shape of the DRP curve determines the scale of over-/under-estimation of DRP at 100% gearing through linear extrapolation.

To empirically test the expected shape of a DRP curve for a utility company and potential measurement error, we have built a Merton model and tested sensitivities for a reasonable range of inputs. In common with Mason and Wright, we do not claim that the Merton model (or an alternative model, such as Merton with jumps) is the sole way of estimating the DRP; however, unlike Mason and Wright, we aim to calibrate the model using an empirical parameter range that is consistent with the characteristics of a regulated network utility.[18]

The Merton model allows us to assess the risk of a company's debt by considering the relationship between the values of a company's assets and liabilities, and hence the likelihood of default. It builds upon the principles of the Black–Scholes option pricing framework by treating equity as a call option on the company's assets. Therefore, it allows the modelling of expected risk premia for a given level of expected return, leverage and volatility of assets.

5.1 Model specification

We base the model parameters on the SSMD 'early view'—risk-free rate of 1.18%, weighted average cost of capital (WACC) of 4.06% and 3%

[18] Mason, R. and Wright, S. (2024), 'A Note for Ofwat on what the cost of debt means for the cost of equity', 18 February, p. 23.

dividend yield. Under this specification, the main determinants of the shape of the DRP curve are asset volatility and model time interval.

We assume the time interval of the model to be equal to 20 years, to align with the risk-free rate tenor assumption of Ofgem, reflective of a reasonable expectation of equity investment horizon. This provides a conservative starting point for the assessment of the shape of the DRP curve as convexity is stronger for shorter time intervals under the specified return levels.

In order to assume a reasonable range of volatility to be used in the model, we estimate the historical realised equity volatility of companies used in Ofgem's beta sample (National Grid, United Utilities, Severn Trent, Enagás, Red Eléctrica, Terna and Snam). As shown in Table 5.1 below, based on one-month, three-month and one-year annualised volatilities, this gives us an annualised equity volatility range of 13%–27%.

Table 5.1 Annualised historical realised equity volatility

Historical volatility period	ENG SM Equity	RED SM Equity	TRN IM Equity	SRG IM Equity	NG/ LN Equity	UU/ LN Equity	SVT LN Equity	IG IM Equity	Average
One month	16.0%	14.8%	15.1%	15.1%	17.8%	14.8%	17.6%	13.5%	15.6%
Three months	21.8%	16.5%	15.6%	16.1%	16.6%	25.5%	26.8%	15.4%	19.3%
One year	22.1%	15.6%	16.3%	17.0%	21.7%	21.6%	23.0%	18.0%	19.4%

Note: We take the daily volatility as of 7 October 2024, calculated over 21- , 63- and 252-day windows, and annualise it assuming 252 business days per year.
Source: Oxera analysis based on Bloomberg data.

There are several academically accepted approaches to estimating asset volatility (Merton model input) based on equity volatility.

Regardless of the methodology adopted, asset volatility of these firms will be lower than the historical equity volatility, as asset volatility is a combination of equity and debt volatility and debt is less risky and less volatile than equity. Table 5.2 below presents the implied asset volatilities for the average of the chosen sample based on two methodologies.

- A simple approximation of asset volatility as equity volatility adjusted for the level of gearing—investment grade debt is likely to have very low or near zero debt volatility (similar to debt beta). Hence, this simple approximation may provide a good estimate of the underlying asset volatility in practice.
- Asset volatility based on the Merton model—the options pricing framework embedded in the Merton model provides an explicit link between asset and equity volatilities, hence, allowing it to estimate asset volatility for a given level of gearing.

