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Office of Gas and Electricity Markets

Advice on the cost of capital analysis for DPCR5

FINAL REPORT

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PRICEWATERHOUSECOOPERS

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1. Summary and conclusion

The Office of Gas and Electricity Markets (Ofgem) is currently undertaking the fifth Distribution Price Control Review (DPCR5) to set revenue allowances for electricity Distribution Network Operators (DNOs) for the five year period 2010-2015. An estimate of the cost of capital is necessary to determine the level of allowed returns included within the revenue allowance. In this context, PricewaterhouseCoopers LLP (PwC) have been commissioned by Ofgem to provide an assessment of the DNOs' weighted average cost of capital (WACC) for regulatory purposes. This report presents our analysis and findings.

Our intention has not been to derive a precise estimate of the WACC, but rather to set out for Ofgem's consideration the plausible range of estimates based on different approaches, to inform Ofgem's own decision. The table below sets out our view on this range for the WACC for DNOs over DPCR5.

Table 1: PwC proposed WACC for DNOs over DPCR5

	PwC calculations (Low)	PwC calculations (High)	Ofgem's calculations – DPCR4 final decision	Ofgem's calculations – DPCR4 initial decision (Low)	Ofgem's calculations – DPCR4 initial decision (High)
Risk-free rate	2.0%	2.5%	2.6% (implied)	2.25%	3.0%
Equity beta	0.7	1.1	1.0	0.6	1.0
EMRP	4.5%	5.5%	4.9% (implied)	2.5%	4.5%
Gearing	55%	65%	57.5%	50%	60%
Debt premium	1.3%	1.5%	1.5% (implied)	1.0%	1.8%
Cost of equity (post-tax real)	5.10%	8.47%	7.5%	3.75%	7.50%
Cost of debt (pre-tax real)	3.3%	4.0%	4.1%	3.3%	4.8%
WACC (post-tax real)	3.60%	4.84%	4.8%	3.0%(based on individual parameters)	5.0% (based on individual parameters)
WACC (vanilla real)	4.11%	5.57%	5.5%	3.5% (based on individual parameters)	5.9% (based on individual parameters)
WACC (pre-tax real)	5.00%	6.72%	6.9%	4.3% (based on individual parameters)	7.2% (based on individual parameters)

Source: Ofgem's regulatory decisions and PwC analysis

Note: The precise equity beta figures used in our WACC calculation are 0.689 (low) and 1.086 (high)

We summarise below our recommended approach to calculating the cost of capital for DPCR5:

- **Methodology for calculating the cost of equity:** We believe that the capital asset pricing model (CAPM) is the most appropriate framework for calculating the cost of equity.

- **Risk-free rate:** Despite some market distortions caused by demand and supply factors, we consider that index-linked gilts (ILGs) provide the best source of evidence on the level of the risk-free rate (RFR). We recommend a range of 2.0% to 2.5% for the RFR for DPCR5. The lower end of the range is broadly consistent with the 5 and 10 year averages for 10 year ILGs as well as being consistent with other recent regulatory precedent, namely Ofwat and Stansted. The upper end of the range is consistent with the mid-point level for the real RFR that has generally been used in regulatory determinations since 2000.

- **Equity beta:** We recommend that beta is estimated using a range of comparators including National Grid and UK water companies. We recommend that the Blume adjustment is applied, and although we tested the sensitivity of the beta estimate to a debt beta of 0.1 we ultimately did not include a debt beta in our final WACC calculations. Our equity beta range is 0.7-1.1.

- **EMRP:** A key issue for Ofgem to consider for its DPCR5 determination is whether it believes the EMRP fluctuates in the short-term, and, if so, whether Ofgem would wish to reflect such fluctuations in its determination. If the EMRP is viewed as fluctuating in the short-term, then methodologies such as the Dividend Growth Model (DGM) are relevant to the calculation of the short-term EMRP, and would suggest a relatively high figure for the EMRP based on recent market conditions. Taking a longer-term approach, we consider that a range of 4.5% to 5.5% is appropriate. The upper end of this range is broadly consistent with long-term evidence on the actual excess returns on equities in the UK. The lower end is consistent with regulatory decisions since 2005 and towards the top end of the range used in the most recent regulatory determinations. The range does not include any uplift for any additional returns required for illiquidity risk, which the Bank of England suggests may lie between 0.5 and 1%. This illiquidity premium is not a normal component of the cost of equity and its inclusion implies a shorter-term approach than that which we employ here, we have not included it.

- **Debt premium:** As with the EMRP, if Ofgem decides to use short-term estimates of the debt premium this would result in higher figures than using a longer-term approach. Using a long-term approach, we recommend a range of 1.3% to 1.5% for the debt premium over DPCR5. The lower end of our final range is based on the 10 year average debt premia across UK comparators, whereas the upper end of the range is close to the average of recent evidence from the primary markets. This range does not include any uplift for transactions costs.

- **Gearing:** We recommend a gearing range of 55% to 65%. This range reflects the views of the credit rating agencies on the gearing levels consistent with a credit rating range of A-/BBB+.

Overall our real Vanilla WACC range is 4.1% to 5.6% which is consistent with a real post-tax cost of equity range of 5.1% to 8.5% and a real pre-tax cost of debt range of 3.3% to 4.0%. As noted above, these figures do not include any uplift for illiquidity risk (affecting the cost of equity) or transactions costs (affecting the cost of debt). Our aim has been to advise on the WACC itself rather than costs associated with accessing capital markets.

Our range is relatively wide, reflecting the high level of uncertainty associated with the cost of capital under current market conditions. Moreover, given these market conditions, we considered at length submissions that suggested a different approach to the calculation of the cost of capital, particularly the EMRP, would be appropriate for DPCR5. Our range is appropriate if Ofgem wishes to set a cost of capital that reflects longer-term conditions. On balance we believe that this is appropriate. We have set out our reasoning in the relevant sections of our report below, but also include a discussion of these issues in Appendix V.

To assess the relevance of using the WACC approach, we have undertaken a relative risk analysis of the electricity and gas distribution industries, a task which underlines the complexities in regulatory price control setting and the importance of basing controls on true expected cash flows. The imposition of a low cash buffer on regulated activities implies a high level of certainty regarding these costs. We therefore believe it is of utmost importance to ensure that expected costs are fully and thoroughly assessed in advance of any regulatory decision.

2. Introduction

2.1 Context and our role

The Office of Gas and Electricity Markets (Ofgem) is currently undertaking the fifth Distribution Price Control Review (DPCR5) to set revenue allowances for electricity Distribution Network Operators (DNOs) for the five year period 2010-2015. The outcome of this review will be a decision by Ofgem in the second half of 2009, which will set the return for the five year period 2010-2015 and therefore determine the maximum revenue which the DNOs can earn from regulated charges over this period.

Ofgem's regulatory duty entails setting price controls that allow the DNOs to finance efficient investments, recover efficient operating costs and earn an appropriate return on investment whilst delivering specified outputs. An estimate of the cost of capital is necessary to determine the level of allowed return.

In this context, PricewaterhouseCoopers LLP (PwC) have been commissioned by Ofgem to provide an assessment of the DNOs' weighted average cost of capital (WACC) for regulatory purposes. This report presents our analysis and findings, which consists of:

- An overview of the current financial market conditions;
- An analysis of the regulatory precedents across a selection of UK regulatory authorities, including the recent cost of capital decisions taken by utilities regulators and the Competition Commission (CC) in the UK; and
- A description of our methodology and recommendations on individual cost of capital parameters for DPCR5 along with the rationale for alternative methodologies where appropriate.

It is ultimately for Ofgem to decide the WACC to incorporate into its price determination. Our task has therefore not been to derive a precise estimate of the WACC, or give our own opinion on the appropriate figure, but rather to set out for Ofgem's consideration the plausible range of estimates based on different approaches, to inform Ofgem's decision. This necessarily implies that the ranges we present for the WACC and its components are wider than would be the case were our task to derive an implementable estimate ourselves. We have sought to set out the full range of possible estimates – together with an explanation of how they are derived – to inform Ofgem's decision.

2.2 Background on DNOs

Ofgem regulates fourteen DNOs all of which are regional monopolies[1]. Following privatisation, and a number of mergers and acquisitions, the fourteen DNOs are now owned and operated by seven companies. These are set out in the table below.

[1] In addition to these, there are currently five independent distribution networks (IDNOs) operating in Great Britain (GB). However these are not formally part of this regulatory review.

Table 2: Owners and operators of the DNOs

Company	Number of DNOs owned and operated
EDF Energy	3
CE Electric	2
E.ON Central Networks	2
Western Power Distribution	2
Scottish and Southern Energy	2
Scottish Power (SP)	2
Electricity North West (ENW)	1
Total	**14**

Source: “Electricity Distribution Price Control Review Policy Paper”, Ofgem, December 2008

For the purposes of cost of capital analysis, an important consideration is that no DNO is individually listed. Whilst some DNO owners are listed, these are usually large conglomerates such as Iberdrola and EDF. UK DNOs account for only a small proportion of their total business and market evidence on them does not necessarily reflect the risk/return profile of the UK DNO’s business. Considering this we have undertaken a detailed comparator analysis that is described in Section 3.4.

2.3 Structure of the report

The remainder of this report is organised as follows:

- Section 3 sets out our approach to determining the cost of equity parameters and presents our view on the appropriate range for each for DPCR5;
- Section 4 sets out our approach to determining cost of debt parameters and presents our view on the appropriate range for each for DPCR5;
- Section 5 sets out our approach to determine gearing and presents our view on the appropriate range for that for DPCR5; and
- Section 6 sets out our conclusions.
- Section 7 sets out our relative risk analysis

3. Cost of equity

3.1 Equity capital markets

Since the onset of the credit crisis, there has been a dramatic decline in share prices[2] combined with an increase in overall stock market volatility in an uncertain economic and financial environment. These developments have raised fundamental questions relating to the underlying cost of equity. In particular, there has been significant debate as to whether falling share prices indicate that the cost of equity has risen, and how the cost of equity should be estimated given the volatile market conditions.

Traditionally, Ofgem has tended to take a long-term view of the cost of equity and has used rigorous methodological frameworks such as the Capital Asset Pricing Model (CAPM), and the aggregate return on equity approach for estimating the cost of equity. These frameworks use historic data over a long period to estimate the cost of equity. The underlying assumption is that historic expectations are an adequate reflection of long-term future expectations. However more recently, given recent market conditions, there have been calls for Ofgem to review its approach and focus more on current market evidence when formulating its view on the forward looking market rate of return required by equity investors. It has been argued that the recent falls in share prices indicate that the cost of equity has increased.

In particular, a number of submissions by regulated DNOs have argued that Ofgem should place more weight on current market evidence and use forward looking frameworks such as the Dividend Growth Model (DGM). The DGM assumes that the current share price of a quoted business is equal to the present value of all future expected dividend payments. Therefore, given the current market share price and future dividend growth rate expectations, the cost of equity implicit in the share price can be determined as follows:

$$Ke = (D_0 * (1+g) / P_0) + g$$

Where:

Ke is the post-tax cost of equity

D_0 is the current dividend

g is the dividend growth rate (assumed to be constant)

P_0 is the current share price

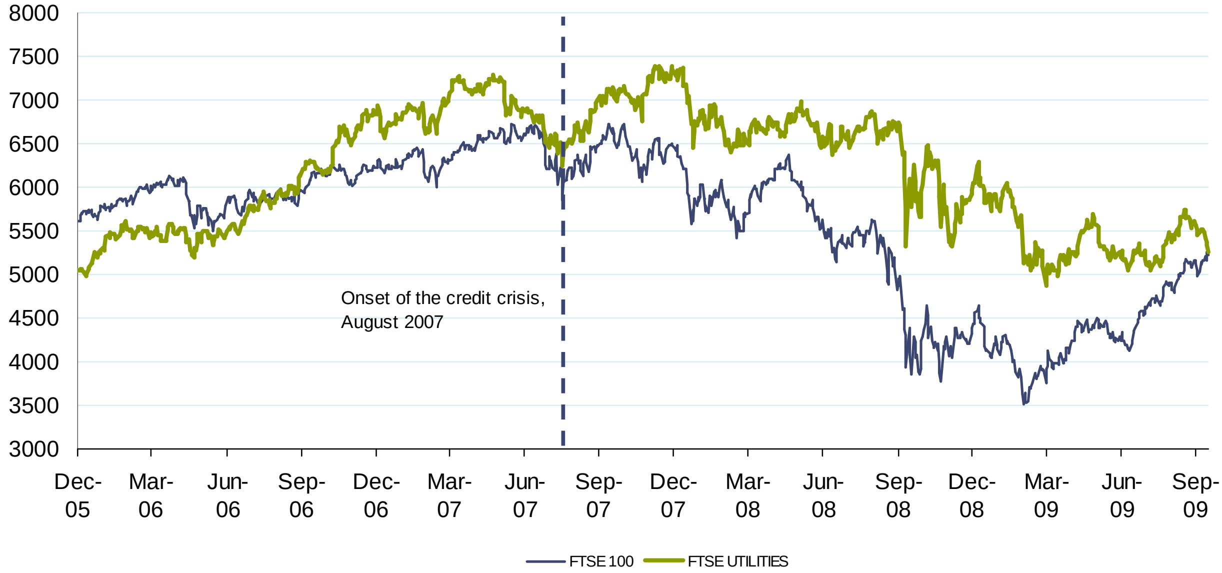
In general the main limitation of the DGM is that it relies on an accurate view of the dividend growth forecasts incorporated in share price valuations. This is problematic because there are no generally accepted sources for these. Short-term estimates are available from the businesses themselves, or are estimated by equity analysts. Neither source provides clear evidence of the growth assumption underpinning share prices. Perhaps because of this, our regulatory database indicates that the DGM is seldom used as the primary method for estimating the cost of equity in the UK[3], but instead is sometimes used as a check on the cost of equity derived from the CAPM.

If, despite these limitations, the DGM is applied to the market portfolio (FTSE-100) or the utilities sector (FTSE-Utilities index) it is likely to point towards an increase in the cost of equity. The significant drops in equity valuations evidenced by falls in share prices may in part be explained by reductions in expectations of future dividend growth (for example, reflecting the current recession). However, it is not clear that reduced

[2] Although UK share prices have recovered strongly during 2009 they are still significantly lower than they were before the onset of the crisis.
[3] The Federal Energy Regulatory Commission (FERC) has traditionally used the DGM/DCF method as described on page 156 of “Basic Practice: FERC”, American Bar Association, James H McGrew, 2003.

dividend growth forecasts alone can account for the falls in share prices seen. For example, the data set out in Figure 1 shows that since the onset of the credit crisis in August 2007, the FTSE-100 index has dropped by 16%, whilst the FTSE-Utilities index has decreased by 19%, though the paths followed over this period have been substantially different.

Figure 1: Evolution of the FTSE-100 and FTSE-Utilities indices



Source: Datastream

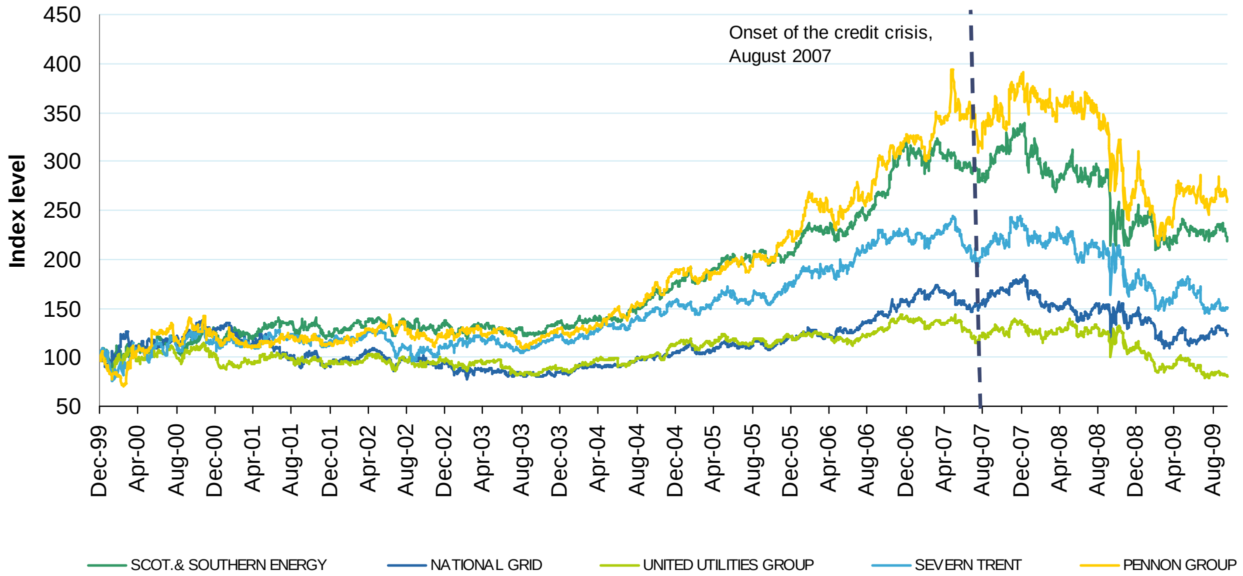
At least some of the decline in equity value, both for utilities and for the market as a whole, is likely to have been associated with reduced expectations of economic and dividend growth. Regulated utilities traditionally have had very stable dividends and have been protected from the effects of economic cycles because of the nature of the services they provide and the duties of regulators to set prices which allow them to recover their efficiently incurred costs and earn a fair return. However, in the year to the third quarter of 2009, the period for which the latest figures are available[4], utilities output was down by 9.6%, whilst overall GDP was down by 5.2%. Short term contractions associated with the recession should not necessarily feed through into long-term views of depressed dividend growth, but are likely to have influenced perceptions of dividends in the short- and medium-term, and may have reduced longer-term expectations as well.

Nevertheless, given the stability associated with their market positions and regulated status, it seems unlikely that such a significant drop in share price valuations across the utilities sector can be solely attributable to lower expected growth in dividends. An increase in the cost of equity seems to be a possible explanation for some proportion of the fall in utility sector valuations.

The figure above includes the share prices of all utilities. Our analysis of the share prices of quoted companies that we consider comparable to the DNOs is set out in Figure 2 and Table 3.

[4] ONS Preliminary estimates.

Figure 2: Evolution of utilities' share prices



Source Datastream

Table 3: Impact of the credit crisis on share prices of selected comparators[5]

Local currency	Share price as of 31/07/07	Share price as of 15/10/09	Percentage change
Scottish and Southern Energy	293	219	-25%
National Grid	149	122	-18%
United Utilities	121	80	-34%
Severn Trent	200	149	-25%
Pennon Group	347	258	-26%
Average			**-26%**

Source: Datastream

Our analysis indicates that the stock prices of all of our sample utilities have decreased over the 26 month period since the onset of the crisis, with an average decrease of 26%. Under the DGM framework, and as discussed above, this would point towards an increase in the cost of equity for DNOs. However, several factors need to be taken into consideration before using this evidence from the DGM methodology to increase the cost of equity.

First, any calls on Ofgem to reassess its approach of setting the cost of equity on a long-term basis using rigorous methodologies such as CAPM, should take into account that Ofgem did not deviate from this approach in DPCR4, when the share prices of DNO comparators increased significantly. Using the same logic that now suggests the cost of equity should be increased, the increases in share prices historically should have implied a cost of equity lower than that allowed on a long-term basis. A change at that time to a more spot rate based approach such as the DGM would have resulted in a lowering of the allowed cost of equity.

This raises a second point: using stock market prices as the basis for estimating the cost of equity (as the DGM does) inevitably implies that as share prices fluctuate, so will the cost of equity. The figures above illustrate the volatility of share prices. In the early stages of the recent crisis DNO comparator share prices actually tended to rise as a result of a "flight to quality" (see Table 4 below). Share prices do not solely reflect expectations of dividend growth and the cost of equity as the DGM assumes – they also reflect market

[5] The share price assessment above only considers utilities we consider as appropriate comparators to DNOs. We also exclude those delisted by 15/10/09, although, these are included in our beta calculations in section 3.4.2.

sentiment and speculation. They are therefore far more volatile than would be expected if they moved only in relation to changes in dividend growth forecasts and the cost of equity – neither of these would be expected to fluctuate substantially on a month-to-month or even day-to-day basis.

Table 4: Impact of the credit crisis on utility share prices as of 25/02/08

	Share price as of 31/07/07	Share price as of 25/02/08	Percentage change
Scottish and Southern Energy	293	302	3%
National Grid	149	163	9%
United Utilities	121	127	5%
Severn Trent	200	220	10%
Pennon Group	347	363	5%
Average			**6%**

Datastream

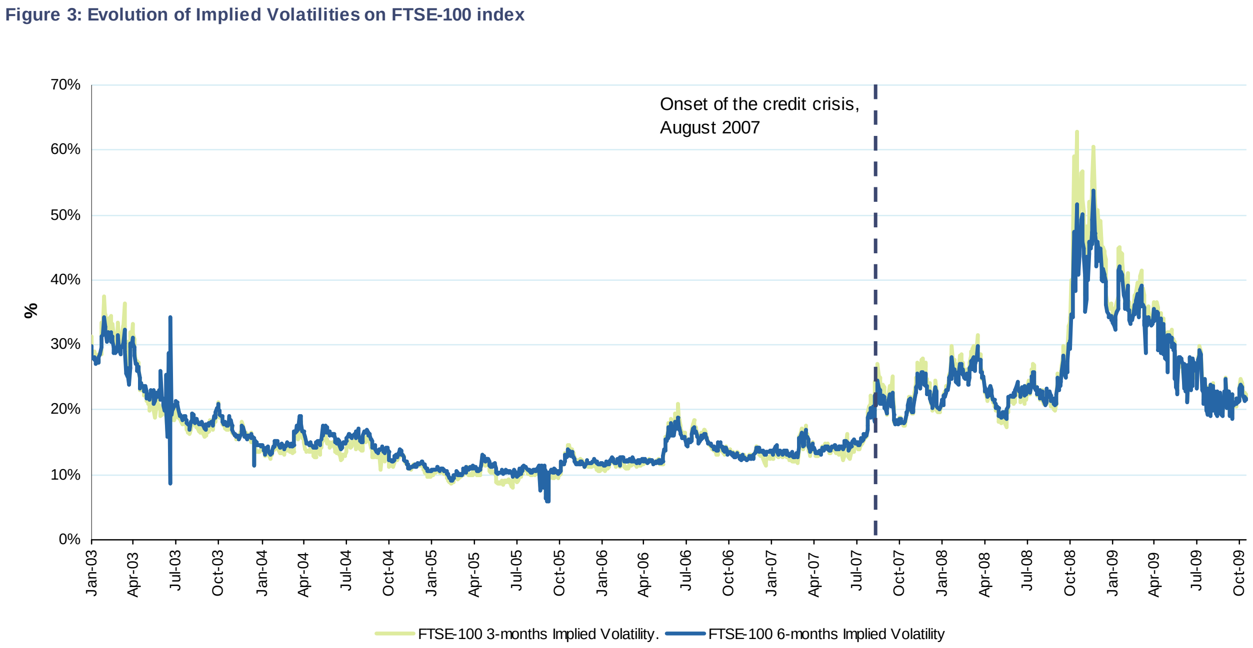
Third, it is not clear whether the current market conditions of low equity market valuations and high credit spreads will persist over the medium- to long-term. Recent market evidence appears to point to a recovery in both the equity and the debt markets, although the sustainability and the pace of this relative recovery remain highly uncertain.

Therefore, whilst the low share prices of utilities in general, and of DNO comparators in particular, may be indicative of an increase in the cost of equity, and this increases the relevance of the DGM as a methodology for evaluating the cost of equity, we do not believe that this justifies a substantial deviation from Ofgem's previous approach of using rigorous techniques such as CAPM and taking a long-term view of the cost of equity.

Another argument that has been put forward in support of using a more forward looking approach is based on the evidence on implied volatilities (IVs) from derivative markets. IVs give a forward looking measure of risk that reflects investors' expectations about the future volatility of returns[6]. Figure 3 illustrates the movement in IVs for options based on the FTSE-100 index.

[6] Options pricing models, such as the Black-Scholes model, include a volatility term. Because the actual prices of options can be observed from market data, and all the other variables in the option pricing formula are known, it is possible to infer the value attributed by participants in the derivatives market to the volatility term. The value of the volatility variable obtained in this way is the implied volatility, or IV.

Figure 3: Evolution of Implied volatilities on FTSE -100 index



Source: Datastream

One interpretation of the data on IVs is that, in response to dramatic changes in the global financial system (including the collapse of Bear Sterns, Lehman Brothers, Northern Rock and the Icelandic banks, along with the part nationalisation of two major banks), equity investors' perception of risk has increased significantly and that this shift is likely to be sustained over the medium- to long-term. However, the figure above shows that since October/November 2008 IVs have fallen and are currently in line with the levels observed in mid-2003 following the collapse of the dot.com boom (although they remain above the levels of the 2004-07 period).

Moreover, there are several limitations of IVs that should be taken into account. First, as they are implied from option prices using the Black-Scholes formula[7], their predictive power is implicitly dependent on the accuracy of the Black-Scholes formula. Second, only 1-18 months IVs evidence is available on databases such as Bloomberg and Datastream. Such evidence reflects investors' expectations about market risk over the short-term, whereas in determining the allowed cost of capital for the DNOs we are interested in investors' exposure to systematic risk over a longer period. On the basis of these limitations, we consider that no medium- to long-term conclusions about investor perceptions of equity market risk can be drawn on the basis of IV evidence.

The market evidence, from both share and equity options price movements, points towards some increase in the cost of equity, at least in the short-term. We believe that this evidence needs to be considered by Ofgem when it forms its view of the allowed cost of equity for DPCR5 – further analysis of current market conditions is contained in Appendix V. However, we consider that, given the unusual equity market conditions since the onset of the economic crisis, and the most recent evidence of some movement towards more normal conditions, a long-term view on the cost of equity still remains the most important approach for a regulatory determination. The required approach for estimating this is to undertake a more rigorous and methodological analysis that takes into account long-term historical data. These methodologies are discussed in the next section.

[7] Black, F and Scholes, M, "The pricing of options and corporate liabilities", Journal of Political Economy, 1973.

3.2 Conceptual framework

In formulating its decision on the cost of equity for DPCR4, Ofgem had regard to a number of conceptual approaches including CAPM, the DGM and most notably the aggregate return on equity approach. The latter approach directly estimates the overall return required by equity investors rather than estimating individual parameters such as the risk-free rate and EMRP whilst implicitly assuming an equity beta of 1.

In this section we set out our recommendation as to the most appropriate conceptual framework for estimating the cost of equity for DPCR5.

3.2.1 Capital asset pricing model

The methodology used most often in estimating the cost of equity is the CAPM. This assumes that equity investors require their investment to yield at least the return available on risk-free instruments. Added to this risk-free rate of return, equity investors expect a premium for the risk involved in an equity investment. This premium is equal to the general equity market risk premium (EMRP) multiplied by the equity beta.

The EMRP represents the additional expected return investors require to compensate them for the additional risk associated with investing in equities rather than risk-free instruments. The equity beta is a measure of the riskiness of a particular equity investment relative to the average equity investment. In particular, it is a measure of the degree of “systematic risk” for a particular investment. A key aspect of the CAPM framework is that it distinguishes between specific risks and systematic risks, as follows:

- **Specific risks** are those risks which are specific to a company or project. They can be eliminated or “diversified away” by holding a well-diversified portfolio of investments in which, on average, investments which perform badly due to specific risk factors can be expected to be offset by investments which perform well for specific risk reasons and vice versa; and

- **Systematic risk** refers to risk factors which affect all equity investments simultaneously in the same direction to a greater or lesser extent, and hence cannot be diversified away. Movements in economy-wide factors such as changes in the GDP growth rate, interest rates, savings rates and inflation contribute to systematic risk.

Since equity investors can diversify away specific risks, they do not affect required returns, and hence under the CAPM framework are not reflected in the cost of equity. Required or expected equity returns reflect only exposure to systematic risk. However it is important to note that the consideration of specific risk is an important aspect in the calculation of the expected cash flows from any business or project being evaluated.

Under the CAPM framework, the cost of equity is defined as follows:

$Ke = Rf + \beta * [EMRP]$

Where:

Ke is the cost of equity

Rf is the risk-free rate

β is the equity beta

EMRP is the equity risk premium (Rm – Rf), where Rm is the equity market return

3.2.2 Alternative methodologies

We discussed the DGM in the earlier section reviewing recent equity market trends, and concluded that it is unreliable as the prime methodology for calculating the cost of equity, but could be used by Ofgem as an additional piece of evidence, particularly if Ofgem wishes to consider a more short-term approach to the cost of equity. In addition to CAPM and the DGM, the cost of equity can be estimated using a number of alternative methods. These include:

- The Fama French Three-Factor model; and
- Arbitrage Pricing Theory.

We discuss each of these in turn below.

Fama French Three-Factor Model

Some academic tests of the CAPM have shown that the explanatory power of CAPM does not always perform well. The most prominent contradiction is the "size effect" discovered by Banz (1981)[8], who found that the average returns of smaller US companies appeared high relative to the returns implied by the CAPM framework. This was further investigated by Fama and French (1993)[9], who found that two variables, size and book-to-market value, capture most of the variation in stock returns not captured by the CAPM framework. Fama and French proposed the Fama French three-factor model (FFTM) that attempts to adapt the conventional CAPM by adding additional explanatory variables for size and book-to-market value. In particular, under the FFTM:

$$Ke = \beta i*EMRP + si*E(size) + hi*E(book/market)$$

Where:

EMRP is the equity market risk premium

βi is the sensitivity of security i to the EMRP

E(size) is the extra return expected for small capitalisation companies

si is the sensitivity of security i to E(size)

E(book/market) is the extra return expected for companies with high book-to-market ratios

hi is the sensitivity of security i to E(book/market)

The FFTM is usually considered when estimating the cost of capital for small or distressed firms. As the model is really an adaptation of the CAPM, for non-distressed firms the most common practice is to extend the CAPM to a two-factor model in which a small company risk premium is added to the conventional CAPM model.

8 Banz, Rolf W., (1981) "The relationship between return and market value of common stocks", Journal of Financial Economics.
9 Fama, E., French, K., (1993) "Common risk factors in the returns on stocks and bonds", Journal of Financial Economics.

This is shown below:

$$Ke = Rf + \beta * EMRP + S$$

Where:

Rf is the risk-free rate

β is the equity beta

EMRP is the equity market risk premium

S is the small company premium

A small company risk premium has been used in the past by regulators, including Ofgem, when determining the cost of equity for small companies.

Arbitrage Pricing Theory

Arbitrage Pricing Theory (APT) extends the three-factor model even further to an unlimited number of explanatory variables and beta coefficients:

$$Ke = R_f + \beta_1 * E_1 + \beta_2 * E_2 + \beta_3 * E_3 \ldots + \ldots . \ \beta_n * E_n$$

Where:

R_f is the risk-free rate

β_i is the sensitivity of the security to each of the 1 to n risk factors

E_i is the expected risk premium associated with each unit of risk for factors 1 to n

In practice, the individual APT variables and associated betas can be seen as a decomposition of the single beta factor of the CAPM. So, for example, although APT theory does not tell us what the APT factors are, typically they are related to systematic macroeconomic variables such as the level of GDP, inflation and interest rates.

3.2.3 PwC's recommendation

Table 5 below summarises PwC's assessment of the alternative methodologies for calculating the cost of equity (including the DGM) compared to the CAPM approach.

Table 5: Evaluation of methodologies for estimating the cost of equity

Methodology	Explanation	Advantage	Disadvantage
CAPM	The intuition behind CAPM is that investors are only rewarded for being exposed to non-diversifiable risk (also known as systematic or market risk).	Widely used and applied in valuations.	Empirical tests have found that beta may not be the only variable that has explanatory power.
Dividend Growth Model	The DGM is a simple forward-looking model that assumes that current share prices are equal to the present value of all future dividend payments.	Simple to compute.	Relies on accurate knowledge of dividend growth assumptions underpinning share prices. Cost of equity estimates tend to be highly volatile.
Fama French Three-Factor Model	Some academic tests of CAPM have shown that there may be some mis-specification with regard to size and book-to-market value. The Fama French Three-Factor Model attempts to compensate for the perceived mis-specification.	Has achieved some empirical support.	In practice, this model is not widely used in its pure form but practitioners may increase the cost of equity in a judgemental way to reflect greater perceived risk for a small company.
Arbitrage Pricing Theory	The principle behind APT is similar to CAPM: investors are incrementally rewarded for incremental (non-diversifiable) risk.	Theory is sound and intuitively appealing.	APT is rarely used because of problems with data availability and remains more of a conceptual academic model than a practitioners' tool.

Source: PwC's analysis

We consider CAPM to be the most appropriate framework for calculating the cost of equity for DPCR5, as it is the most widely used and accepted of the techniques. The DGM is useful as an additional check.

3.3 Risk-free rate

The risk-free rate (RFR) is the rate of return that can be earned on a risk-free investment, i.e. an investment that guarantees a fixed return, with no possibility whatsoever of any variation in the level of return. Whilst there are no investments that are absolutely risk-free, it is conventional practice to determine the RFR by examining the yield on "safe", liquid financial instruments that are considered to have negligible default risk. To determine the nominal RFR the yields on conventional treasury bills and government bonds are normally used, whilst the real RFR can be measured using index-linked government bonds (ILGs), if these are available.

3.3.1 Ofgem's approach and regulatory precedents

In its initial determination for DPCR4, Ofgem considered a number of estimates for the RFR before deciding to adjust the range based on recent CC decisions, which was in turn based on examining the real yields for 20-year, 10-year and 5-year ILGs. In its final determination, Ofgem used the aggregate return on equity framework that does not require estimation of individual cost of equity parameters, although the RFR implied in the cost of debt for the final determination was consistent with the mid-point of the initial determination range.

The table below illustrates the range of real RFRs used by UK regulators and the CC in their recent cost of capital decisions. Most of them have used a real RFR ranging between 2% and 3%. In the period from 2000 to 2004 there was a general tendency for the figure to be in the top half of this range, whilst since 2005 the chosen real RFR has tended to be in the bottom half of the range.

Table 6: Regulatory precedents for the real risk-free rate

Regulator	Review	Real RFR	Maturity of financial instrument (years)	Index-linked or Nominal gilt?	Comments
ORR (Oct 2000)	Periodic review of Railtrack's access charges: final conclusions	3.0%	5, 10 and 20	Index- linked	- Also considered regulatory precedents such as CC (2000) Mid Kent/Sutton and East Surrey Water, and MMC (1998) Cellnet/Vodafone inquiry. - An adjustment for UK-specific liquidity-related issues was made (e.g. arising from the high demand for long dated bonds from pension funds).
CC (Nov 2002)	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	2.5%-2.75%	5, 10 and 20	Index- linked	- Considered both long-term averages and spot rates. - Considered regulatory precedents such as CC (2000) Mid Kent/Sutton and East Surrey Water, and MMC (1998) Cellnet/Vodafone inquiry.
CAA (Feb 2003)	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	2.5%-2.75%	5, 10 and 20	Index- linked	- Primarily based its decision on CC (November 2002) analysis.
CC (Feb 2003)	Mobile Phone inquiry	2.5-2.75%	5, 10 and 20	Index- linked	- Considered data on index-linked gilt yields since 1985. - Considered regulatory precedents: MMC (1998) Cellnet/Vodafone inquiry, CC (2000) Mid Kent/Sutton and East Surrey Water. - Considered demand pressures from pension funds and recognised a downward trend in the RFR, although the chosen range was still higher than the current spot rate (around 2.2%).
Ofgem (Nov 2004)	Electricity Distribution Price Control Review 4	2.25 – 3.0% (initial decision) 2.6% (final decision-implied)	5,10 and 20 (initial decision)	Index linked (initial decision)	- For initial decision considered regulatory precedents such as CC (2000) Mid Kent/Sutton and East Surrey Water. - For final decision, used the aggregate return on equity framework that does not require estimation of individual cost of equity parameters, although the RFR implied in the cost of debt for the final determination was consistent with the mid point of the initial determination range.

Regulator	Review	Real RFR	Maturity of financial instrument (years)	Index-linked or Nominal gilt?	Comments
Ofwat (Dec 2004)	Future water and sewerage charges 2005-10	2.5%-3.0%	10	Index- linked	- Noted that short-term data for yields on medium maturity gilts supported a rate of 2.0% and that current yields were significantly below the long-term average. - Analysis of time series data confirmed a shift from yields in the range of 3%-4% to yields of just over 2% from late 1998. - The eight-year average gilt yield was 2.5% and the 13-year average was 3.0%. - Considered regulatory precedent such as CC (Nov 2002) and Ofgem (Mar 2004 consultation document). - Placed more weight on long-term averages than on recent spot rates.
Ofcom (Aug 2005)	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	2.0%	5	Both	- Considered data on both nominal and real rates from January 2000. - Noted that spot rates are volatile and preferred analysing yields over a longer period of time.
CAA (Dec 2005)	NATS Price Control Review 2006-2010 (CP2)	2.5%	5, 10 and 20	Index- linked	- Noted that the UK yield curve was currently relatively flat. - Noted that spot rates on UK ILGs ranged from 1.6% to 2.0%, across a maturity range of 5-10 years, and instead chose a rate in line with the Joint Regulators report (Smithers & Co. 2003) which suggested 2.5% as the real RFR, based on longer-term averages and the mean reversion tendency of the real RFR over time. - Also noted that the historical average of the RFR between January 1994 and January 2003 (hence avoiding recent historically low rates) would support a similar assessment of the projected RFR.
Postcomm (Dec 2005)	Royal Mail Price and Service Quality Review	2.5%	Medium term	Index- linked	- Considered regulatory precedents including CC (Nov 2002) for BAA, Ofgem (Nov 2004) for DPCR4, Ofwat (Dec 2004) for water and sewerage, and CAA (Dec 2005) for NATS, which ranged from 2.5%-3%. - This range was higher than the spot rates on ILGs.
Ofgem (Dec 2006)	Transmission Price Control Review, 2007-2012	2.5%	10	Index- linked	- Considered the yield on 10 year ILGs (1.7%), and the 10-year trailing average of this (2.3%).

Regulator	Review	Real RFR	Maturity of financial instrument (years)	Index-linked or Nominal gilt?	Comments
Ofcom (Mar 2007)	Mobile Call Termination Statement	2.1%	5, 10 and 15	Both	- Considered data on both nominal and real rates from January 2000. - Acknowledged the recent rise in nominal rates to 5% as a result of higher inflation expectations. - Acknowledged the recent marginal rise in real rates, particularly those of a shorter duration (yield on 5 year gilts being the highest of the three in February 2007).
Ofgem (Dec 2007)	Gas Distribution Price Control Review 2007-13	2.5% (implied)	10	Index-linked	- Used the aggregate return on equity approach that does not separately estimate RFR. - We have The final RFR estimate We have inferred the RFR by subtracting from the cost of debt of 3.6% the stated regulatory precedent (Ofgem Dec 2006) for the debt premium of 1.1% - But did comment on the market evidence as following: - Noted that spot rates had increased, but were still historically low and quite volatile. - The trailing average on 10 year bonds continued to fall, and on current trends was expected to fall by approximately 0.2 percentage points between 2006 and 2007. - Considered the decline in rates since the 1990s. Considered yields on 10 year gilts. Noted that current spot rates were volatile and lower than the RFR used in regulatory determination.
CAA/CC (Mar 2008)	Economic Regulation of Heathrow and Gatwick Airports	2.5%	5 and 10	Index- linked	- Noted the recent decline in yields but considered it prudent to maintain a long-term focus consistent with the risk premium assumption. - Hence considered estimates based on historic trends (data since December 1999) as well as forward rates to the midpoint of Q5.
CC (Nov 2008)	Stansted Price Control Review (2009-14)	2.0%	3 and 5	Index- linked	- Noted that long-dated gilts are an unreliable indicator of the RFR since strong demand from pension funds had lowered these yields. - Considered forward rates (as derived by the Bank of England) which implied that 10 year gilts were not a suitable indicator (and hence gave these less weight). - Noted the spot rate (and averages thereof) had recently spiked although historic averages remained below 2%. The 10-year averages of three and five year ILGs were 2.22% and 2.09%.
CAA (Mar 2009)	Stansted Price Control Review (2009-14)	2.0%	3 and 5	Index- linked	- Primarily based its decision on CC (Nov 2008) analysis.

Source: PwC analysis. Further details are provided in Appendix I and V.

For estimating the real RFR, regulators have generally considered evidence on yields on medium- to long-term ILGs. Moreover, when setting the allowed cost of capital in the past, regulators have generally taken a longer-term view on the appropriate level of the real RFR. This also explains why the ranges used in recent regulatory determinations (after the onset of the credit crisis) are generally in line with the ranges used in pre-crisis determinations.

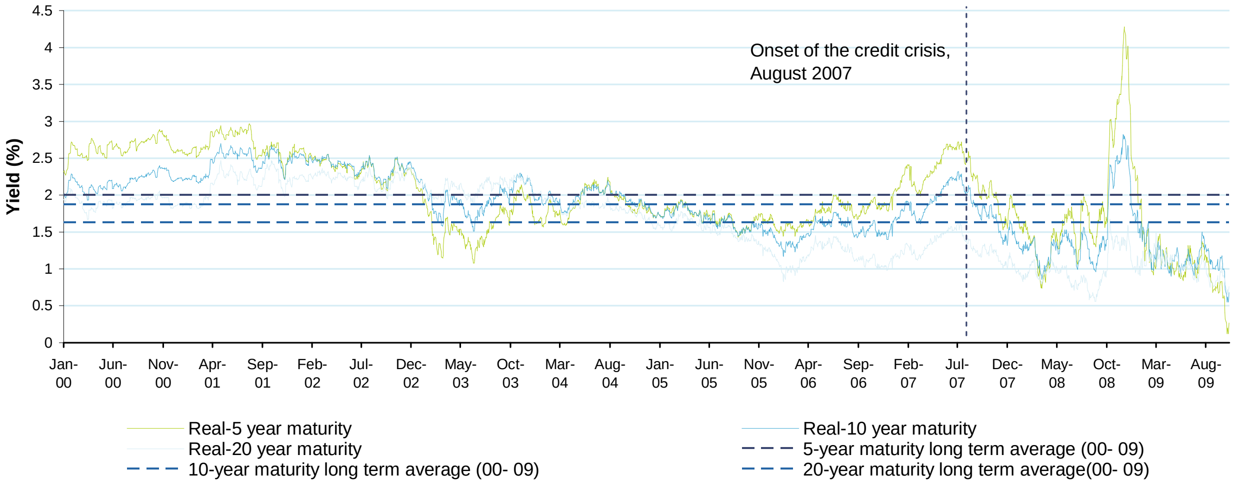
3.3.2 PwC's approach

We examined three approaches to estimating the real RFR. First, we considered market evidence on the yields on ILGs. Second, we examined the real RFR implied in yields on nominal gilts. Lastly, we considered evidence on the real RFR embedded in interest rate swaps. These approaches are discussed below.

Index linked gilts

ILGs are assets with negligible default risk and relatively insignificant inflation risk and are generally considered to give the best available indication of the return investors would require in exchange for holding a truly risk-free asset. The figure below presents market evidence on yields on 5, 10 and 20 year UK ILGs since January 2000, along with long-term averages across the three maturities[10].

Figure 4: Evolution of yields on ILGs



Note: the last data point on the chart above is 15/10//09.
Source: Bank of England (BOE)

Figure 4 depicts a number of important points. First, it shows that between July 2002 and July 2007, yields across the three maturities were generally below 2.5% (the midpoint of the range that regulators have typically used), with longer-term averages of 2.0% (5 years), 1.9% (10 years) and 1.6% (20 years). The latter two figures are below the bottom end of the range typically used by regulators.

Second, as set out in Table 7, the current spot rates across all the three maturities are significantly below long-term averages, and below the range used by regulators. Specifically, the spot rates on 5 year, 10 year and 20 year ILGs are 1.7, 1.2 and 0.8 percentage points respectively below the long-term (10 year) averages. Under the current volatile market conditions, it is likely that increased demand for low risk assets has driven down the yields on ILGs.

Lastly, our analysis indicates that since the onset of the credit crisis, yields on ILGs have been much more volatile. For example, the volatility (which we proxy using the standard deviation) of yields on 5 year ILGs

[10] Long term averages have been calculated as the average yield over approximately a 10 year period from January 2000 to October 2009.

over the 26 months since the onset of the credit crisis, has increased by 110% (from 0.3% to 0.7%) relative to the 26 months immediately prior to the credit crisis. An important implication of this is that it complicates the use of current market data on ILG yields and potentially requires more emphasis to be placed on long-term averages. Another implication, given the different levels of volatility across the three maturities, is that more weight should be put on relatively longer maturity ILGs as the yields on these have tended to be more stable.