Table 5.2 Average asset volatility estimates (based on 60% notional gearing assumption)

Average asset volatility	Simple de-levering approach	Merton model approach
One month	6.24%	8.71%
Three months	7.72%	10.95%
One year	7.76%	10.95%

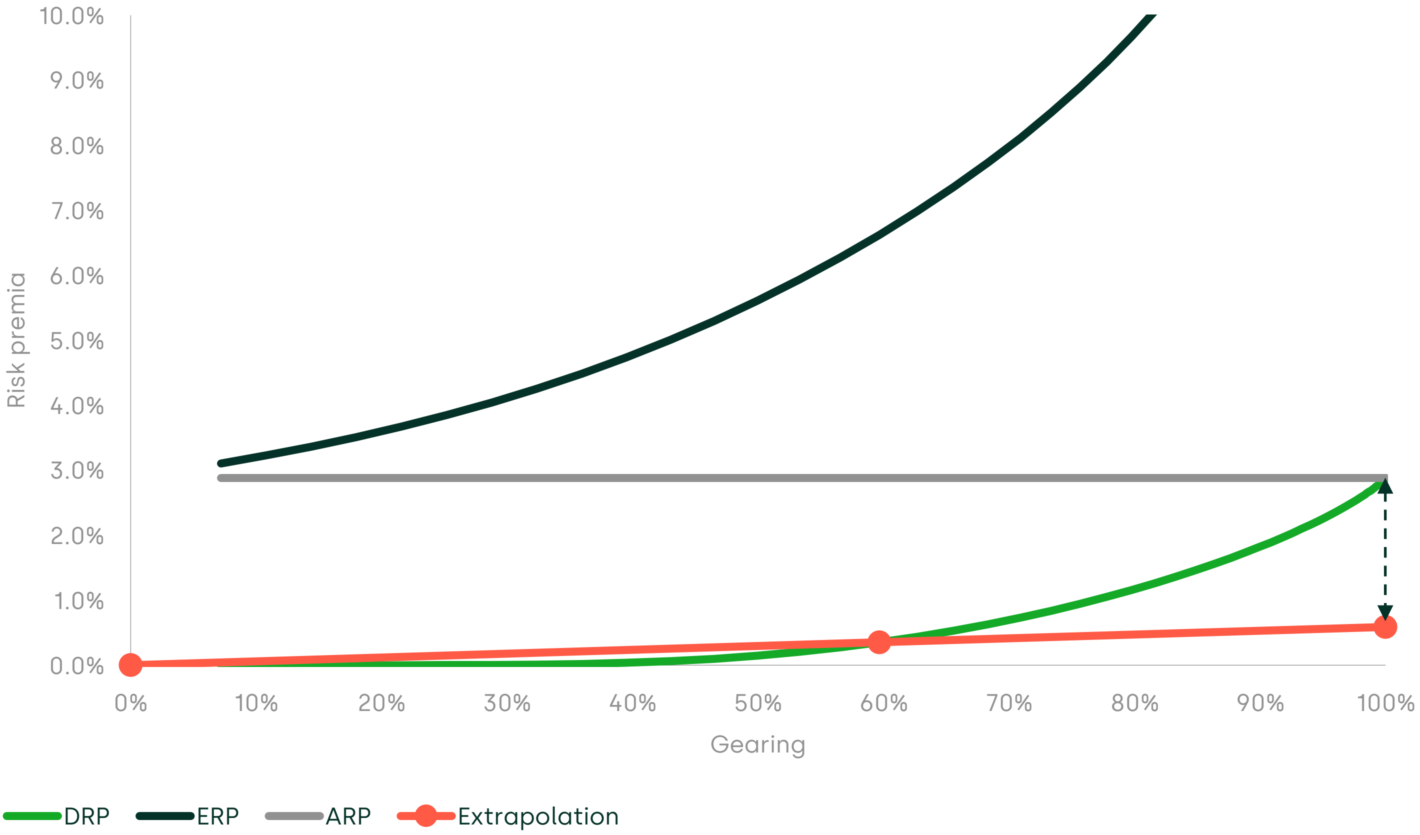
Note: de-levering approaches estimates asset volatility by dividing equity volatility by one minus gearing assumption.

To be conservative in our approximation we use a wide range of asset volatility of 8.72% (the average of the asset volatilities presented in Table 5.2) and 26.8% (top end of the historical equity volatility). The top end of this range is not realistic, as it would imply that the companies in Ofgem's beta sample are financed exclusively by equity capital. However, it helps illustrate that the convex DRP assumption holds even at levels of volatility that would be unrealistically high for a utility company.