Table 7: Summary statistics, yields on ILGs

	ILGs - 5 year maturity	ILGs - 10 year maturity	ILGs - 20 year maturity
Spot rates as of 14/10/09 (%)	0.3	0.7	0.8
Average since August 2007 - onset of the crisis (%)	1.6	1.4	1.0
5 year average (%)	1.8	1.6	1.2
10 year average (%)	2.0	1.9	1.6
Standard deviation 08/07 - 10/09 (%)	0.7	0.4	0.2
Standard deviation 06/05 - 08/07 (%)	0.3	0.2	0.2

Source: BOE and PwC calculations

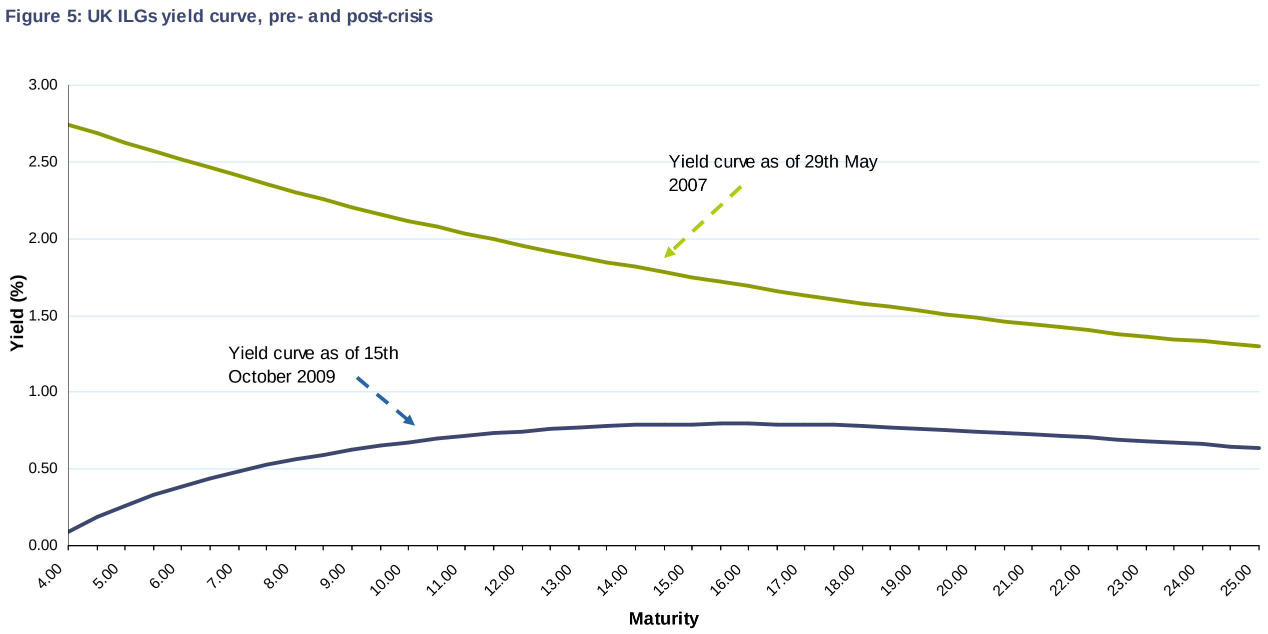
The main advantage of using the yields on ILGs to determine the real RFR is that it gives a direct market measure and does not require any additional assumptions about other parameters, such as the inflation rate, that are required by alternative methods (explained in more detail below).

The main caveat regarding the use of yields on ILGs is that they may have been affected by supply and demand factors. Specifically, regulatory and accounting rules (Minimum Funding Requirements and FRS17/IAS19) in the UK have encouraged pension funds to invest their funds in long maturity ILGs in order to match the terms of their liabilities with those of assets that are indexed to inflation and therefore to wages. As a result of this high demand, yields have been forced down, and hence using the yields on long maturity ILGs to calculate the real RFR is likely to result in relatively low estimates. This effect is evidenced by yields on longer dated gilts being lower than those on shorter dated gilts (i.e. an inverted yield curve), which is contrary to what would be expected in an undistorted market.

However, recent evidence indicates an easing of demand from pension funds. In particular, a survey of the UK's 200 largest privately sponsored pension schemes indicates that pension funds have been moving from gilts into higher risk corporate bonds to take advantage of historically high yields[11]. This is illustrated in the figure below which compares the pre- and post-credit crisis ILG yield curves. The pre-crisis yield curve is highly inverted (reflecting market distortions), whereas the post-crisis yield curve seems to have a more normal shape as would be expected in an undistorted market (although there are still some distortions at the very long end, i.e. for maturities greater than 20 years).

[11] FT, "Credit crunch persuades trustees to take a more sophisticated approach" August, 2008.

Figure 5: UK ILGs yield curve, pre- and post-crisis



Source: BOE

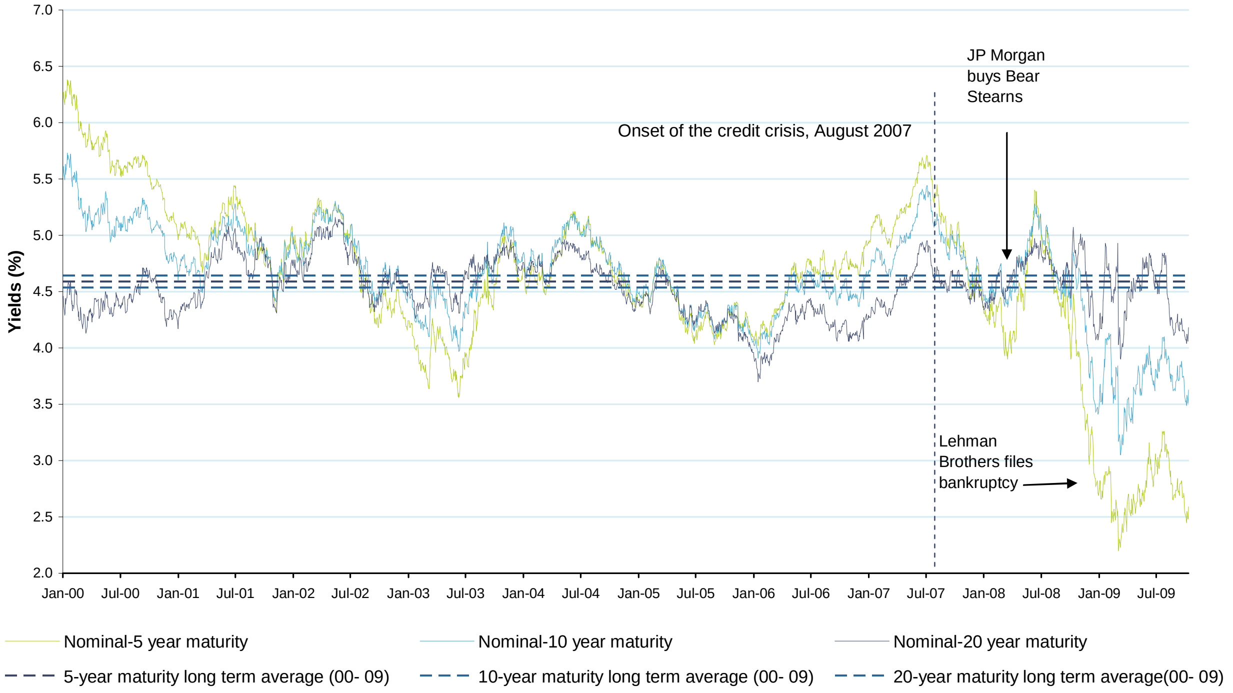
Overall, we consider that, although imperfect, ILGs continue to provide a useful measure of the real RFR. Having regard to the distortions mentioned above, we consider that more weight should be placed on ILGs with 5-10 years maturity. This approach is also in line with the views that were expressed by the CC during the recent Stansted Airport price control review, although the CC placed more emphasis on ILGs with 3-5 years maturity[12]. The current volatility of yields on shorter maturity ILGs complicates their use, and therefore on balance we consider that both short- and medium-term maturities should be considered when formulating the decision on the RFR for DPCR5.

[12] CC, "Stansted Airport Ltd, Q5 price control review", Appendix L, October 2008.

Nominal gilts

Another possible approach is to calculate the real RFR implied by yields on UK conventional or nominal gilts (NGs). Figure 6 below shows yields on 5, 10 and 20 year NGs since January 2000.

Figure 6: Evolution of yields on NGs



Note: the last data point on the chart above is 15/10/09.
Source: BOE

Yields across all the three maturities over the seven year period between July 2000 and July 2007 were generally between 4.0% and 5.0%. After the onset of the credit crisis in August 2007, nominal yields across all three maturities fell consistently (although they did recover slightly after the acquisition of Bear Stearns by JP Morgan) until March 2009, after which they have showed some recovery, though this appears to have reversed in recent months.

Table 8; Summary statistics, NGs

	NGs – 5 year maturity	NGs – 10 year maturity	NGs – 20 year maturity
Spot rates as of 15/10/09 (%)	2.6	3.6	4.2
Average since August 2007 - onset of the crisis (%)	3.9	4.3	4.6
5 year average (%)	4.3	4.4	4.4
10 year average (%)	4.6	4.6	4.5
Standard deviation 08/07 - 10/09 (%)	1.0	0.6	0.2
Standard deviation 12/04 - 08/07 (%)	0.4	0.3	0.2

Source: BOE and PwC calculations

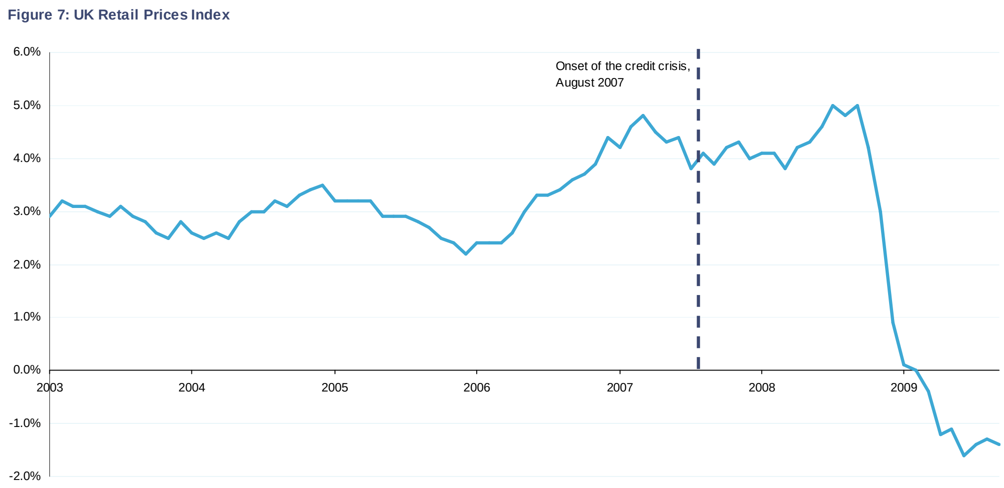
As with ILGs, the spot rates on NGs of 5 and 10 year maturities are significantly below their long term averages, and this appears to reflect a flight to quality under the current market conditions. Spot rates on 20 year NGs seem to be more in line with their long-term average. This is consistent with the view that beyond the current short term recessionary conditions the markets expect a return to normality.

Furthermore, the yields on 5 and 10 year NGs have been very volatile over the last few months, whereas yields on the 20 year bonds have been relatively stable. For the latter, the standard deviation over the 26 month period since the onset of the current crisis has been approximately the same as the standard deviation over the same period prior to the crisis.

The main limitation of using NGs for real RFR calculations is that this requires an estimate to be made of the expected inflation rate embedded in the nominal market yield for the length of the chosen maturity. Estimating inflation expectations with any accuracy is difficult, particularly under current volatile market conditions.

The primary measures of inflation used in the UK are based on two different price indices produced by the Office for National Statistics (ONS); the Consumer Prices Index (CPI) and the Retail Prices Index (RPI). For our analysis, the relevant inflation index to consider is the RPI as this is used for the indexation of DNOs' price caps. Figure 7 below shows the evolution of the UK RPI since 2003.

Figure 7: UK retail prices index



Source: ONS

In order to assess inflation expectations we examined the inflation forecasts of Consensus Economics (CE) and the Bank of England (BOE).

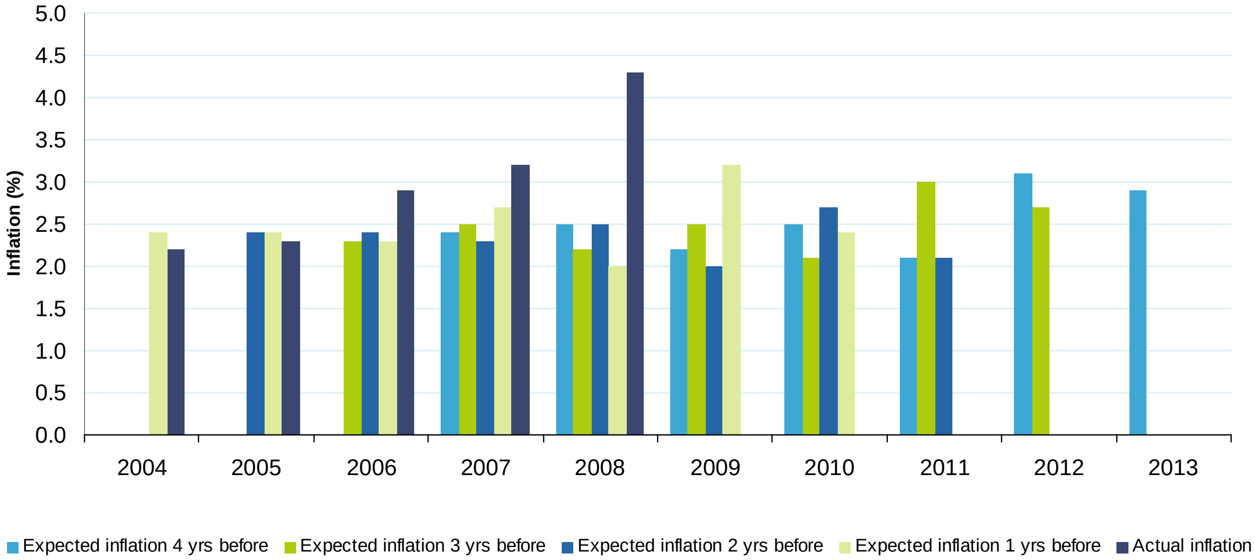
CE publishes long-term (10 year) inflation forecasts based on a survey of 240 financial analysts. The RPI inflation forecasts presented in CE reports differ from the actual RPI that is usually used to deflate yields as it excludes mortgage interest payments. This measure is commonly referred to as RPIX. BOE publishes CPI forecasts on a quarterly basis. BOE forecasts CPI inflation for up to three years and data are only available from 2004 onwards[13]. As with RPIX, CPI does not reflect mortgage interest payments, and is also based on a differently composed consumption basket.

Figure 8 sets out the evolution of CE's forecast of annual RPIX inflation over 2004 to 2013 along with actual RPIX inflation. This indicates that analysts in the past, on average, have been able to predict short term inflation reasonably accurately. For example, the average analyst forecast in 2003 for the annual RPIX inflation in 2004 was 2.4% whereas the outturn inflation was 2.2%. The difference between the actual inflation in 2007 and that forecast by analysts in 2006 was only 0.5 percentage points. However analysts on average have not been able accurately to forecast medium- to long-term inflation. For example, in 2003 analysts on average expected inflation in 2008 to be 2.3% whereas the outturn inflation was 4.6%.

[13] This is primarily because prior to that the BOE forecast and used RPIX inflation as its main inflation measure.

Another important issue is the evolution of the forecasts – the extent to which analysts change their inflation forecasts over time. Prior to the current financial market crisis, analysts' forecasts did not tend to vary significantly over time. For example, in 2005 the analysts' inflation forecast for 2007 was 2.3%, and 12 months later it was 2.7%. However, this variability has increased over time, especially under the current market conditions. So while in October 2007 analysts expected inflation in 2009 to be 2.0%, a year later they changed their forecast to 3.2%, an increase of 1.2 percentage points.

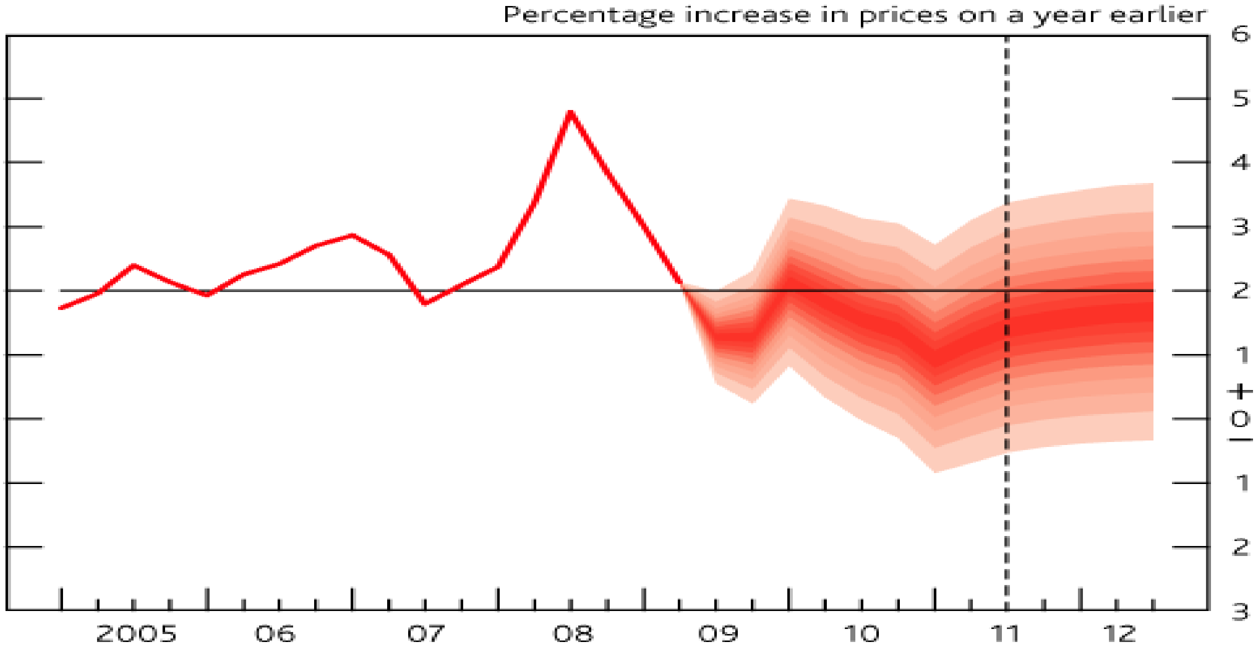
Figure 8: Evolution of analysts' forecasts of RPIX inflation



Source: CE

Figure 9 shows the BOE's current forecast of CPI inflation over the next three years. The BOE expects inflation in 2012 to lie between -0.3% and 3.7%, a spread of 4 percentage points, illustrating the difficulty in estimating steady-state inflation over the medium- to long-term under the current market conditions.

Figure 9: Bank of England's CPI inflation projections



Source: BOE, August 2009

Given the difficulty in determining what forecasts of inflation are embedded in NG yields over the chosen maturity period, we do not consider that the real RFR should be determined on the basis of using NGs. However, we do consider it to be a useful cross check to the real RFR calculated using ILGs.

In order to use NG yields to estimate the spot implied real RFR, we first calculate the average RPIX inflation forecast for each duration of the NGs we are considering, which are 5, 10 and 20 years. For this we have used CE's inflation expectations as of October 2009. Since the inflation expectation only extends as far as 2019 (i.e. ten years), we have used the ten year expected inflation rate to deflate the spot rates on both 10 and 20 year NGs.

Second, we adjust our RPIX inflation forecast for each bond maturity by the average historical difference between RPIX and RPI inflation over a 20 year period (1988-2008). Our analysis indicates that on average RPI inflation is 0.2 percentage points higher than RPIX inflation. We then use the expected RPI inflation measures to deflate the yields on 5, 10 and 20 year maturity NGs. Our calculations for the implied spot rates are set out in Table 9 below.

Table 9: Implied spot risk-free rates from nominal government bonds

	5 year maturity	10 year maturity	20 year maturity
Inflation			
Expected RPIX Inflation (%)	2.2	2.7	2.7
Average difference between actual RPIX and RPI inflation (calculated on the basis of outturn inflation of both measures between1988-2008)	0.2	0.2	0.2
Expected RPI inflation (%)	2.4	2.9	2.9
Yields			
Nominal spot rates (%)	2.6	3.6	4.2
Implied real spot rates (%)	0.2	0.7	1.3

Source: CE for inflation forecasts, ONS for actual RPI and RPIX inflation between 1988 and 2008 and BOE for yields on NGs.

Calculating the long-term average yields across the three maturities requires two steps. First the nominal yields for each maturity need to be deflated so as to calculate the implied real yields. To do this with precision would not be straightforward as it would require expected 5, 10 and 20 year inflation forecasts at each point in time for the length of the time period over which the average is estimated. So for example, in our case where we use daily data over ten years, it would require daily 5, 10, and 15 year inflation expectations over a ten year period. This step would be very data intensive. The second step is more straightforward and involves averaging the implied real yield time series to calculate 5, 10, and 20 year implied real yields on NGs.

Considering the data intensity and use of this approach, we undertook a rather simpler approach that is broadly in line with the method outlined above. First, using the CE dataset, we calculated five and ten year inflation forecasts for each year from 2003-2009. In order to calculate the long-term average implied yields, we also needed inflation expectations for the period 2000 to 2002. Given that CE inflation data is not available for this period, we assumed that the 5 and 10 year inflation expectations for each of these three years were equal to the average 5 and 10 year inflation expectation between 2003 and 2009. We then uplifted these RPIX inflation forecasts by 0.2 percentage points to obtain an estimate of RPI inflation expectations. Our results from this step are set out in Table 10.

Table 10: Expected RPI inflation

Inflation	Expected 5 year RPI inflation (%)	Expected 10 year RPI inflation (%)
2000-2002	2.6	2.6
2003	2.7	2.7
2004	2.6	2.8
2005	2.5	2.6
2006	2.8	2.8
2007	2.3	2.3
2008	3.5	3.3
2009	2.4	2.9

Source: ONS for actual inflation data between 1988 and 2008, CE for RPIX inflation forecasts between 2003 and 2009 and PwC calculations

Second, we use these RPI inflation forecasts to calculate the implied real RFR from yields on NGs across all the three maturities. Specifically, we deducted the five year inflation forecast from the yields on the 5 year maturity NGs, whereas for yields on both 10 and 20 year maturity NGs we used 10 year expected inflation estimates to calculate the implied RFR.[14] We then calculated the average over the 5 and 10 year period. Our results are presented in the table below.

Table 11: Real RFR implied from yields on NGs

	5 year maturity	10 year maturity	20 year maturity
5 year average (%)	1.6	1.7	1.7
10 year average (%)	1.9	1.7	1.8

Source: PwC's calculations

One limitation of this approach is that it can result in extremely low real RFR under very volatile market conditions when spot rates have been artificially driven down due to the flight to quality – see, for example, the estimated real spot rate for NGs of 5 years maturity. Furthermore, because the real value of returns received by investors is affected by changes in inflation the estimate includes an inflation risk premium which in principle should not form part of the real RFR (although it is not clear whether this causes any material distortion). However, unlike ILGs, the distortion in yields caused by demand from pension funds is not a material concern for NGs.

[14] Note that there is a mismatch between the frequency of the yield data (daily) and the inflation forecasts (annually). We have chosen this approach to avoid the data intensity issues discussed in the text. For each year we have used the single annual figure to deflate all of the daily yields.

Within this approach we consider that more weight should be placed on the long term averages of 10-20 year maturity bonds as they appear to be somewhat more stable, possibly better reflecting fundamentals.

Moreover, the recent quantitative easing policy that was announced by the Monetary Policy Committee (MPC) on March 5 2009 has complicated the use of yields on NGs to calculate the RFR. As part of this policy, the BOE has been buying significant amounts of NGs in order to boost the money supply in the economy, as indicated in Figure 10. Our analysis indicates that between March 7 and May 9 2009 the BOE bought conventional gilts worth around £50billion. This excessive demand has put more downward pressure on spot yields. This also supports our view that more weight should be put on long-term averages as opposed to spot rates.

Figure 10: Impact of quantitative easing on NGs

Source: BOE, Inflation Report 2009

Interest rate swaps

An alternative approach to calculating the RFR was proposed in a recent cost of capital study for Water UK[15], based on interest rate swaps. The approach involves estimating a real RFR by taking the 5 year swap rate for the 6 month London inter-bank offer rate (Libor) and deducting a measure of expected inflation and an estimate of the default premium embedded in the swap rate (which is based on Credit Default Swaps (CDS) premia[16]).

The rationale for this approach is as follows. Providers of 5 year Libor swaps determine the fixed yield they are prepared to offer over a 5 year period in return for being exposed to movements in 6 month Libor. This fixed yield, the swap rate, is set such that the expected present value of the payments to the provider of the swap is equal to the expected value of 6 month Libor over the 5 year period. Thus, the swap rate gives a market estimate of Libor over a 5 year period (Libor itself is only available for durations of up to 1 year). Unlike ILGs or NGs, Libor does not provide a direct estimate of the RFR – it reflects the credit risk associated with the banks participating in the London wholesale money market. However, it is calculated from the rates offered by a panel of banks, the composition of which can change if member banks suffer a drop in credit rating. Hence the 5 year swap rate includes a premium for the default risk associated with creditworthy financial institutions. The size of the additional return required for bearing this default risk can be inferred from CDS premia. In principle, subtracting this from the swap rate gives an estimate of the nominal RFR, requiring only expected inflation to be subtracted in order to derive an estimate of the real RFR.

[15] Nera, "Cost of capital for PR09 – Final report for Water UK", June 2008.
[16] In a CDS contract the buyer of the contract makes a series of payments to the seller and, in exchange, receives a payoff, usually equivalent to the face value of the credit instrument (typically a bond or loan), if it defaults. The periodic payments are calculated as the product of the CDS premia and the face value of the credit instrument.

The market for swaps is large and liquid so it may be an alternative or supplementary source of data on the RFR given possible distortions in the ILG and NG markets. However, this approach is based on the London wholesale money market which has itself been disrupted during the recent financial crisis. Furthermore, because the swap rate is a nominal rate, it suffers from some similar disadvantages as NGs. First, it includes a premium for inflation risk which ideally should not be included in an estimate of the real RFR. Second, it requires estimates of expected inflation, which adds to the complexity and degree of uncertainty associated with the calculations.

Furthermore, in addition to a time series of 5 year inflation forecasts, applying this approach requires a time series of the CDS premium on financial institutions' debt so that for each swap rate at each point in time we can deduct the corresponding CDS premium and inflation to obtain the implied real RFR. This approach is outlined in more detail below.

First, in order to develop a steady state CDS premium time series for an approximate ten year period (January 2000 to October 2009), we have examined evidence on 5 and 10 year financial institutions senior debt CDS set out in Figure 11 below[17].

Figure 11: 5 year CDS premia on financial institutions senior debt

Note: the last data point on the chart above is 15/10/09.

Source: Thomson Reuters

Our analysis indicates that since the onset of the credit crisis CDS premiums have been very volatile with the current premium being higher than the levels observed prior to the crisis. Including this data in the calculations might result in biased estimates of the RFR. However, excluding this data would restrict the data to only a few years prior to the onset of the current crisis. Whilst these data depict a very stable level of the premium, from an estimation perspective it is a rather small sample set for estimating a steady premium over a long-term period such as ten years.

Despite this limitation, we calculated the real RFR embedded in interest rate swaps to assess whether they differ significantly from the figures based on ILGs, and if so what drives that difference. Since we only have approximately two years data on CDS premiums prior to the onset of the crisis, it is not possible to develop a bespoke time series over the ten year period under consideration. Therefore we have made the simplifying assumption that the CDS premium on financial institutions debt has been constant over time and have used the data on the 5 year CDS between September 2005 to December 2007 as the basis for calculation[18]. This

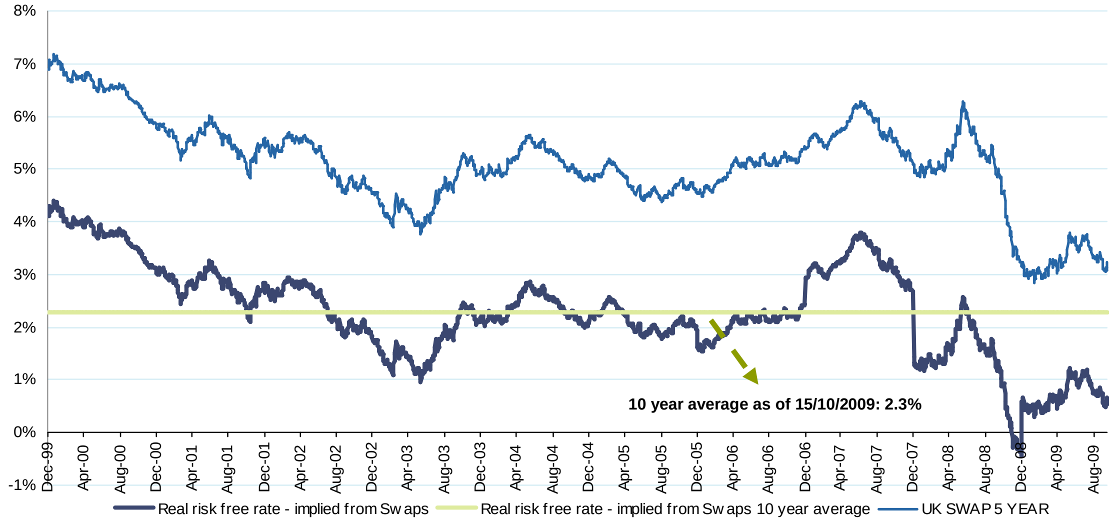
[17] Data for these was only available from September 2005.
[18] Considering this assumption our estimates from this approach should be only considered as illustrative.

gives an average CDS premium of 10 basis points. Subtracting this from the data on the 5 year swap rate for 6 month Libor gives the implied nominal RFR.

To calculate the spot real RFR implied in the nominal RFR we deduct CE's current market 5 year inflation forecast from the nominal RFR (using the Fisher equation[19]). This gives a spot real RFR implied from interest rate swaps of 0.7%.

In order to calculate the long term average, in principle we should deduct the 5 year expected inflation at each point in time from January 2000 onwards from our corresponding nominal RFR. However for the same reasons as discussed in the NGs section, the practical application of this is challenging and data intensive. On this basis, we apply the same approach as we did for NGs, and have used the inflation figures set out in Table 10. Our results for the real RFR under this approach are set out in the figure below.

Figure 12: Real risk-free rate implied from interest rate swap options



Note: the last data point on the chart above is as of 15/10/09.
Source: Datastream for swap rates, Thomson Reuters for CDS premia, CE for inflation forecasts, ONS for actual RPI and RPIX inflation and PwC calculations

Our analysis indicates that the overall long term real RFR based on this approach (2.3%) is close to that derived using market evidence on ILGs. However, the real RFR estimated calculated using interest rate swap options is very sensitive to the underlying assumption about inflation and the default risk on financial institutions debt. During late 2008 the spot real RFR estimated using this method dropped dramatically, reflecting increases in default premia and a dramatic drop in Libor in response to the BOE cutting its base rate to a record low. In the recent Stansted price control review, the CC reviewed this approach and, based on data concerns, rejected it in favour of the continued use of ILGs as the best estimate of the real RFR. We agree with the CC that, although imperfect, yields on ILGs continue to provide the most robust estimate of the real RFR.

Overall, considering the close proximity of the results under the two approaches, the reliance on accurate estimation of two parameters that are difficult to forecast under the current market conditions, as well as data concerns, we do not consider that this approach has any advantage over ILGs as the basis for estimating the real RFR for DPCR5.

[19] Fisher equation: $(1 + RR) = (1 + NR) / (1 + \Pi)$, where RR is the real risk free rate, NR is the nominal risk free rate and Π is the rate of inflation.

3.3.3 PwC's recommendations

The table below summarises our real RFR calculation under the three approaches.

Table 12: Real risk free rate – Summary of results

	5 year maturity	10 year maturity	20 year maturity
ILGs			
Spot rate as of 15/10/09(%)	0.3	0.7	0.8
10 year average (%)	2.0	1.9	1.6
NGs			
Spot rate as of 15/10/09(%)	0.2	0.7	1.3
10 year average (%)	1.9	1.7	1.8
Interest rate swap options			
Spot rate as of 15/10/09(%)	0.7	n/a	n/a
10 year average (%)	2.3	n/a	n/a
Regulatory precedents			
Since 2000 (%)	2.0 – 3.0		

Source: Datastream for swap rates, Thomson Reuters for CDS premia, CE for inflation forecasts, ONS for actual RPI and RPIX inflation, BOE for yields on ILGs and NGs and PwC calculations

In formulating our view we have considered that:

- Under the current volatile market conditions there is a lot of uncertainty around the level of RFR that is likely to prevail over DPCR5 irrespective of the approach used to calculate it. This inherent uncertainty around estimates suggests the use of a wide range for the real RFR;
- Evidence on ILGs provides the best estimate of the real RFR;
- Yields on 5-10 year maturity ILGs are relatively less distorted as a result of supply and demand imbalances; and
- Regulators in general, and Ofgem in particular, have generally taken a long-term view on the real RFR for regulatory determinations. This has often resulted in the real RFR allowed in the regulatory determinations being higher than the prevailing spot rates.

Considering this, our view is that a range of 2.0% to 2.5% is appropriate for DPCR5. The lower end of the range is consistent with the 5 and 10 year averages on 10 year ILGs. The upper end of the range is consistent with the mid-point of the range for the real RFR that has generally been used in regulatory determinations since 2000.[20]

Our recommendation is to use a range of 2.0% to 2.5% for the real RFR.

[20] Although we do note that in the CC's recent decision on Stansted airport it used a real RFR of 2% which is at the bottom end of the range used in regulatory determinations since 2000.

3.4 Equity beta

Under the CAPM framework, investors are only compensated for bearing systematic risk. The degree of systematic risk associated with any individual investment depends on the correlation between movements in returns on that investment and returns on the market portfolio. The stronger the correlation, and the greater the amplitude of any movement in returns as a result of market-wide events, the higher the systematic risk. For a particular equity investment this is measured by the investment's equity beta. Specifically the equity beta is equal to:

> $Be = Cov(R_e, R_m) / Var(R_m)$
>
> Where;
>
> R_e is the return on the specific stock
>
> R_m is the return on market portfolio

3.4.1 Ofgem's approach and regulatory precedents

During DPCR4, Ofgem determined a range for equity betas based on a report by Smithers & Co[21]. The beta range was established using a selection of comparable companies[22] which were considered to be representative of DNOs.

The table below sets out our findings on issues related to the estimation of equity betas. The key observations are as follows:

- Most regulators have undertaken comparator analysis in order to calculate the equity beta. This involves estimating comparator equity betas that are then de-levered and averaged resulting in the average asset beta; and

- There is mixed evidence on the estimation period and frequency of data used. Some regulators estimate an equity beta over a 1 to 2 year period, whereas others use a 5 year period. Similarly, some regulators have used monthly data whereas others have used daily or weekly data.

[21] Wright, S. (Birkbeck College) and Smithers & Co, "Beta Estimates", March 2004.
[22] These were Scottish Power, Scottish & Southern Energy, Viridian Group, Centrica, International Power, National Grid Transco, United Utilities, Kelda Group and Severn Trent.

Table 13: Regulatory precedents, Equity beta.

Regulator	Review	Equity beta	Estimation period	Comments
ORR (Oct 2000)	Periodic review of Railtrack's access charges: final conclusions	1.1 - 1.3	Monthly / 5 years	- Based its analysis on London Business School ("LBS RMS" - 98) beta estimates, which suggested that Railtrack's beta is higher than those of other regulated utilities (National Grid, Water Group, BG, PES Group) except BAA. - Sense checked LBS estimates against regulatory precedents such as MMC BAA (1996) analysis as it considered airports to be the most relevant comparators for Railtrack.
CC (Nov 2002)	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	0.8 - 1.0	Monthly / 5 years	- Considered LBS equity beta estimates as well as evidence provided by BAA and CAA.
CAA (Feb 2003)	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	0.8 - 1.0	Monthly / 5 years	- Primarily used CC (Nov 2002) equity beta analysis.
CC (Feb 2003)	Mobile Phone Charges Inquiry	1.0 - 1.6	Daily and monthly /1 to 5 years	- Considered regulatory precedents set by Oftel (2001) and submissions by the mobile network operators.
Ofgem (Nov 2004)	Electricity Distribution Price Control Review 4	1.0 (implied)		- Used aggregate cost of equity approach that implicitly assumes an equity beta of 1.
Ofwat (Dec 2004)	Future water and sewerage charges 2005-10	1.0		- Used the upper end of ranges proposed by CC (2000) Mid Kent/Sutton and East Surrey Water and Ofgem DPCR 4
Ofcom (Aug 2005)	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	0.8 – 0.9	Daily / 1 year	- Considered LBS RMS daily equity beta estimates but preferred Ofcom's analysis method using monthly data over five years. Used cross-sector UK utility firms (such as National Grid, Scottish Power, etc.) as a sense-check which, after adjusting for gearing had an equity beta of less than one. - Considered academic studies that suggested that access services have a lower equity beta since their demand is not closely correlated with aggregate demand (Loomis and Lester (Eds.), Taylor ('94)) since the income elasticity of demand for access is significantly lower than the corresponding elasticities for various call types. - Used book value of assets (40% copper access) to disaggregate BT's group equity beta of 1.1.
CAA (Dec 2005)	NATS Price Control Review 2006-2010 (CP2)	1.7	Monthly / 5 years	- NERL is not publicly listed, so considered betas from utility, air transport and airport sectors in UK and Western Europe. Unlevering these betas gives NERL an estimated asset beta of 0.5 to 0.6. However, increased demand risk widens the range to 0.3-0.8 (commensurate with airport betas). - Argued that betas had been low in recent years and considered it prudent to remain at the top end of the range (at 0.6). Also took into account risk from NERL's profit volatility (due to high operational gearing and the relatively small size of the RAB compared to turnover). Equity beta was obtained from asset beta without disaggregation.

Regulator	Review	Equity beta	Estimation period	Comments
Postcomm (Dec 2005)	Royal Mail Price and Service Quality Review	.8 - .9		- Royal Mail is not a publicly listed company, so considered betas of other large regulated businesses in the UK (from LBS Risk Measurement) such as Scottish and Southern Energy, National Grid, etc.
Ofgem (Dec 2006)	Transmission Price Control Review, 2007-2012	1.0 (implied)		- Used aggregate cost of equity approach that implicitly assumes an equity beta of 1.
Ofcom (Mar 2007)	Mobile Call Termination Statement	1.0 - 1.6	Daily and monthly / 1 to 5 years	- Also considered regulatory precedent such as CC (Feb 2003) Mobile Phone Charges Inquiry.
Ofgem (Dec 2007)	Gas Distribution Price Control Review 2007-13	1.0 (implied)		- Used aggregate cost of equity approach that implicitly assumes an equity beta of 1.
CAA/CC (Mar 2008)	Economic Regulation of Heathrow and Gatwick Airports (Heathrow / Gatwick)	.9 – 1.2 / 1.0 - 1.3	Daily / 2 years	- Disaggregated BAA group beta to calculate Heathrow/Gatwick's equity betas. - For disaggregation, assumed Gatwick's asset beta was 0.04 higher than Heathrow's asset beta.
CC (Nov 2008)	Stansted Price Control Review (2009-14)	1.0 - 1.2	Daily data / 1 years	- Estimated Stansted's asset beta by disaggregating BAA's asset beta on the basis of proportion of assets. -To calculate BAA group equity, considered one and two-year rolling equity beta estimates from 1988-2006.
CAA (Mar 2009)	Stansted Price Control Review (2009-14)	1.0 - 1.2	Daily data / 1 years	- Based its estimate on CC (Nov 2008).

Source: PwC analysis. Further details are provided in Appendix I and V.

3.4.2 PwC's approach

As mentioned earlier in this report, none of the UK DNOs themselves are listed and therefore we consider that the best practice for estimating beta is to use a range of suitable comparator equity betas. This involves an assessment of the equity betas of quoted companies with business risk profiles similar to those of the DNOs. For this we considered a potential of 76 comparators we identified from sources including:

- Previous work e.g. NERA's "Analysis on the Cost of Equity for DPCR5" (23 Jan 2009), and Oxera's report "Is there a risk differential between energy networks?" (5 Sep 2007);
- PwC industry team knowledge; and
- Regulatory precedents in other jurisdictions e.g. Belgium, Australia.[23]

A main consideration for investors in utilities such as the DNOs is the degree of exposure to regulatory risk, which tends to vary across regions due to differences in the regulatory regimes. Taking this into account we have grouped our sample set on a geographical basis to separate out UK and international comparators. Since regulatory risk for international comparators differs from that faced by UK DNOs, we have based our analysis primarily on UK comparators, although we consider that international comparators can provide a useful cross check to our UK comparator set analysis. Moreover, geographical segmentation groups together companies that operate under similar market dynamics. Potentially a comparison of companies across different geographical groups might help us understand the impact of factors such as differences in regulatory regimes on asset betas. For each group we discarded companies that had:

- A market capitalisation of less than £500m, as we considered that these companies were too small and would bias our beta estimates;
- Earned the majority of their operating profit from non network activities[24]; and
- Insufficient information available for undertaking the equity beta analysis.

However there are a number of key exceptions to these rules. For example in the case of the UK, only National Grid (NG)[25] and Scottish Power (SP) satisfy the above criteria. However we have also considered Scottish and Southern Energy (SSE) even though the proportion of its operating profit attributable to network operations is only 29%. We consider it is still useful to include it in our sample set as it is the only listed UK based energy business that owns two DNOs.

In addition to energy network comparators operating within UK, we have also considered UK water and sewerage companies (WaSCs). We have included them in our sample set as the majority of their businesses operate under a similar regulatory regime, and face broadly similar demand risk. Moreover, water companies have been used as comparators in several studies in the past (including the study done by Smithers & Co for Ofgem for DPCR4).

Our beta calculations entail several steps that are explained below separately for each geographical set.

UK comparators

Table 14 below presents an overview of our UK comparators. Specifically, for network companies the table below set outs the proportion of operating profit earned from different business segments namely, Electricity Distribution (ED), Electricity Transmission (ET), Electricity Network (EN – this refers to a combination of ED and ET), Gas Distribution (GD), Gas Transmission (GT), Gas Network (GN – refers to a combination of GD

[23] Frontier Economics, "The cost of capital for electricity and gas networks: issues raised during public consultation", June 2006 and AER, "Electricity transmission and network service providers: Review of weighted average cost of capital parameters", May 2009.
[24] Network collectively refers to both transmission and distribution businesses. We calculated business segments on the basis of 2008 annual accounts except in the case of Scottish Power where we have based this on 2007 annual accounts because although operating profit break down was available for some business segments for 2008, the total operating profit figure was not provided. For Red Electrica and Sana Rete Gas, business segmentation is based on the proportion of revenues as no operating profit breakdown was available.
[25] Note that although NG has operations in US, for the purpose of this analysis we have assumed it to be a primarily UK based energy business.

and GT), Electricity and Gas Network (EGN – refers to the combination of EN and GN), Retail and Generation (R/G), and Water and Sewerage Company (WaSC).

Table 14; UK network and water companies

	Business segmentation (%)									
	ED	ET	EN (ED+ET)	GD	GT	GN (GD+GT)	EGN (EN + GN)	R/G	WaSC	Vertically integrated
National Grid	0	38	38	n/a	n/a	36	74	23	n/a	Yes
Scottish and Southern Energy	n/a	n/a	39	n/a	n/a	n/a	n/a	52	n/a	Yes
Scottish Power	43	15	58	n/a	n/a	n/a	n/a	n/a	n/a	Yes
Dee Valley	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	100	No
United Utilities	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	92	No
Severn Trent	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	99	No
Pennon	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	76	No
Northumbrian	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	98	No

Source: Annual Accounts

For UK comparators, first we estimated equity betas by assessing the co-movement of the share prices of the companies with the FTSE-100 index. Equity betas can be calculated using daily, weekly and monthly data. We consider that in overall terms monthly estimates are more reliable than weekly or daily estimates, as explained in the table below.