5.2 Modelling results

The resulting DRP curves estimated via a Merton model under the assumptions specified above are illustrated in Figure 5.1 and Figure 5.2 below.

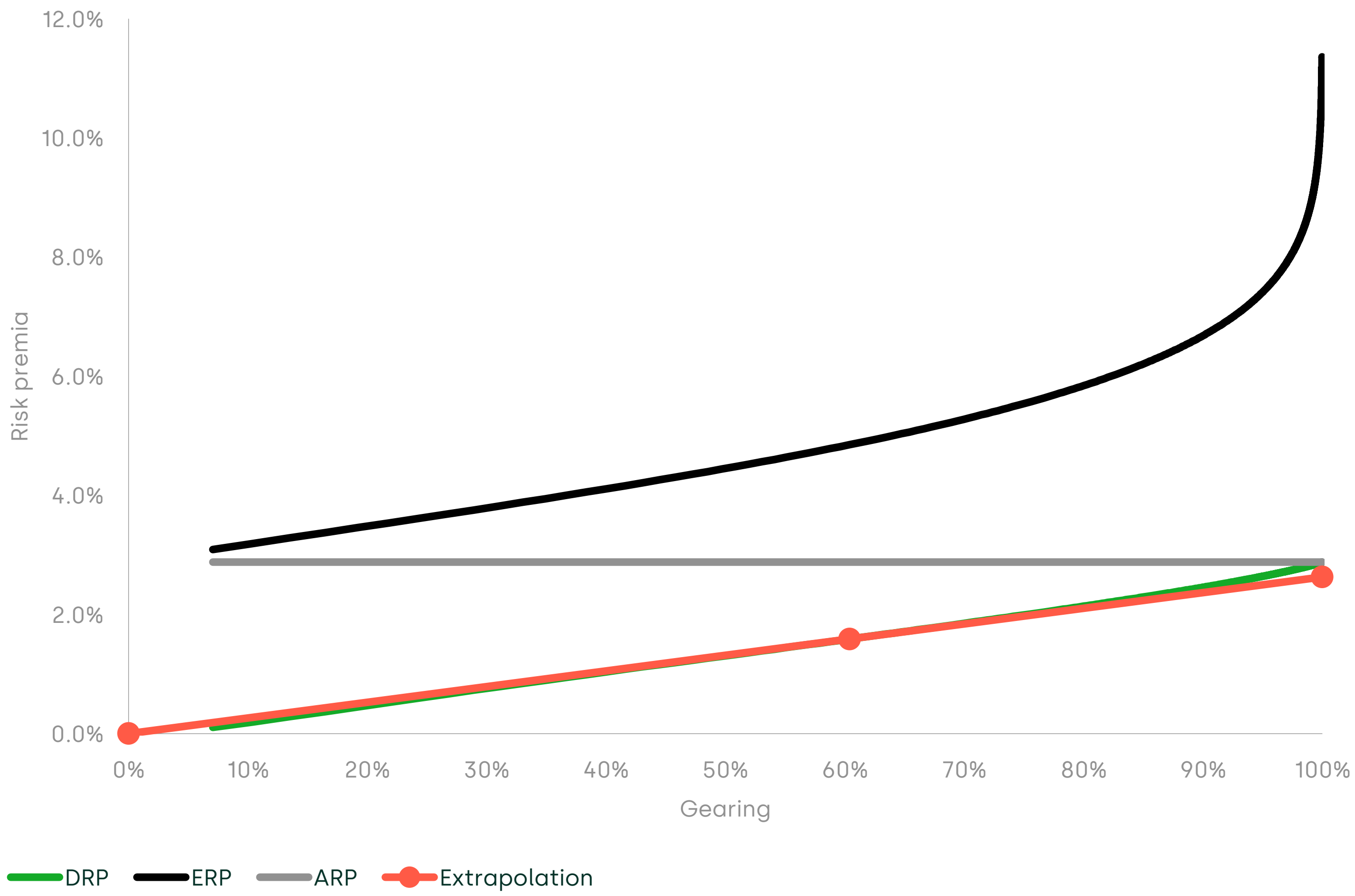
Figure 5.1 ARP–DRP extrapolation under Merton model framework (8.72% asset volatility)



Note: model assumes, risk-free rate=1.18%, WACC=4.06%, time period=20 years, dividend yield=3%, annualised asset volatility=8.72%.
Source: Oxera analysis.