Table 15: Assessment of alternative frequencies for estimating equity betas

	Frequency – daily	Frequency – weekly	Frequency – monthly
Advantages	Large number of observations	More observations relative to monthly data Less noise relative to daily data	Low standard errors relative to daily or weekly data Are likely to be more representative of the underlying risk
Disadvantages	High standard errors Daily returns are very volatile	High standard errors Different results depending upon which day of the week is used	Requires 5 years of data to provide sufficient observations. Over a 5 year period the corporate risk profile of the company may change

Source: PwC analysis

The key points to note are as follows:

- Weekly estimates suffer from the problem of different results depending upon the day of the week chosen as the basis for the regressions;
- Daily and weekly betas are less stable than monthly betas, reflecting the fact that monthly share price movements are less volatile than daily and weekly share price movements; and
- Movements in monthly returns are more likely to be representative of underlying systematic risk than daily and weekly movements because daily and weekly returns may be influenced by short-term factors that have little to do with systematic risk — this is known as "noise" because it obscures the relationship being measured. As a result standard errors of monthly betas are lower than those for daily and weekly betas as they suffer from less noise.

A related issue is the time period over which the equity beta should be estimated. We consider that in order to calculate a reliable monthly beta, 5 years of data are required to provide sufficient observations for the regression. This approach is appropriate only if the corporate risk profile has not changed over this 5 year period. However, if this is not the case, and the company has undergone significant changes over the past 5 years, it may be more appropriate to use a shorter time period with higher frequency of data (for example daily data over one year). For the purpose of this analysis therefore we have used 5 year monthly betas. However, for completeness and comparison, for our final estimates we have also presented 3 year weekly and 2 year daily asset beta estimates.

Second, we have calculated asset betas by de-levering the equity betas at the actual gearing of the company using the following formula:

$$\beta_a = (1\text{-}G)\ \beta_e + G\ \beta_d$$

Where:

βe is the asset beta

βa is equity beta

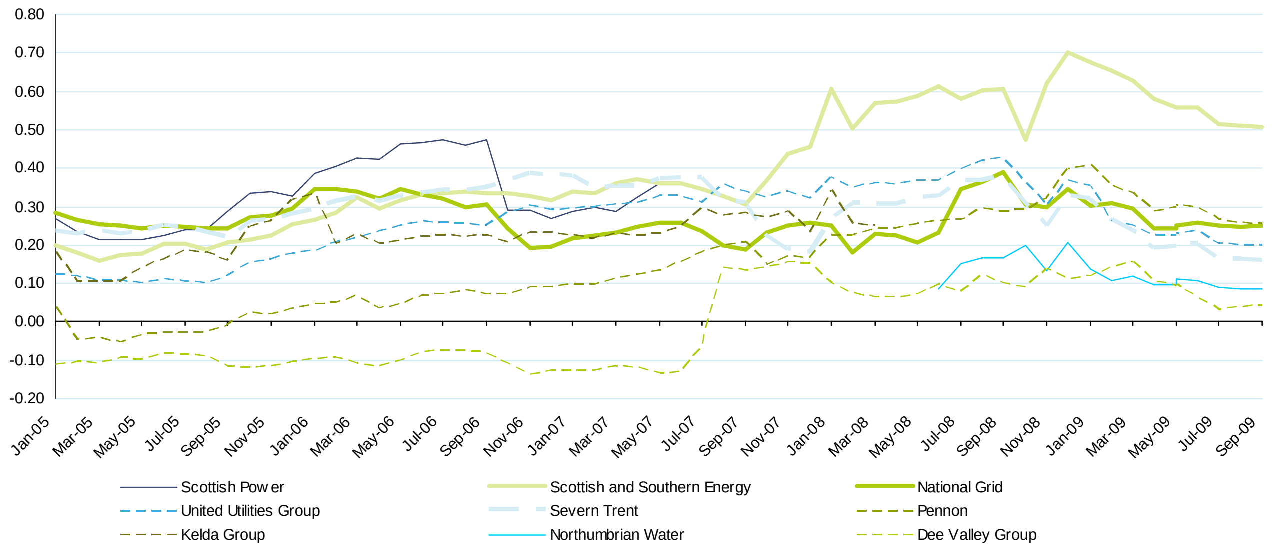
βd is the debt beta

G is the level of gearing

The underlying reasoning for de-levering is that equity betas reflect the financial as well as the business risk faced by equity investors. Whereas suitable comparators have been chosen on the basis that they can be expected to have similar business risk, they may differ in their exposure to financial risk (because of different gearing levels) and therefore comparator companies can be expected to have similar asset betas (reflecting just business risk) but not necessarily similar equity betas.

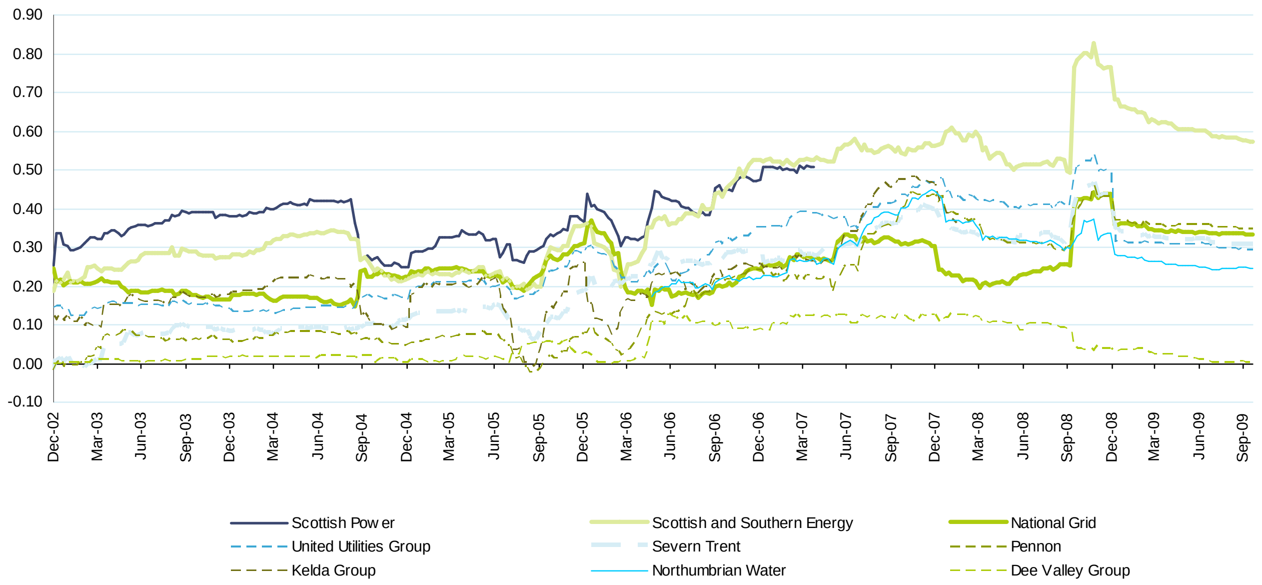
An important issue to consider when measuring asset betas is the level assumed for the debt beta, which reflects the systematic risk faced by debt investors. Generally most practitioners assume a debt beta of zero when calculating the asset beta. However the CC in its cost of capital analysis for Heathrow, Gatwick and Stansted Airports assumed a debt beta of 0.1. Taking this into consideration, and to assess the impact of a non-zero debt beta, we have used debt betas of 0 and 0.1 for calculating asset betas, although we believe that more emphasis should be placed on the results using a debt beta of 0. Figure 13-15 below set out the evolutions of our monthly, weekly and daily unadjusted asset betas, assuming a debt beta of 0 for our UK comparators.

Figure 13: Evolution of unadjusted 5 year monthly betas, assuming zero debt beta



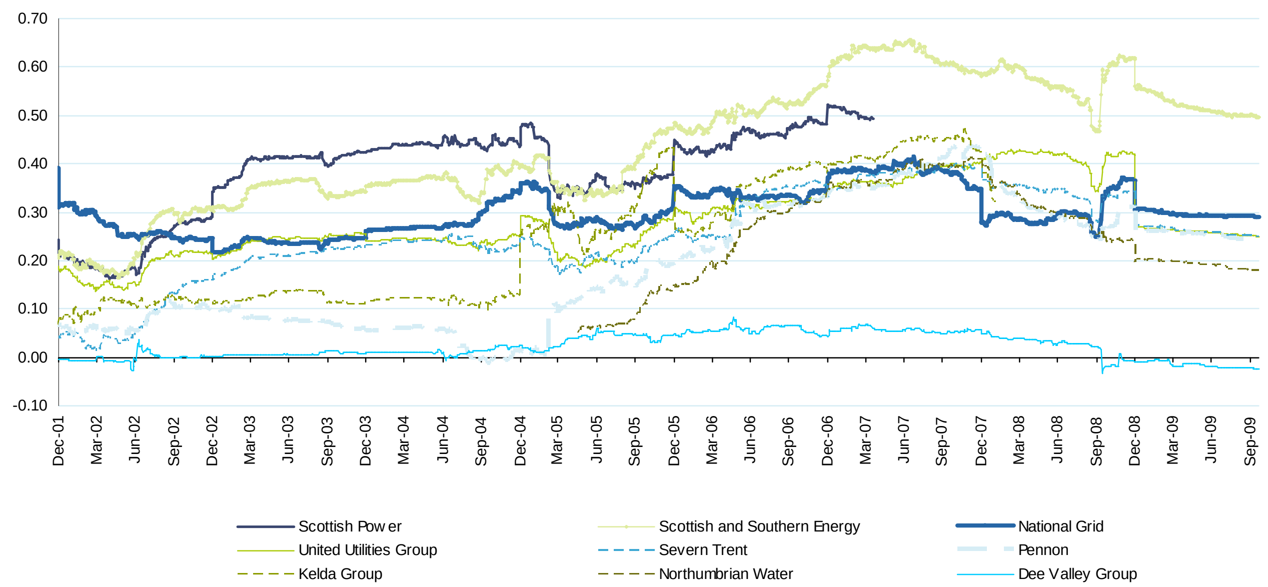
Note: Kelda share ceased to trade in February 2008 and Scottish Power share ceased to trade in April 2007..
Source: Datastream and PwC calculations

Figure 14: Evolution of unadjusted 3 year weekly betas for UK comparators, assuming zero debt beta



Note: Kelda share ceased to trade in February 2008 and Scottish Power share ceased to trade in April 2007..
Source: Datastream and PwC calculations

Figure 15: Evolution of unadjusted 2 year daily betas for UK comparators, assuming zero debt beta



Note: Kelda share ceased to trade in February 2008 and Scottish Power ceased to trade in April 2007.
Source: Datastream and PwC calculations

The key aspects to note are:

- The WaSCs' assets betas have remained quite stable since the PR04 settlement in 2004/05. They did increase marginally after the onset of the credit crisis in August 2007 but have since decreased to their pre-crisis level. Our analysis indicates that WaSCs have been generally unaffected by the credit crunch and recession, and are considered low risk assets by investors;

- The low asset betas for Northumbrian Water (NW) and Dee Valley Group (DWG) primarily reflect their small size (relative to other WaSCs) and the potential illiquidity of their stocks, and on this basis we exclude them from our sample set;

- SSE has a significantly higher asset beta (across all frequencies) relative to all other comparators, reflecting the higher business risk faced by an integrated player that generates a significant proportion of its revenue from retail and generation; and

- National Grid (NG), which primarily generates its revenue from network operations and whose risk profile is likely to be much more closely in line with those of the DNOs, shows a similar evolution of the asset beta to that of the WaSCs. Its asset beta increased slightly after the onset of the crisis but then dropped back to pre-crisis levels.

Consistent with our earlier arguments, the evidence indicates that 5 year monthly betas are more stable compared to 2 year daily and 3 year weekly betas.

The asset betas calculated above for SP and SSE reflect the systematic risk exposure of their vertically integrated business operations. However what we want are asset betas for their network operations only. We have inferred the asset beta for network operations using the following approach.[26]

First we assessed the extent to which the asset beta of a pure play network business would increase if it had vertically integrated business operations. This could be assessed by comparing the asset beta of a pure-play network business with that of a vertically integrated one. Specifically, of our international comparators (see the next section), we compared the 5 year monthly unadjusted asset beta of TransCanada, a vertically

[26] We did not undertake a similar approach to NG's beta as it is primarily a network business.

integrated GN, with pure-play GNs including New Jersey Resources, Northwest Natural Gas, Piedmont Natural Gas and WGL Holdings (see Table 18).[27] Our analysis showed that the 5 year unadjusted asset beta of our sampled vertically integrated GN was approximately 0.1 higher than the average of the unadjusted asset betas across the sampled pure-play GNs.[28] Second, we apply this adjustment to the 5 year unadjusted group asset betas of SP and SSE and lower them by 0.1 to infer their network operations asset betas. All of the figures presented below are subject to this adjustment.

Our spot betas for our UK comparators at May 8, 2009 are summarised in the table below.

Table 16: Summary results for UK comparators unadjusted asset betas

	5 year monthly (assuming zero debt beta)	5 year monthly (assuming 0.1 debt beta)	3 year weekly (assuming zero debt beta)	3 year weekly (assuming 0.1 debt beta)	2 year daily (assuming zero debt beta)	2 year daily (assuming 0.1 debt beta)
National Grid	0.25	0.31	0.33	0.39	0.29	0.35
Scottish and Southern Energy	0.41	0.43	0.57	0.59	0.50	0.52
Scottish Power	0.26	0.27	0.51	0.52	0.49	0.50
United Utilities	0.20	0.26	0.29	0.35	0.25	0.31
Severn Trent	0.16	0.22	0.31	0.37	0.25	0.31
Pennon	0.25	0.31	0.35	0.40	0.24	0.29
Kelda	0.25	0.30	0.36	0.41	0.32	0.37

Note: Kelda and SP betas are as of their last trading days which were 08/02/08 and 19/04/07 respectively
Source: Datastream and PwC's calculations

Applying the same approach for the unadjusted asset betas, we have calculated adjusted asset betas. The only difference is that for calculating adjusted betas we first apply the Blume[29] adjustment to our equity betas and then de-lever them to calculate the asset betas. The Blume adjustment is widely used by financial practitioners and takes account of the tendency of betas to converge towards one over the long-term.

$$\beta e\text{-}adjusted = 0.67 * \beta e\text{-}unadjusted + 0.33*(1)$$

Our adjusted asset beta results are summarized in Table 17 below.

[27] We did not compare the weekly and daily asset betas due to their limitations set out in Table 15. Moreover using daily and weekly betas indicate that TransCanada, a vertically integrated GN, has an asset beta lower than that of the average asset beta across pure-play GNs, which is counterintuitive and points towards the caveats associated with using daily and weekly data.
We have excluded Kinder Morgan which is another vertically integrated gas network from our analysis because of the volatility of its asset betas. For more detail please see the next section.
[28] The TransCanada unadjusted 5 year asset beta is 0.21 whereas the average of the pure-play GNs is 0.06.
[29] Blume, Marshall (1971), "On the assessment of risk", The Journal of Finance.

Table 17: Summary results for UK comparators adjusted asset betas

	5 year monthly (assuming zero debt beta)	5 year monthly (assuming 0.1 debt beta)	3 year weekly (assuming zero debt beta)	3 year weekly (assuming 0.1 debt beta)	2 year daily (assuming zero debt beta)	2 year daily (assuming 0.1 debt beta)
National Grid	0.31	0.35	0.36	0.40	0.34	0.37
Scottish and Southern Energy	0.50	0.51	0.64	0.66	0.59	0.61
Scottish Power	0.43	0.44	0.63	0.64	0.62	0.63
United Utilities	0.26	0.30	0.33	0.37	0.30	0.34
Severn Trent	0.24	0.28	0.34	0.38	0.30	0.34
Pennon	0.33	0.36	0.39	0.42	0.32	0.35
Kelda	0.35	0.38	0.42	0.45	0.40	0.43

Source: Datastream and PwC calculations

The table suggests that, based on UK comparators, the DNOs' asset beta lies within the range 0.24-0.38. The lower end of the range is the Severn Trent 5 year monthly asset beta and the upper end of the range is Kelda's 5 year monthly asset beta. This range is based on:

- 5 year monthly betas, which tend to be more stable and therefore may be more reliable for use in the context of a regulatory determination where prices are being set for a five year period;
- Exclusion of SSE and SP, as the adjustment made to infer their network operations asset betas is imprecise;
- Adjusted betas, as this approach is in line with regulatory precedents and the generally accepted view that beta tends to 1 over the long-term; and
- Beta estimates calculated assuming both a zero and a 0.1 debt beta.

For the purpose of recommending a final range for the asset beta we note that the bottom end of the range is influenced by two low figures for Severn Trent and United Utilities. Not only do these appear as low amongst the 5 year monthly estimates, they are also low relative to the alternative methods of calculating beta for these two companies. We therefore exclude them when presenting our recommended range, implying a low end figure of 0.31 (based on National Grid). Second, we believe that our final range for WACC should not include a debt premium. In principle this would result in a reduction in the top end value of the asset beta range to 0.35 from 0.38. However, whilst we are not confident in their accuracy, such a low top end value would be significantly lower than our estimated asset betas for the network operations of SSE and SP. We therefore propose to continue to use 0.38 as the top end of our asset beta, despite not using a debt beta in our WACC range.

Our final range for the asset beta is therefore 0.31-0.38. To cross check our range derived using UK comparators of the DNOs, we calculate a range for DNOs using our international comparators. Details of this analysis are set out in the next section.

International comparators

The table below presents an overview of our international comparators.

Table 18: International comparators

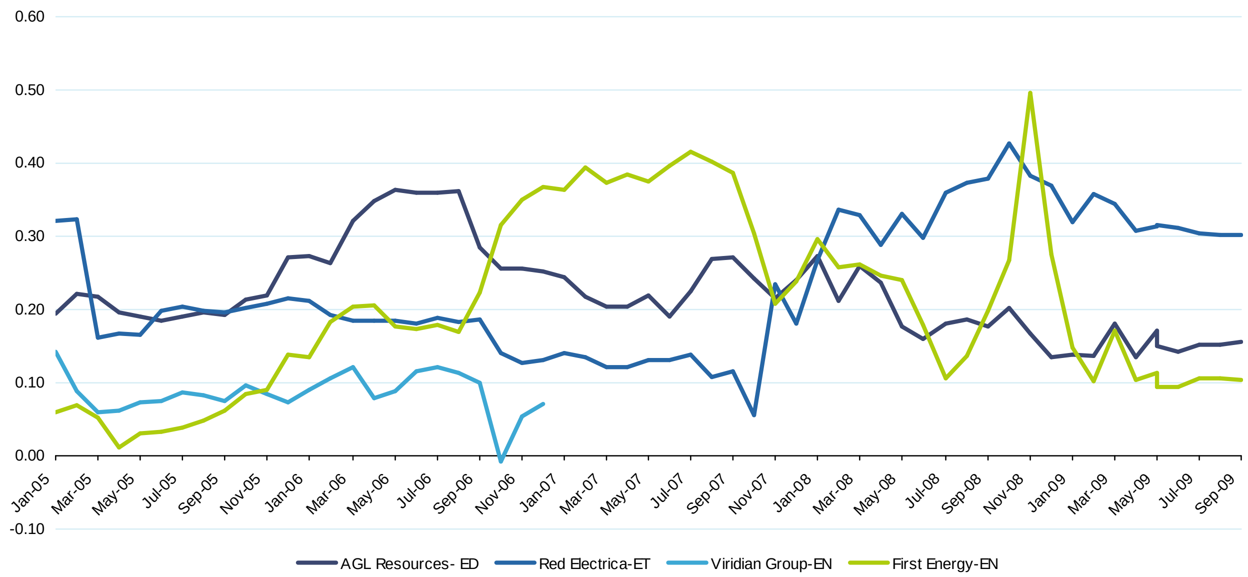
	Business segmentation (%)									
	ED	ET	EN (ED+ET)	GD	GT	GN (GD+GT)	EGN (EN + GN)	R/G	Others	Vertically integrated
Primarily ED										
AGL Resources	68%	n/a	n/a	n/a	n/a	n/a	n/a	28%	4%	Yes
Primarily ET										
ITC Holdings Corp	n/a	100%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No
Red Electrica Corporacion SA	n/a	93%	n/a	n/a	n/a	n/a	n/a	n/a	7%	No
Terna SpA	n/a	100%	n/a	n/a	n/a	n/a	n/a	n/a	n/a	No
Primarily EN										
Viridan	n/a	n/a	65%	n/a	n/a	n/a	n/a	35%	n/a	Yes
First Energy	n/a	n/a	59%	n/a	n/a	n/a	n/a	41%	n/a	Yes
Primarily GD										
Nicor Inc	n/a	n/a	n/a	67%	n/a	n/a	n/a	14%	19%	Yes
Primarily GT										
Envestra Limited	n/a	n/a	n/a	n/a	100%	n/a	n/a	n/a	n/a	No
Snam Rete Gas SpA	n/a	n/a	n/a	n/a	99%	n/a	n/a	n/a	1%	No
APA Group	n/a	3%	n/a	n/a	88%	n/a	95%	n/a	9%	No
Enagas	n/a	n/a	n/a	n/a	97%	n/a	n/a	n/a	3%	No
Primarily GN										
Kinder Morgan Inc	n/a	n/a	n/a	n/a	n/a	48%	n/a	n/a	52%	No
New Jersey Resources Corp	n/a	n/a	n/a	n/a	n/a	100%	n/a	n/a	n/a	No
Northwest Natural Gas Company	n/a	n/a	n/a	n/a	n/a	100%	n/a	n/a	n/a	No
Piedmont Natural Gas Company Inc	n/a	n/a	n/a	n/a	n/a	100%	n/a	n/a	n/a	No
TransCanada Corp	n/a	n/a	n/a	n/a	n/a	68%	n/a	32%	n/a	Yes
WGL Holdings Inc	n/a	n/a	n/a	n/a	n/a	97%	n/a	3%	n/a	Yes (marginally)
Primarily EGN										
Sempra Energy	n/a	n/a	36%	29%	6%	35%	71%	16.6%	12.4%	Yes

Note: Although UniSource Energy is not included in this table as information on its business segmentation was not available, we have still considered it for our beta calculations because it is clear from the qualitative information available on its website and annual accounts that it is a vertically integrated EGN.

Source: Annual Accounts

Applying the same approach as we did in the case of the UK comparators we first estimated the equity betas and then de-leveraged them to calculate the asset betas. However for international comparators we did not adjust the betas of vertically integrated companies, as we saw little value in doing so given that we primarily use them as a cross check. For estimating beta, we used the primary index of the stock exchange on which each of the stocks are listed. For example for US comparators we used the S&P 500, and for TransCanada we used the S&P/TSX Composite Index. The figures below set out the results of unadjusted monthly asset betas. Charts showing the evolution of 2 year daily and 3 year weekly unadjusted asset betas are set out in Appendix III.

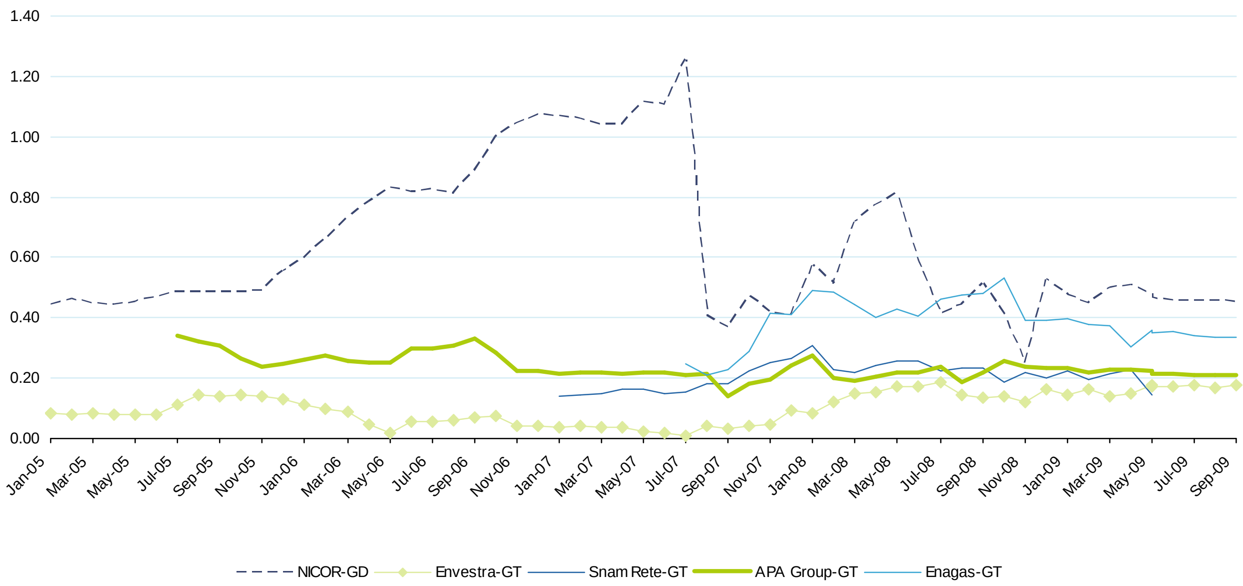
Figure 16: International electricity comparators, evolution of 5 year monthly unadjusted monthly asset beta, assuming zero debt beta



Source: PwC calculations based on share price data obtained from Datastream

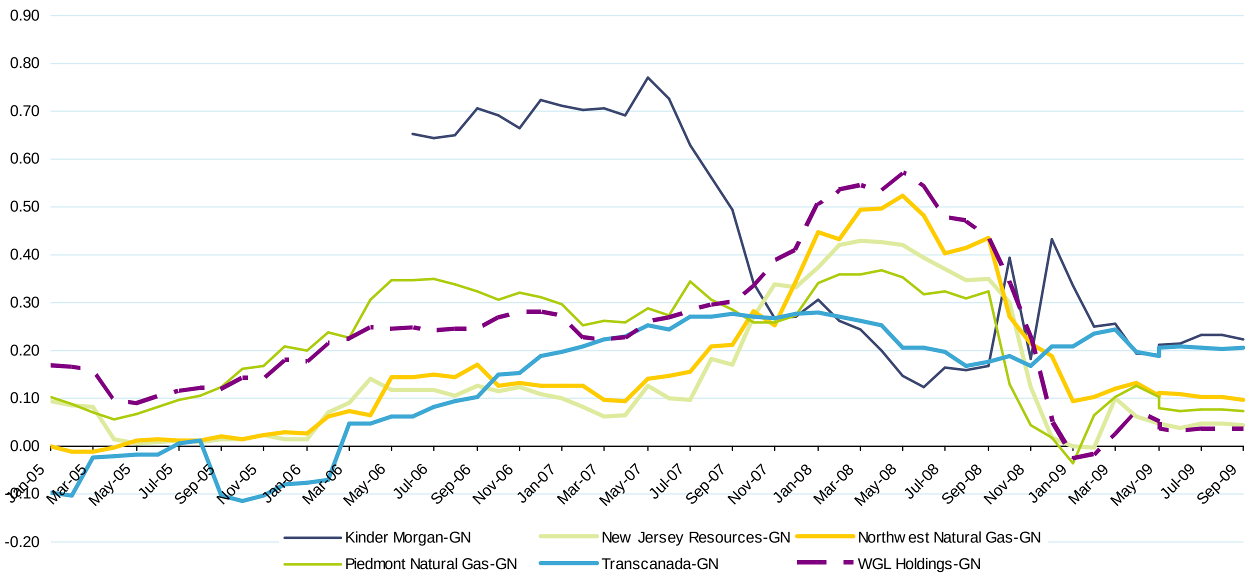
Note: Viridian was ceased to trade in December 2006 and not enough share price data was available to calculate five year monthly betas for ITC Holdings and Terna SpA.

Figure 17: International Gas Distribution and Transmission comparators, evolution of 5 year monthly unadjusted asset beta, assuming zero debt beta



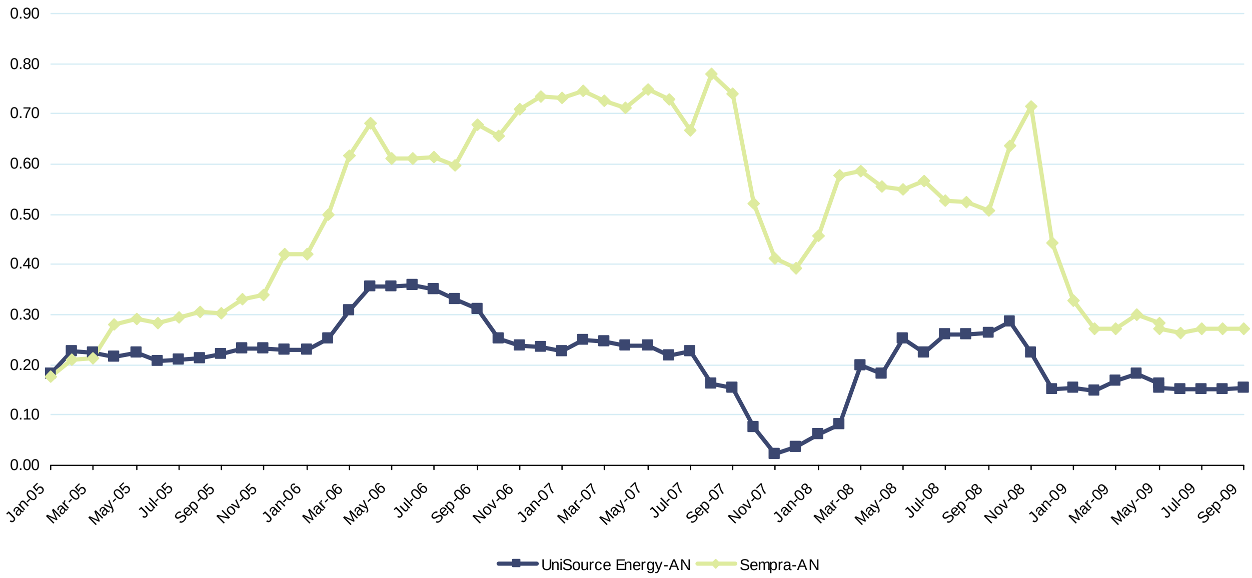
Source: PwC calculations based on share price data obtained from Datastream

Figure 18: International Gas Networks, evolution of 5 year monthly unadjusted asset beta, assuming zero debt beta



Source: PwC calculations based on share price data obtained from Datastream

Figure 19: International Electricity and Gas Networks, evolution of 5 year monthly unadjusted beta, assuming zero debt beta



Source: PwC calculations based on share price data obtained from Datastream

There are several important factors to note:

- Among electricity companies, vertically integrated companies in general seem to have higher and more volatile asset betas relative to pure network business indicating that these businesses are more susceptible to economic shocks. The exception is Viridian, whose asset beta has been consistently below the others, primarily reflecting the illiquidity of the stock, and it has therefore been excluded from our analysis.[30] Moreover, after the onset of the crisis the asset betas of the electricity companies did increase, but over the last year asset betas have fallen and are currently in line with their long-term level;

- Asset betas for Gas Transmission companies have been quite stable over time. The asset beta for Nicor, our only Gas Distribution comparator, has been very volatile. This might be a result of factors such as an increase in the operation leverage of the firm and due to the fact that it is vertically integrated. The asset beta of Envestra has been consistently below that of other companies, primarily reflecting the illiquidity of the stock. Considering the above reasons, we exclude Envestra and Nicor from our sample set;

- Asset betas across Gas Networks seem to be closely aligned and depict similar dynamics to those of Gas Transmission only and Distribution only businesses, as would be expected given that the underlying business risks across these companies are very similar. Considering the volatility in the Kinder Morgan asset beta, we exclude it from the sample set; and

- Among our Electricity and Gas Network comparators we exclude Sempra as it seems to be an outlier with an asset beta significantly higher then all the other comparators.

Table 19 and Table 20 below present our spot adjusted and unadjusted asset betas as of May 8 2009 across the three frequencies, both assuming a debt beta 0 and a 0.1 debt beta.

[30] Although it should be noted that AGL's asset beta has remained relatively stable over time, despite it having retail and generation operations.

Table 19: International comparator asset beta results, assuming zero debt beta

	5 year monthly – unadjusted beta	5 year monthly – adjusted beta	3 year weekly –unadjusted beta	3 year weekly –adjusted beta	2 year daily– unadjusted beta	2 year daily– adjusted beta
Primarily ED						
AGL Resources	0.16	0.29	0.39	0.45	0.35	0.43
Primarily ET						
ITC Holdings Corp	n/a	n/a	0.45	0.47	0.39	0.43
Red Electrica Corporacion SA	0.30	0.40	0.37	0.45	0.31	0.41
Terna SpA	0.00	0.22	0.23	0.37	0.25	0.38
Primarily EN						
First Energy	0.10	0.24	0.41	0.44	0.39	0.43
Primarily GT						
Snam Rete Gas SpA	0.15	0.32	0.19	0.35	0.12	0.30
APA Group	0.21	0.26	0.23	0.27	0.25	0.28
Enagas	0.34	0.43	0.37	0.45	0.34	0.43
Primarily GN						
New Jersey Resources Corp	0.04	0.27	0.41	0.51	0.44	0.54
Northwest Natural Gas Company	0.10	0.29	0.32	0.43	0.38	0.48
Piedmont Natural Gas Company Inc	0.07	0.26	0.38	0.47	0.45	0.51
TransCanada Corp	0.21	0.35	0.30	0.41	0.33	0.43
WGL Holdings Inc	0.04	0.27	0.45	0.55	0.50	0.58
Primarily EGN						
UniSource Energy	0.15	0.22	0.24	0.28	0.26	0.29

Source: Datastream and PwC calculations

Table 20: International comparator asset beta results, assuming 0.1 debt beta

	5 year monthly – unadjusted beta	5 year monthly – adjusted beta	3 year weekly –unadjusted beta	3 year weekly –adjusted beta	2 year daily– unadjusted beta	2 year daily-adjusted beta
Primarily ED						
AGL Resources	0.20	0.32	0.44	0.48	0.40	0.46
Primarily ET						
ITC Holdings Corp	n/a	n/a	0.50	0.50	0.44	0.46
Red Electrica Corporacion SA	0.34	0.43	0.41	0.47	0.35	0.43
Terna SpA	n/a	n/a	0.26	0.39	0.28	0.40
Primarily EN						
First Energy	0.15	0.27	0.46	0.47	0.44	0.46
Primarily GT						
Snam Rete Gas SpA	0.18	0.34	0.23	0.37	0.16	0.32
APA Group	0.28	0.30	0.29	0.31	0.31	0.33
Enagas	0.38	0.45	0.41	0.48	0.38	0.46
Primarily GN						
New Jersey Resources Corp	0.07	0.29	0.44	0.53	0.47	0.55
Northwest Natural Gas Company	0.13	0.31	0.35	0.46	0.42	0.50
Piedmont Natural Gas Company Inc	0.11	0.29	0.41	0.49	0.49	0.54
TransCanada Corp	0.24	0.37	0.34	0.43	0.37	0.45
WGL Holdings Inc	0.06	0.29	0.48	0.56	0.53	0.60
Primarily EGN						
UniSource Energy	0.22	0.26	0.31	0.32	0.32	0.33

Source: Datastream and PwC calculations

For the same reasons mentioned above, we consider that from an estimation perspective 5 year monthly adjusted betas calculated using a debt beta range of 0-0.1 are the most appropriate to use for deriving a range for the DNOs' asset betas. Our results across different business segments using this approach are summarised in the table below.

Table 21: Summary of results

	5 year monthly – adjusted betas (debt beta 0.0 – 0.1)
Primarily ED	0.29 – 0.32
Primarily ET	0.40 – 0.43
Primarily EN	0.24 – 0.27
Primarily GT	0.26 – 0.45
Primarily GN	0.26 – 0.37
Primarily EGN	0.22 – 0.26

Source: Datastream and PwC calculations.

Overall our analysis of the international comparators indicates an asset beta range of 0.22-0.45 as being relevant to UK DNOs. This range is very wide, as might be expected for a group of comparators operating in different countries, but includes the range we have derived using UK comparators. As mentioned earlier we consider that, for the purpose of inferring the asset beta of DNOs from comparators, it is more appropriate to use UK based companies as they operate under a very similar regulatory environment and face similar demand/supply dynamics. On this basis our proposed asset beta range for UK DNOs is 0.31-0.38 and is based on the range derived using our UK comparators.

So far our analysis has focused on calculating asset betas. However, calculating the cost of equity under the CAPM framework requires equity betas and therefore our next step is to calculate an equity beta range for the DNOs. Details of our equity beta calculations are set out in the next section.

3.4.3 DNOs' equity beta calculations

The following formula, which is a re-arrangement of that used for de-gearing, was used to calculate the equity beta implied by our asset betas.

$$\beta_e = \beta_a - G\,\beta_d /(1 - G)$$

Calculating the equity beta implied in asset betas requires two other parameters; the debt beta and gearing. As set out above, we decided not to include a debt beta in our WACC. For gearing we have used a range of 55% to 65% (see Section 5 for details). Our equity beta estimates for DNOs are therefore set out in the table below.

Table 22: Equity betas for UK DNOs

	Min	Max
Asset betas	0.31	0.38
Debt betas	0.0	0.0
Gearing (%)	55%	65%
Equity beta	0.7	1.1

Source: PwC analysis

3.4.4 PwC's recommendation

In summary when formulating our range:

- We have primarily used our UK comparator sample set, in order to avoid any distortions caused by differences in regulatory risk across different countries;
- We consider that our International comparator analysis provides a useful cross check to our UK comparator analysis;
- We have given more weight to five year monthly betas as they tend to be more stable and reflect a long-term view on the DNOs' asset betas;
- We have used adjusted asset betas, acknowledging regulatory precedents and the generally accepted view that in the long-run equity betas tend to 1; and
- We have not included a debt beta.

On this basis we recommend a range of 0.7-1.1 for the UK DNOs' equity beta for setting price caps for DPCR5. Our range is slightly wider than generally used, but we consider that the current uncertainty justifies the use of a larger range.

We recommend an equity beta range of 0.7-1.1 for DPCR5.

3.5 Equity market risk premium (EMRP)

The EMRP represents the premium of the market portfolio above the RFR. It is the return investors expect over and above the RFR to compensate for the additional risk associated with investing in equities instead of investing in risk-free assets. Arithmetically, it is calculated as:

$$EMRP = Rm - Rf$$

Where:

Rm is the expected return on the market portfolio

Rf is the risk-free rate

3.5.1 Ofgem's approach and regulatory precedents

For its initial decision in DPCR4, Ofgem considered several studies to determine the EMRP, including those by Dimson, Marsh and Staunton[31] (DMS) and Welch[32], but decided to use the CC estimate of 2.5%-4.5%. For the final decision, Ofgem used an aggregate return on equity method that estimates an overall cost of equity as opposed to individual parameters. However, our analysis shows that an EMRP of 4.9% was implied in the final cost of equity decision.

The table below sets out the approach that UK regulators have taken when estimating the EMRP. Our regulatory database indicates that regulators have consistently set an EMRP in the range 2.5%-5.0% both prior to and after the onset of the current financial market crisis. Regulators have primarily considered three main sources of data for the EMRP:

- Regulatory precedents — for example, Ofcom (2005) looked at the EMRP estimates that had been used by other UK regulators, Ofwat, Ofgem, the ORR and the MMC;
- Third party estimates — for example, the CC (2008), during the Heathrow and Gatwick airport price control review, primarily based its EMRP estimates on the analysis undertaken by DMS and Gregory (2007); and
- Surveys — for example, the CC (2003) considered survey-based evidence on market practitioners' views on the EMRP.

[31] Dimson, E., Marsh, P. and Staunton, M. (2001), "Millennium Book II – 1010 Years of Investment Returns", ABN/AMRO- London Business School.
[32] Welch, I. (2000), "Views of Financial Economists on the Equity Premium and on Professional Controversies" in *Journal of Business*, 2000, vol.73, no.4, p.501-537.

Our database indicates that most regulatory decisions have put more weight on ex-post estimates (i.e. estimates based on historic data) than on ex-ante estimates (i.e. estimates based on forward-looking expectations).

Table 23: Regulatory precedents - EMRP

Regulator	Review	EMRP (%)	Ex-ante / ex-post	Comments
ORR (Oct 2000)	Periodic review of Railtrack's access charges: final conclusions	4.0	Both	- Considered regulatory precedents such as the CC (2000) Mid Kent/Sutton and East Surrey Water and MMC (1998) Cellnet / Vodafone [3.5-5%). - Concluded that the best estimate of EMRP was 4%, noting that this was somewhat below the historical average but above the current estimates of market expectations.
CC (Nov 2002)	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	2.5 – 4.5	Both	- Considered a range of ex-post and ex-ante evidence including DMS (2002) estimates along with surveys from evidence of finance practitioners.
CAA (Feb 2003)	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	2.5 – 4.5	Both	- Primarily considered CC (Nov 2002) analysis.
CC (Feb 2003)	Mobile Phone Charges Inquiry	2.5 – 4.5	Both	- Considered alternative approaches such as the Fama and French (2002) three-factor model.
Ofgem (Nov 2004)	Electricity Distribution Price Control Review 4	2.5 – 4.5 (initial decision) 4.9 (implied final decision)	Both (initial decision)	- Considered both ex-post evidence such as DMS (2001, 2002, 2003) and ex-ante evidence such as Welch (2000). - For the final decision, Ofgem used an aggregate return on equity method that estimates an overall cost of equity as opposed to individual parameters. However our analysis show that an EMRP of 4.9% was implied in its final cost of equity decision.
Ofwat (Dec 2004)	Future water and sewerage charges 2005-10	4.0 – 5.0	Both	- Considered Smithers & Co. (2003) which uses historic UK and US data to estimate a range of 3-5%. - Considered DMS (2003) forward-looking estimates of 3-5%. - Considered Ofgem's analysis for DPCR4 in March 2004.
Ofcom (Aug 2005)	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	4.5	Both	- Considered ex-post and ex-ante estimates by DMS (2004), and ex-ante surveys by Cable & Wireless (C&W) and PwC. - Considered CC (Feb 2003) and the on-going CAA deliberation (Dec 2005).
CAA (Dec 2005)	NATS Price Control Review 2006-2010 (CP2)	3.5 – 5.0	Both	- Considered DMS (2002), forward-looking surveys and recent regulatory precedents (referred to Ofgem, Ofwat and CC without citing previous decisions). The CAA noted that forward looking techniques typically estimated the EMRP from surveys of investor expectations, either directly or in conjunction with the DGM, and gave a range of 2-6%.
Postcomm (Dec 2005)	Royal Mail Price and Service Quality Review	3.5 – 5.0	Both	- Primarily considered regulatory precedents such as CC (2002) Airports, Ofgem (2004) DPCR4, Ofwat (2004) Water and Sewerage Companies determination (2004) and CAA (2005) NATS.

Regulator	Review	EMRP (%)	Ex-ante / ex-post	Comments
Ofgem (Dec 2006)	Transmission Price Control Review, 2007-2012	4.5 (implied)		- Estimated cost of equity using aggregate return approach which does not require the estimation of individual cost of equity parameters. - However for comparison we have calculated the EMRP as implied from the cost of equity of 7%, RFR of 2.5% (as assumed by the regulator based on market evidence from 10-year index linked gilts) and an implicit equity beta of 1.
Ofcom (Mar 2007)	Mobile Call Termination Statement	4.5	Both	- Considered ex-post and ex-ante estimates by DMS (2004), ex-ante surveys by C&W and PwC. - Considered CAA (Dec 2005) and CC (Feb 2003).
Ofgem (Dec 2007)	Gas Distribution Price Control Review 2007-13	4.5 – 5.0 (implied)		- Estimated cost of equity using the aggregate return approach which does not require the estimation of individual cost of equity parameters. - However for comparison we have calculated the EMRP as implied from the cost of equity of 7.0%-7.5%, RFR of 2.5% (as implied from the cost of debt of 3.6% and debt premium of 1.1%) and an implicit equity beta of 1.
CAA/CC (Mar 2008)	Economic Regulation of Heathrow and Gatwick Airports	2.5 – 4.5	Both	- Considered a range of ex-post and ex-ante evidence including DMS (2002, 2007) estimates along with surveys from evidence of finance practitioners.
CC (Nov 2008)	Stansted Price Control Review (2009-14)	3.0 – 5.0	Both	- Considered several sources ranging from its own regulatory precedents to ex-ante estimates calculated using recent market data.
CAA (Mar 2009)	Stansted Price Control Review (2009-14)	3.0 – 5.0	Both	- Based its decision on CC (Nov 2008) analysis.

Source: PwC analysis. Further details are provided in Appendix I and V

3.5.2 PwC's approach

The size of the EMRP is contentious as it cannot be directly observed in the market and must instead be estimated. In principle, the EMRP is an ex-ante (forward-looking) rather than an ex-post (historic) concept. However in practice both historic and forward-looking approaches are commonly used in its estimation.