Under low asset volatility assumptions based on the empirical market the DRP curve implied by the Merton model is strongly convex. A linear extrapolation of DRP significantly underestimates the ARP.

Figure 5.2 ARP–DRP extrapolation under Merton model framework (26.8% asset volatility)



Note: model assumes, risk-free rate=1.18%, WACC=4.06%, time period=20 years, dividend yield=3%, annualised asset volatility=26.8%.
Source: Oxera analysis.

Under a very high asset volatility assumption for a utility company the Merton model maintains a slight convexity in the DRP curve. Based on this model estimation, linear extrapolation underestimates the DRP by 0.25% relative to the ARP specified in the model. This suggests that one may expect for convexity to hold for most specifications of a Merton model that are reasonable for a regulated network company.

The Merton model underestimates the total level of DRP due to a high recovery rate assumption embedded into the model. Adjusting for a lower recovery rate would lead to an upward shift of the DRP curve rather than a change in the shape of the DRP curve.

On balance, empirical testing of Merton model specifications consistent with the parameters of a regulated utility suggest that the ARP–DRP ‘implied’ lower bound approach is much more likely to underestimate the ‘true’ market ARP rather than overestimate it. This is further supported by the convexity assumption holding even at asset volatility of 26.8%, which is significantly higher than the empirical level we observe for regulated network utilities.

The standard Merton model is only one way of estimating the shape of the DRP curve. For example, Mason and Wright have also presented an illustrative curve based on a Merton with jumps model.[19] Over a sufficiently long maturity of debt, a model with jumps should not produce results that are materially different from a standard Merton model, if both models are calibrated to represent broadly the same level of asset return variance.

The specification presented by Mason and Wright adds an economically large jump process to an asset volatility input that is already set at a relatively high level of 20%. The resulting total volatility of the process would be significantly higher than is realistic for a utility company. Importantly, it is unclear why predictions of a Merton model with jumps would present an increased level of economic realism relative to a standard Merton model for a regulated network utility.

[19] Mason, R. and Wright, S. (2024), ‘A Note for Ofwat on what the cost of debt means for the cost of equity’, 18 February, p. 23.

6 Conclusion

In this report, we have presented the case for the ARP–DRP framework as a robust approach to evaluating the cost of capital and cross-checking the allowed returns on equity estimated by the regulator through CAPM.

We have made the case for using observable debt market data to inform the calibration of model estimates of the unobservable cost of equity. The ARP–DRP framework has several distinct advantages for this purpose relative to other debt-based cross-checks.

- The ARP–DRP framework converts observable yields into risk premia improving comparability across time and across companies.
- The ARP–DRP framework defines testable lower bounds that are tighter than simpler debt-based cross-checks and are based on strong theoretical foundations in a Modigliani–Miller framework.

We have highlighted the benefits of applying the ARP–DRP framework to a 'through the cycle' CAPM based regulatory regime. Specifically, the ARP–DRP framework ensures that the smoothing of the returns on equity caused by the 'through the cycle' approach does not jeopardise the investability of a specific price control period. It is not realistic to expect investors to invest significant capital at a rate below their required return based on the current market conditions.

This report has engaged with the feedback and the criticisms of the framework raised by regulators and their respective advisors. We have highlighted that the relative measurement errors of the ARP–DRP framework are unlikely to be greater than the uncertainty inherent in a traditional application of the CAPM as used by the regulators.

Additionally, we have examined the relationship between gearing and the DRP based on specifications of a Merton model consistent with a regulated network company. This exercise has confirmed that the shape of the DRP curve is much more likely to be convex than concave under reasonable assumptions using a Merton model. The assumption of convexity implies a lower bound to the level of the ARP, defined by extrapolating the DRP to 100% gearing. As such, the lower bound of ARP can be applied to narrow the cost of equity range suggested by the CAPM by eliminating parts of the range that provide an inadequate risk premium relative to debt.

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