For formulating our view on the EMRP we have considered:

- Third party ex-post evidence;
- Third party ex-ante evidence;
- Illustrative estimates derived using the DGM to assess the impact of the current credit crisis on the EMRP; and
- Recent third party views, in order to assess the extent to which there is a consensus on the forward looking EMRP under the current market conditions.

Each of these is discussed in detail below.

Table 24 provides a summary of some well known studies on the ex-post EMRP.

Table 24: Ex-post estimates of the EMRP

Source	Time period considered	EMRP – geometric mean (%)	EMRP – arithmetic mean (%)
DMS – LBS (2009):			
France	1900 – 2008	3.4	5.7
Ireland	1900 – 2008	2.4	4.4
Italy	1900 – 2008	3.7	7.2
Netherlands	1900 – 2008	3.2	5.6
Norway	1900 – 2008	2.0	5.0
Spain	1900 – 2008	2.1	4.2
UK	1900 – 2008	3.6	5.0
US	1900 – 2008	3.8	5.9
Barclays Capital (2007):			
UK	1900 – 2006	4.2	
Ibboston (2006):			
US	1970 – 2005	4.8	n/a
Canada	1970 – 2005	3.9	n/a

Source: DMS (2009), "Global Investment Returns Sourcebook 2009"; Barclays Capital (2007), "Equity Gilt Study"; Ibboston (2006), "Stocks, Bonds, Bills and Inflation Year Book".

There are two inherent assumptions built into the use of long-run ex-post data on actual historic additional equity returns to estimate the forward looking EMRP. The first is that the long-run historical EMRP is a good guide to the current or future EMRP, so the past is worthy of study. The second assumption is that over the long run the actual returns achieved by equity investors in the past must reflect the returns they needed to compensate them for investing in equities – under- or over-performance of equities could not persist in the long run, because demand for equities would have increased or decreased, changing share prices to bring the available returns back into line. Of course in shorter-run periods, actual returns below or in excess of the EMRP can be experienced which is why practitioners who use the ex-post approach prefer a very long run data series such as that provided by DMS. The use of very long-term historic figures also implies that the EMRP is expected to be a stable figure over the long-run.

An important estimation issue is whether to consider the geometric mean (GM) or the arithmetic mean (AM) for the analysis of historic returns[33]. The GM return for a period gives a measure of the average annual return achieved by an investor as if the investor enters into a buy and hold strategy for the whole period under consideration. The AM return is equal to the average of all the single year returns over the period being considered. The GM return provides a more accurate estimate if one believes that equity investors can realistically be assumed to engage in a buy and hold strategy for the period under consideration. In the case of the EMRP, where actual returns are considered over the long-term (20 years or more) it is unrealistic to assume such a long holding period. If it is considered that it is realistic to assume that equity investors would move in and out of equities over the holding period then the AM is more relevant. On balance, we consider that whilst both AM and GM estimates of the EMRP should be considered, the AM has more relevance, and is generally favoured by academics and practitioners.

Approaches that take a forward looking view on EMRP, putting more weight on current market evidence, are referred to as ex-ante approaches. There are two main sources of ex-ante EMRP estimates:

- Inferred value – the EMRP is inferred from the required rate of return calculated using the DGM; and
- Surveys of expectations – aggregate investors' or others' expectations about returns from investing in the market as a whole are derived by survey.

Table 25 below shows some example of ex-ante estimates of EMRP.

Table 25: Ex-ante estimates of EMRP

Source:	EMRP (%)	Comments
Competition Commission (2008)	3.8–5.0	Based on DGM
Welch — GM (2008)	4.0–6.0	Based on a survey of 400 finance professors
Welch — AM (2008)	4.5–7.0	Based on a survey of 400 finance professors
Gregory — GM (2007)	1.7–3.3	Based on DGM
Gregory — AM (2007)	2.0–3.9	Based on DGM
Competition Commission (2007)	2.1–3.3	Based on DGM
Claus and Thomas (2001)	3.4	Based on DGM

Sources: Competition Commission (2008), "Stansted Airport – Q5 price control review"; Welch, Ivo (2008) "The Consensus Estimate For The Equity Premium by Academic Financial Economists in December 2007"; Gregory (2007), "How Low is the UK Equity Risk Premium?"; Competition Commission (2007), "A report on the economic regulation of the London airports companies (Heathrow Airport Ltd and Gatwick Airport Ltd)"; Claus and Thomas (2001), "Equity premia as low as three percent? Empirical evidence from analysts earnings".

For DPCR5 a key issue to consider is whether the EMRP has increased as a result of the current capital market conditions. There are several reasons to suggest that this might be the case, including:

- Current high levels of implied equity market volatility;

[33] Given a sample set {u $_1$, u $_2$… u $_n$…u $_N$}, the arithmetic mean is calculated as $\sum_{i=1}^{n} Ui / n$ and the geometric mean is calculated as $\left(\prod_{i=1}^{n} u_i\right)^{1/n}$.

- Low equity valuations, which may not be solely attributable to a reduction in forward looking earnings expectations; and

- The significant discounting required to attract investors for rights issues and share placings.

As mentioned above, to assess the extent to which the EMRP might have increased as a result of the current market conditions, we examined recent third party views on the EMRP, and also calculated the EMRP using the DGM model ourselves.

To calculate a forward looking EMRP we used a one step DGM (due to the limited availability of data on the expected dividend yield on the FTSE-100 index) to assess the EMRP implied in current equity market valuations. Under the one step DGM the cost of equity is calculated using this formula:

$$Ke = (D_1 / P_0) + g$$

The EMRP can then be calculated by deducting the real RFR from the cost of equity. Calculating the cost of equity using the DGM requires two main inputs: a forward looking dividend yield and the steady state dividend growth rate. For the dividend yield for a given year, we used the actual dividend yield on the FTSE-100 index for the next period[34]. For example, the 3.4% figure used to calculate the EMRP in 2008 reflects the current dividend yield on the index whereas for calculating the EMRP in 2007 we used the actual dividend yield for 2008. For the second parameter, we assumed that the long term dividend growth rate is 2.2% which is equal to CE's long term real GDP growth forecast. Given these assumptions, the DGM approach gives us a range of 3.3%-5.3% for the EMRP as set out in Table 26 below.

Table 26: EMRP implied from the DGM

Source	2008	2007	2006	2005	2004	Average over five years
Dividend yield (D/P %)	3.4	3.7	2.9	3.3	3.2	3.3
Long term dividend growth rate (g %)	2.2	2.2	2.2	2.2	2.2	2.2
Real cost of equity (%)	5.8	5.9	5.1	5.5	5.4	5.5
Real risk free rate (%)	2.2	2.2	2.2	2.2	2.2	2.2
EMRP	3.6	3.7	2.9	3.3	3.2	3.3

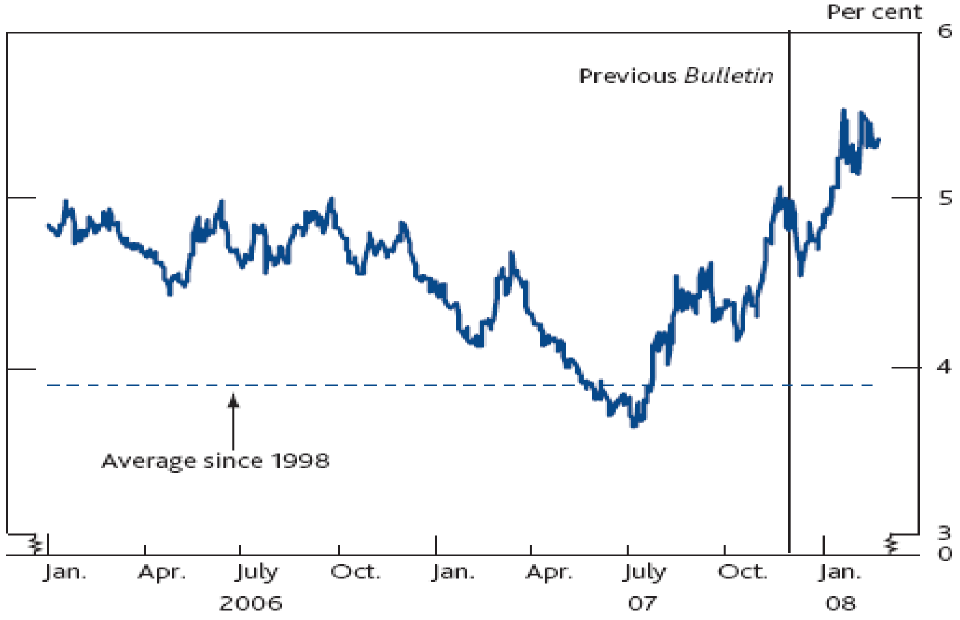
Source: Datastream, CE and PwC calculations

While the figures presented above appear relatively stable over time, it is important to note the underlying volatility of the ex-ante EMRP calculated using the DGM. For instance, in May 2009 the EMRP calculated using this method was 5.3%. The underlying theory underpinning use of long-term ex-post figures regards the EMRP as a relatively stable measure over the long-term. It is possible that, whilst the EMRP is indeed stable in the long-term, it nevertheless fluctuates up and down over short-run periods as the DGM suggests. However, the reason that respected ex-post sources such as DMS provide a very long-term data series is to avoid falling into the trap of inferring the EMRP from actual returns in short-run periods, when achieved returns can be significantly above or below the returns required or expected by investors. It is because actual returns can be different from expected returns that there is an EMRP at all (this is the risk for which equity investors require compensation), and any approach that relies on short-term market data to infer the EMRP could potentially reflect the short-term ex-post market outcome rather than the ex-ante expectation or requirement.

If it is reasonable to suppose that, whilst stable in the long-run, the EMRP nevertheless fluctuates in the short-run, then under very volatile market conditions such as those prevalent currently, an ex-ante estimate of the EMRP would be necessary to determine the short-run EMRP, since the ex-post methodology can only give an estimate of the long-term EMRP. However, at the same time, under such conditions, stock markets become more volatile and it is more difficult to determine market expectations of forecast dividend growth accurately, limiting the applicability of the DGM to such situations. This view is further supported by BOE analysis of the implied EMRP calculated using the DGM. This is set out in Figure 20 below.

[34] These are available on Datastream.

Figure 20: BOE analysis, implied EMRP on FTSE-100



Source: BOE, Q1 2008

The BOE analysis confirms the inherent volatility of estimates calculated using the DGM. If the EMRP is considered to be a variable which changes in the relatively short-term between different periods then the DGM may be considered relevant for formulating such a short-term view but the estimates are very sensitive to stock price fluctuations and assumptions of dividend growth, and it suggests that the EMRP fluctuates significantly over very short time periods.

We have also examined some recent views by financial services industry participants on the current level of the EMRP. These are set out in Table 27 below.

Table 27: Summary of recent EMRP views

Source	Date	EMRP (%) – reflecting the impact of the current financial turmoil	Author's comments
Bank of England Monetary policy Committee	21 October 2009	Returned to long-run average	DGM estimates suggest the EMRP had risen above trend but has now dropped back in line with its 10-year average
Grabowski	30 January 2009	6.0	Using an EMRP derived during "normal" economic times will underestimate the cost of equity.
Citigroup	4 December 2008	5.1 – 5.3	Adjusted from 4.0% to reflect the long term re-pricing of risk.
Nomura	27 October 2008	8.0	Risky financial assets such as equities have significant risk premia embedded in them, to reflect the expectation of policy failure.
McKinsey	December 2008	No change – 4.5% to 5.0%	Conceptual

Sources: Grabowksi, J, Roger (2009), "Problems with cost of capital estimation in the current environment – update", 30th January; Citigroup Global Markets (2008), "Calculating the cost of capital in a downturn", 4th December; McKinsey & Company (2008), "The McKinsey Quarterly", December 2008 and Nomura, "European Strategy Weekly", 27 October 2008.

The table shows that there are mixed views. Those who favour a DGM approach (e.g. Nomura) believe that the EMRP is substantially above the 4.9% we infer was used by Ofgem in DPCR4. However, the same approach would likely have produced significantly lower figures before the recent stock market falls, and thus this suggests that the EMRP is a volatile figure.

Others, such as Citibank and Grabowski, see a higher EMRP of 6.0% to 6.5% now, perhaps falling in the medium-term. We agree that where market valuations can be observed these may be consistent with such high figures. However, we question whether this is clear evidence that the EMRP per se has shifted significantly in such a short timescale. An alternative explanation is that the EMRP has increased by a smaller amount, but that other factors are also affecting current valuations. One explanation of this could be the illiquid conditions in the current market as a whole. This would be consistent with evidence from the BOE which suggests that an illiquidity premium of 0.5% to 1.0% is appropriate in the current market[35]. As this premium is not a normal component of the cost of equity and its inclusion implies a shorter-term approach than that which we employ here, we have not included it. Estimates implied from current market valuations necessarily reflect a short-term view on EMRP and therefore might be less relevant if Ofgem wishes to continue to set the allowed cost of capital on a long-term basis.

McKinsey, like the CC, considers that there has been no significant change in the EMRP and supports the view that caution needs to be exercised in altering the EMRP by any significant amount in reaction to immediate, and potentially short-term, changes in market conditions.

Overall, we consider that ex-ante EMRP approaches, which include calculations using the DGM and surveys of investors, have important limitations. However, despite these limitations we consider that evidence based on these frameworks is useful and should be taken into account, whilst placing more weight on ex-post evidence.

3.5.3 PwC's recommendations

Table 28 below provides a summary of EMRP estimates based on the alternative sources presented above.

Table 28: Summary of EMRP sources

EMRP basis	Minimum (%)	Maximum (%)
Regulatory precedents	2.5	5.0
Ex-post, geometric	2.0	3.8
Ex-post, arithmetic	4.2	7.2
Ex-ante	1.7	7.0
Recent reviews	4.5	8.0

As mentioned previously, estimating EMRP is inherently difficult as it is not directly observable and the current uncertain economic conditions make its estimation now more complicated than normal. A key issue for Ofgem to consider is whether it believes the EMRP to be a relatively stable, long-run variable, or whether it believes it fluctuates in the short-term. If the EMRP is viewed as fluctuating in the short-term, then methodologies such as the DGM point to a significantly higher figure than Ofgem and other regulators have applied in the past – at least 6%, and up to 8%.

Ofgem may wish to consider two issues before adopting this view. First, this would arguably be a departure from Ofgem's past practice of setting a long-term EMRP. Methodologies such as the DGM would have implied a lower EMRP than that adopted by Ofgem at times in the past, and there might be implications for the stability of prices in the future. Second, the methodologies for calculating short-term fluctuations rely on stock prices which fluctuate significantly. The implied EMRP will be very sensitive to the date at which Ofgem decides to set its figure. Conditions could change very quickly such that the figure chosen might seem incorrect, even based on the actual methodology used to determine it, early in DPCR5. Further points which Ofgem may wish to take into account are set out in Appendix V.

[35] BOE, "Decomposing corporate bond spreads", Q4, 2007.

We have assumed that Ofgem will wish to continue to set the EMRP on a long-run basis for DPCR5. Nonetheless, on the basis of the evidence we have reviewed, we consider that the long-run EMRP has probably increased as a result of the on-going credit crisis, although not by the extent that is suggested by the DGM. We consider that the EMRP has increased by a smaller amount, and when this small increase is combined with other factors such as liquidity premia of 0.5%-1.0% based on BOE evidence (which Ofgem may wish to reflect in its determination, but which we have not included in our estimate of the EMRP), and lower expected dividend and economic growth, it also explains current market valuations. Taking these factors into consideration we consider that a range of 4.5% to 5.5% for the EMRP is appropriate for setting the cost of equity for DNOs over DPCR5. The upper end of our range is broadly consistent with the DMS (2009) AM EMRP estimate for the UK (taking into account our view that the long-run EMRP may have increased). The lower end is towards the upper end of the range considered by the CC and CAA in recent decisions, and is in line with regulatory precedent since 2005.

We recommend an EMRP of 4.5%-5.5% for the purpose of DPCR5.

4. Cost of debt

4.1 Debt premium

The debt premium is the additional return over the RFR required by debt investors for holding corporate debt and reflects the compensation required for being exposed to the risk that the company might default on its debt obligations. Specifically the cost of debt is equal to:

Kd = Rf + DP

Where:

Kd is the pre-tax cost of debt

Rf is the risk-free rate

DP is the corporate debt margin

4.1.1 Ofgem's approach and regulatory precedents

For its initial determination in DPCR4, Ofgem allowed a debt premium of 1%-1.8% (and a cost of debt of 3.3%-4.8%). This figure was based on an assessment of the spreads on corporate bonds issued by the DNOs. This is also the general approach we would recommend, using corporate bond maturity assumptions that are consistent with those for the RFR. For its final determination, Ofgem estimated an overall cost of debt of 4.1% which was equal to the mid-point of its initial determination range.

Table 29 below lists debt premia that have been used by sector regulators in the UK and by the CC. Although, the debt premium is a firm-specific factor that would be expected to vary across companies, the debt premia used by UK regulators have mostly been in the range of 0.7%-2.6%.

The table overleaf also shows the sources of information considered by regulators for estimating debt premia. The sources considered include regulatory precedents and spreads on tradable debt issued by the companies themselves and by comparator companies. Most debt instruments considered were of medium- to long-term maturity (between 5 and 20 years).

Table 29: Regulatory precedents, debt premium

Regulator	Review	Debt premium (%)	Comments
ORR (Oct 2000)	Periodic review of Railtrack's access charges: final conclusions	1.5 – 1.8	- Considered recent spreads on Railtrack's current bonds (AA- rated) at 1.4%-1.7%.
CC (Nov 2002)	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	0.9 – 1.2	- Considered spread on AA- rated bonds in the transportation sector (ranging from 69 basis points (one year) to 165 basis points (30 years)). - Considered evidence from BAA which suggested that the spread on its bond due in 2031 had increased to 1.3%.
CAA (Feb 2003)	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	0.9 – 1.2	- Based decision primarily on CC (Nov 2002).
CC (Feb 2003)	Mobile Phone Charges Inquiry	1.0 – 4.0	- Information provided by Oftel indicated that the cost of debt would be lower than spot rates. Oftel estimates (1%) formed the lower bound of the range.
Ofgem (Nov 2004)	Electricity Distribution Price Control Review 4	1.0 – 1.8 (initial decision) 1.5 (final decision)	- For initial decision: noted that the current debt premia for DNOs' UK debt was relatively low, possibly due to increased demand for corporate debt by investment institutions, particularly pension funds. Considered debt premia of DNOs over equivalent government benchmarks over a five-year period to be volatile and hence preferred to use the long-term average of debt premia of DNO's bonds. Preferred to set a wide range for the debt premium given that there was uncertainty surrounding the expected cost of debt. - Final decision: Ofgem estimated an overall cost of debt of 4.1% which is equal to the mid point of its initial determination range. Using an RFR of 2.6 this results in an debt premia of 1.5%.
Ofwat (Dec 2004)	Future water and sewerage charges 2005-10	0.8 – 1.4	- Considered a lower bound set by spreads on A rated bonds (which were historically low) and an upper bound set by spreads on BBB rated bonds.
Ofcom (Aug 2005)	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	1.0	- Considered yields on long term A-rated corporate bonds as at the end of June 2003 (1.0%), June 2004 (0.7%) and June 2005 (0.6%). - Also considered average promised yield on recently issued long term BT debt, as of the end of January 2004.
CAA (Dec 2005)	NATS Price Control Review 2006-2010 (CP2)	1.2	- Considered the cost of debt based on existing debt and debt that NERL might issue during CP2. - Calculated debt premium from the (nominal) cost of debt for A- rated corporate bonds.
Postcomm (Dec 2005)	Royal Mail Price and Service Quality Review	0.5	- Accepted Royal Mail's estimation of a cost of debt of 3.0% at 20% gearing. With Postcomm's RFR assumption of 2.5%, the resultant debt premium was 0.5%.
Ofgem (Dec 2006)	Transmission Price Control Review, 2007-2012	1.3	- Stated DCPR4 as regulatory precedent, and noted that spreads had remained narrow since then. - Considered the average spread (over 5-10 years) of A rated bonds with approximately 10 years to maturity. - Noted that these averages were higher than current yields.

Regulator	Review	Debt premium (%)	Comments
Ofcom (Mar 2007)	Mobile Call Termination Statement	1.0 – 2.0	- Considered spreads of A and BBB rated corporate bonds over 5 year gilts.
Ofgem (Dec 2007)	Gas Distribution Price Control Review 2007-13	1.1 (implied)	- Stated that is has basically used Ofgem (Dec 2006) TPCR cost of debt estimate but has lowered 20 basis points (bps) to reflect an easing in the credit market conditions. - To infer the implied debt premia (which is not stated explicitly in the report), we have assumed that the RFR has remained constant and have applied the 20 bps reduction in the overall cost of debt to the Ofgem (Dec 2006) TPCR debt premia estimate (1.3%).
CAA/CC (Mar 2008)	Economic Regulation of Heathrow and Gatwick Airports (Heathrow / Gatwick)	1.1	- Considered a cost of debt of 3.4% based on the cost of debt that a company with a BBB+/Baa1 rating could be expected to achieve. Also considered refinancing costs and fees (as in the regulatory precedent established by CC (2000) for Mid Kent/Sutton and East Surrey water). Noting that the RFR (2.5%) estimated in their analysis in the current report ignored the lower yields on longer-dated debt, stated that the debt premium estimate must recognise that companies issue long-dated debt. Effective RFR of 2.3% in debt premium estimation. - Considered a debt beta of 0.1.
CC (Nov 2008)	Stansted Price Control Review (2009-14)	1.4 – 1.7	- Considered a weighted average of new and floating debt, embedded debt and an uplift for transaction fees to arrive at a cost of debt figure of 3.4%-3.7%. However, the recommended point estimate of the WACC (7.1%) is consistent with a cost of debt of 3.6%. Using an RFR of 2.0% gives a debt premia of 1.6%.
CAA (Mar 2009)	Stansted Price Control Review (2009-14)	1.7 – 1.9	- Increased the debt premia embedded in the CC (Nov 2008) point estimate of the WACC and increased it by 10 to 30 bps to reflect tighter credit market conditions.

Source: PwC analysis. Further details are provided in Appendix I and V.

4.1.2 PwC's approach

To determine the debt premium for DPCR5 we looked at three sources of information and also considered transaction costs:

- General market evidence: in this section we present an overview of the evolution of corporate spreads in general and assess the extent to which they have increased under the current market conditions;

- Utility specific secondary market evidence: in this section we review secondary market evidence on DNOs' direct comparators and on that basis assess the extent to which the cost of debt has increased under the current volatile market conditions. Another key question we address in this section is the extent to which Ofgem should consider current market evidence relative to long-term historical data;

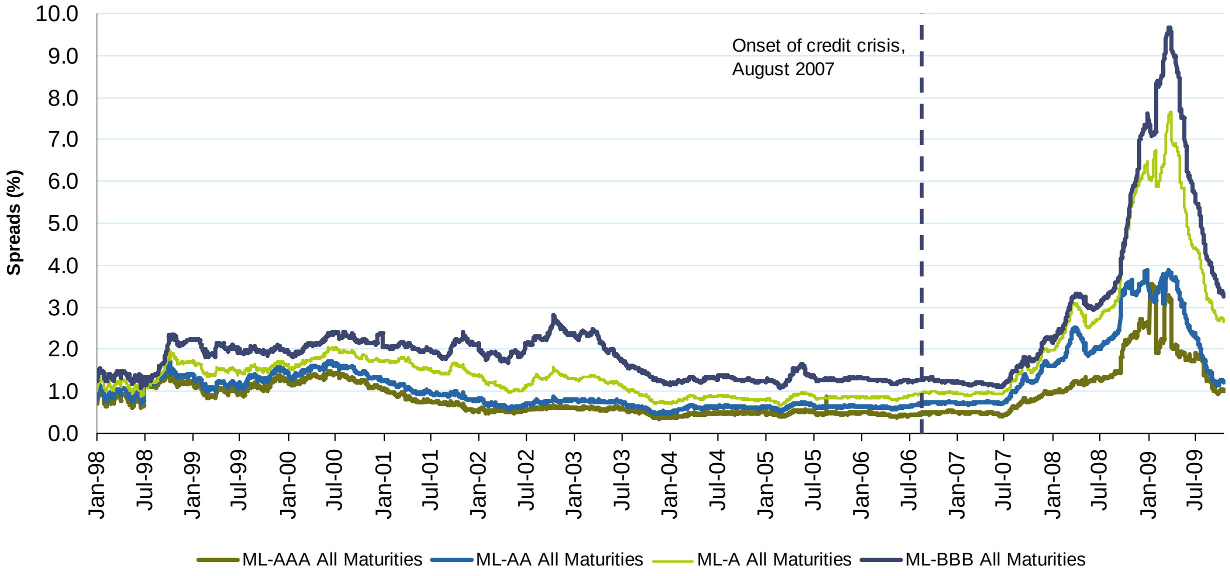
- Utility specific primary market evidence: in this section we consider the advantages and disadvantages of using primary market information and calculate an illustrative range for the DNOs' cost of debt on this basis, for cross checking our main estimates based on secondary market information; and

- Transaction costs: in this section we consider the extent to which transaction costs form a significant proportion of the total cost of debt and whether they should be included in the allowed cost of debt or be included separately in cash flows.

General market evidence

Figure 21 below shows that the immediate impact of the credit crunch and economic slowdown was an increase in credit spreads. Spot rates rose to levels significantly above those observed prior to the onset of the crisis, although they have fallen back towards historic levels in the first and second quarters of 2009. An important point to note is that the impact on the spreads of BBB and A- credit ratings has been more pronounced as compared to AAA and AA rated bonds, implying a decoupling of spreads across different credit ratings that were previously closely aligned. It appears that, faced with the worsening macroeconomic environment and the heightened uncertainty associated with the financial crisis, investors have become more risk averse, and as a result have increased their demanded returns on all bonds, but particularly on those of higher risk.

Figure 21: Evolution of bond spreads across different credit ratings



Source: Datastream

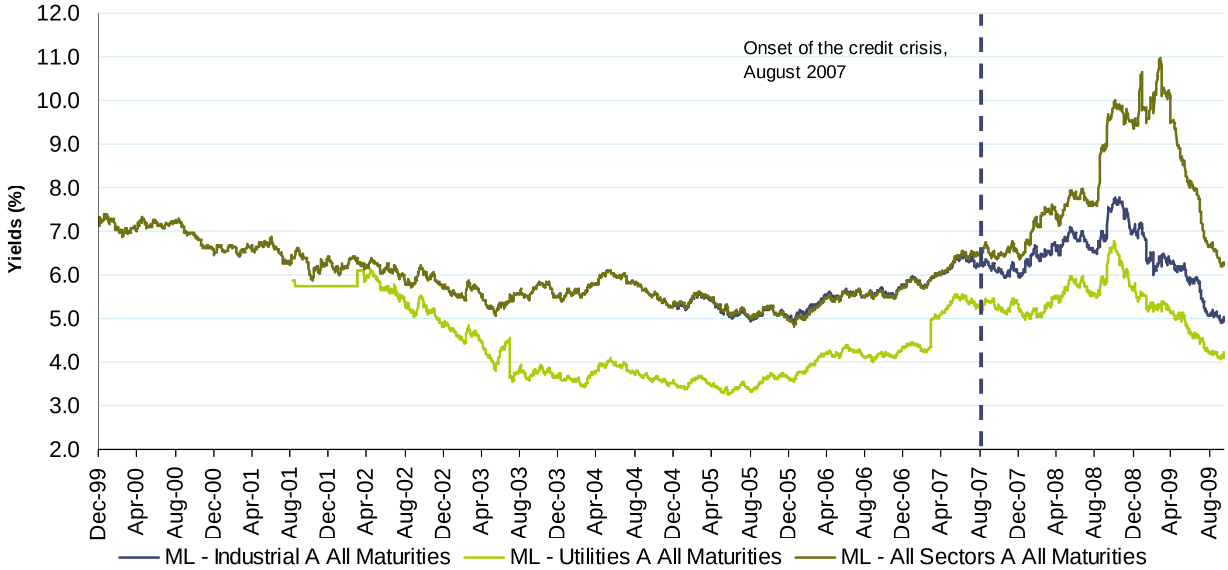
In setting the allowed cost of debt in the past, Ofgem has tended to take a long-term view on both components of the cost of debt; the debt premium and the RFR (discussed in more detail in Section 3.3). However, credit market conditions over the past decade and until August 2007 were relatively stable by historical standards, and in general were characterised by a declining RFR and narrowing spreads with spot rates. In contrast, currently there is substantial evidence indicating a significant increase in the debt premium as a result of the ongoing financial turmoil, and therefore the main consideration for Ofgem for setting the debt premium and cost of debt for DPCR5 is how and to what extent it should take account of the current market evidence in its regulatory decision.

For this Ofgem needs to consider several factors. First, it should be noted that whilst the conventional approach to calculating the cost of debt and debt premium is to use the yield to maturity on corporate bonds, in theory this is incorrect. Consistent with the cost of equity, in principle what is required for the calculation of WACC is the expected or required cost of debt. The conventional calculation gives an estimate of the promised cost of debt – i.e. what a firm will pay its debt providers assuming that it is able to service its debt. The difference between this promised cost of debt and the expected cost of debt therefore reflects the probability that the firm will default on its debt. The current spike in debt premia reflects at least in part an increase in the probability of default and hence the increase in the promised cost of debt may overstate the increase in the expected cost of debt. In principle this distinction should be taken into account in setting the regulated WACC.

Given Ofgem's duty to finance the DNOs, it needs to allow sufficient revenue for them to be able to service their debt at the promised yields, and hence the conventional approach of including the promised cost of debt in the WACC calculation is appropriate. Nevertheless, to the extent that the current debt premia of comparator companies are higher due to default risk, Ofgem should consider whether these are fully relevant to the DNOs, given the reduced default risk to which they expose debt providers.

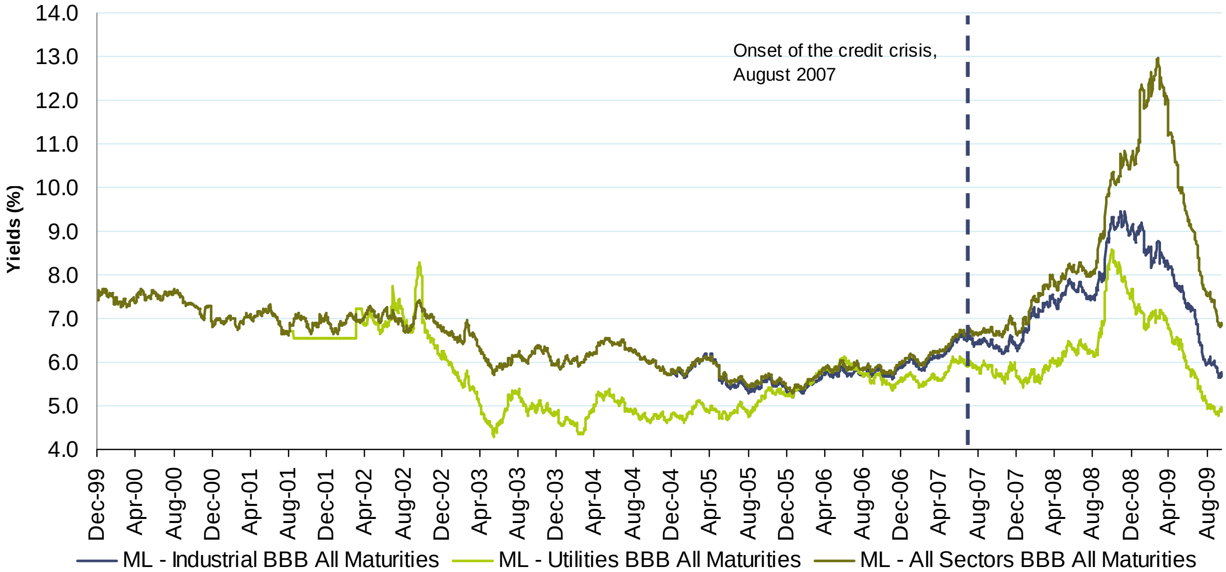
In particular, the evidence presented in Figure 21 above is for corporate issuers in general whereas any evaluation of the extent of the impact of the current financial crisis on the debt premium that is likely to feed into Ofgem's regulatory determination should examine utilities specific market evidence. Our analysis set out in Figure 22 and Figure 23 below indicates that, for the same credit rating and duration, utilities have been less impacted by the broader market turmoil. For example, whereas the yields on BBB rated bonds across all sectors rose to a maximum of 6 percentage points higher than the levels observed in August 2007, those on BBB rated utility sector bonds only moved by 2.5 percentage points, peaking some 5 months earlier than the overall bond market. This reflects the defensive qualities of the sector, including relatively low demand risk exposure and the statutory obligation of regulators to set price controls such that an efficient regulated utility should be able to finance its operations.

Figure 22: Cross sector comparison – A rated bonds



Source: Datastream

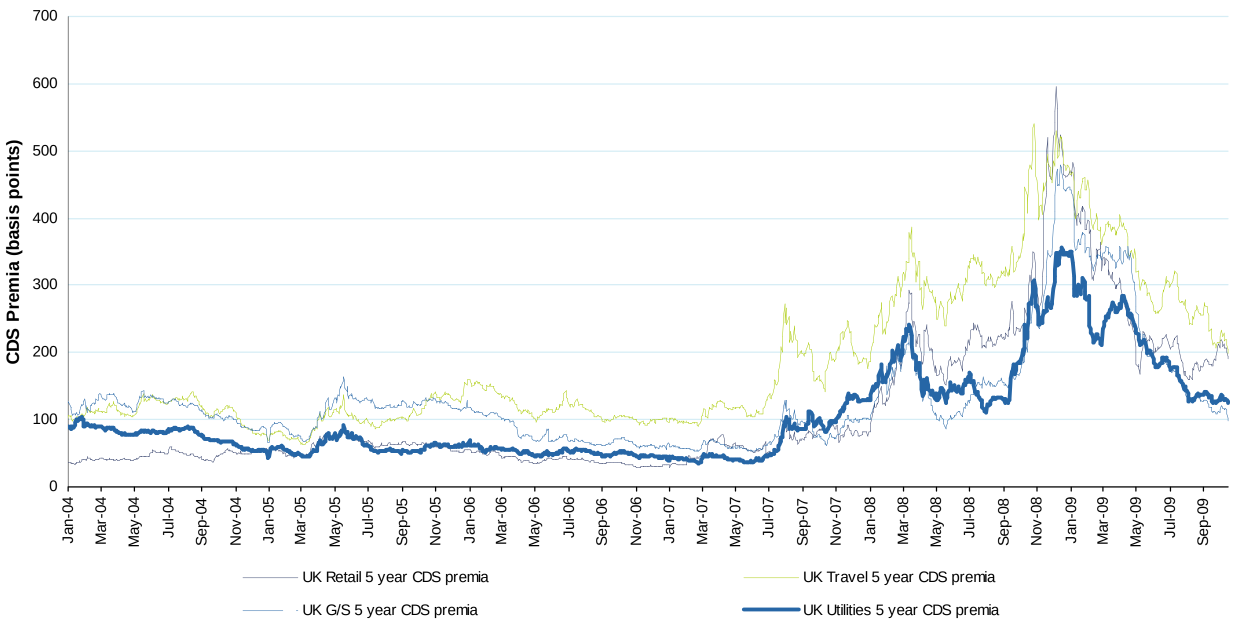
Figure 23: Cross sector comparison – BBB rated bonds



Source: Datastream

Our comparison of the credit default swap (CDS) premia – which reflects the cost of insuring against a default on a debt obligation – across different sectors, also points towards the defensive qualities of the utilities sector.

Figure 24: UK 5 year CDS premia on selected sectors



Source: Datastream

Considering this, our view is that it is more pertinent and meaningful to focus our analysis on utilities specific evidence. Specifically we focus our analysis on utilities that we consider are the most direct comparators of DNOs. These are the same companies that we primarily used for our equity beta analysis consisting of National Grid, Scottish and Southern Energy, Scottish Power, Kelda, United Utilities, Pennon Group and Severn Trent. The only addition to this list is Thames Water which we consider to be a relevant comparator, but which we did not include in our beta analysis as it is not listed.

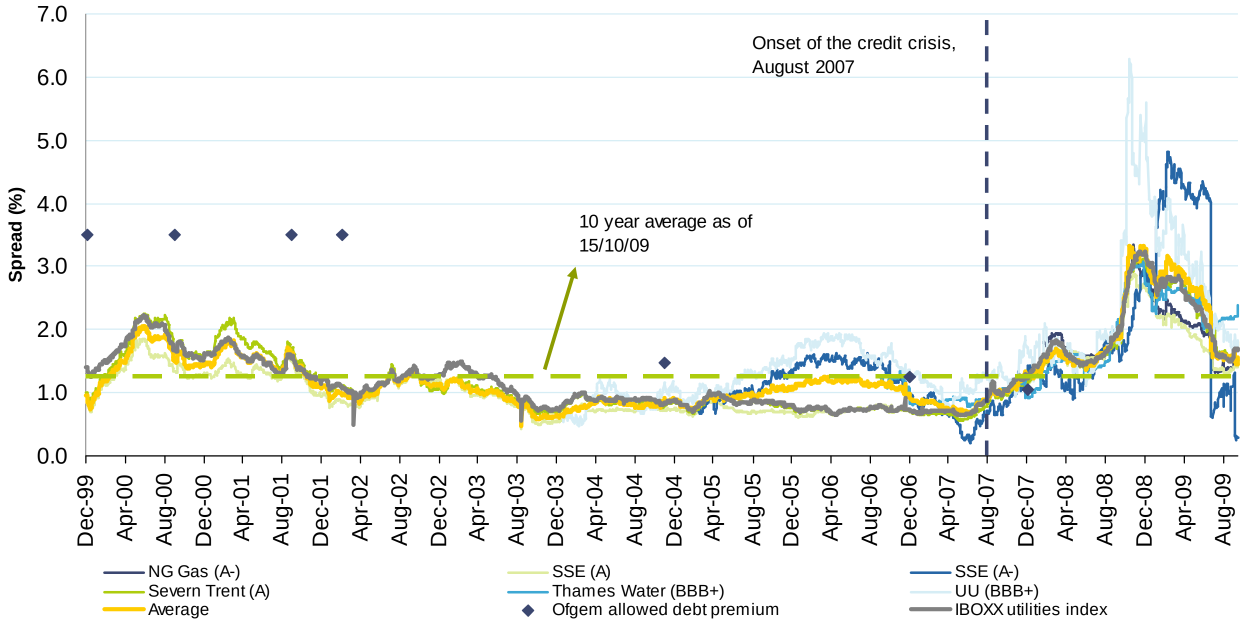
For our analysis, we have also examined the spreads on the iBoxx utilities index. The utility bonds included in this index have a credit rating of A/BBB with an average maturity of 10 years. Since this credit rating range is only slightly wider than our target range, we consider that it is useful to take this evidence into consideration.

Utility sector specific evidence

Figure 25 below sets out the evolution of the spreads on our sampled utilities' bonds with around 10 years maturity and credit ratings of between BBB and A-[36]. We have considered these ratings since the financeability requirements implicit in the price control are consistent with them. We have also included in the figure Ofgem's past debt premia decisions. Figure 26 compares Ofgem's past decisions on the RFR with the spot yield on index linked bonds.

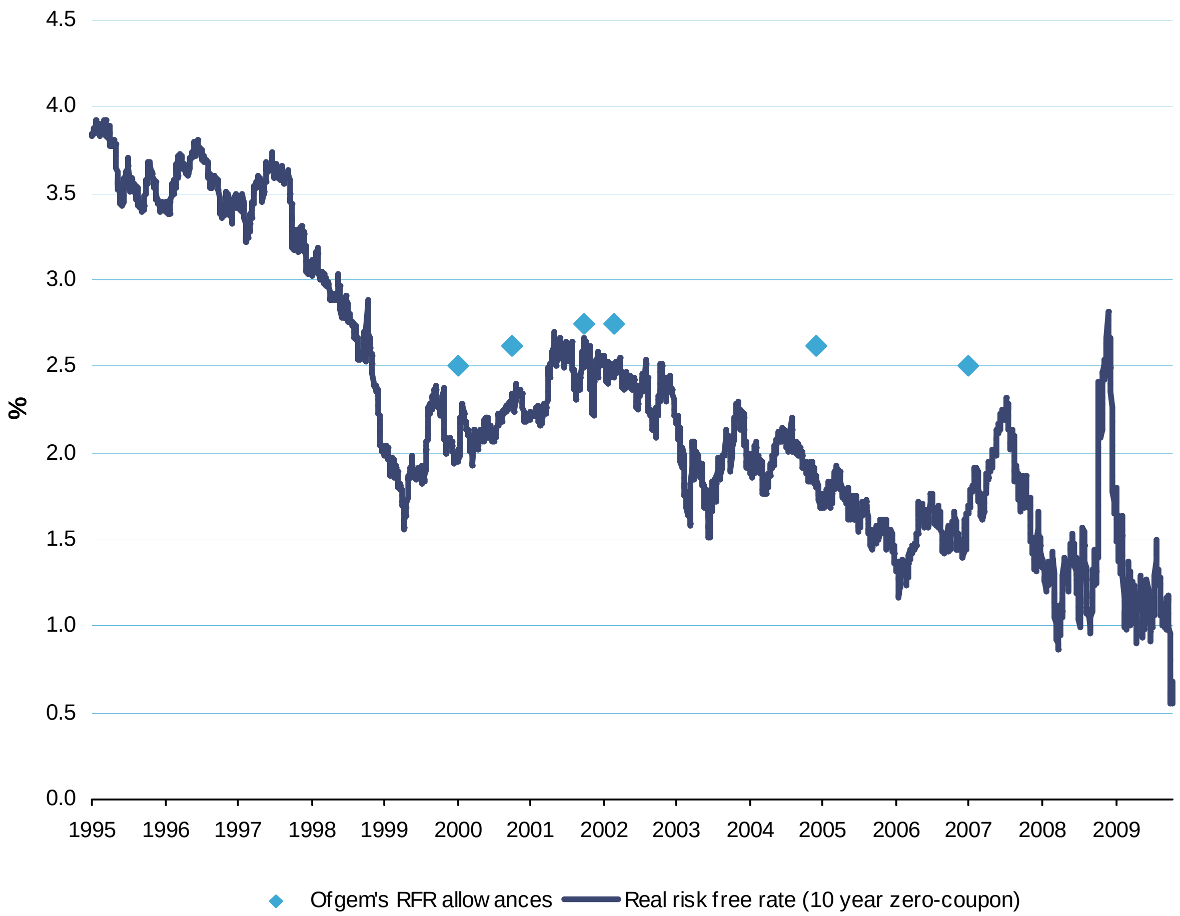
[36] Of our main comparators, we have excluded Kelda, Pennon and Scottish Power as no active bonds in the target credit rating range were available for these comparators. We have treated SSE differently to the other comparators, as we consider that the appropriate target credit rating for SSE should be A/A- to reflect the higher business risk profile of such a vertically integrated business.

Figure 25: Evolution of spreads on comparable utilities



Source: Datastream and Ofgem's regulatory decisions

Figure 26 Allowed risk-free rate compared with actual risk-free rate



Source: Datastream and Ofgem's regulatory determinations

It is evident that Ofgem's most recent determinations have generally been in line with the long-term (10 year) average levels of the debt premium. Over the whole period since December 1999, however, Ofgem's allowed debt premium allowances have been consistently higher than spot rates, with a difference of about 1.5-3.0 percentage points over the four year period from January 2000 to December 2004 and around 0.5 percentage points since then until December 2007, resulting in windfall gains for equity holders. This might be taken into account in considering whether Ofgem should depart from its approach of setting the cost of debt components on a long-term basis on the grounds that current spot rates are significantly higher than long-term averages.

Moreover, if Ofgem were to continue to set the debt premium on a long-term basis, by taking an average over a substantial length of time such as 5 or 10 years, it would to a certain extent take into account the current high spread levels, as this average has clearly increased (as long as the calculation includes post-August 2007 data). For example, if debt premia had remained constant between August 2007 and May 2009, the average 10 year debt premium would have been 1.1 instead of the actual figure of 1.3.

One factor that supports Ofgem's long-term approach to debt is the long lives of the DNOs' assets and hence the long-term debt they might be expected to obtain. This is relevant because current spreads reflect the debt premium that DNOs are likely to bear on any new debt they raise either to re-finance existing debt or to fund new capital expenditure. Our analysis indicates that, as set out in Figure 27, of the total outstanding debt portfolio across all DNOs only 11% (£0.55bn) is likely to mature over DPCR5, and even within that a large proportion will mature over the last two years. This illustrates that the DNOs' exposure to current credit conditions is muted by their long-term funding needs.

Funding of new capital expenditure is expected to increase significantly over DPCR5[37], however, and this is a relevant concern, as raising financing over the short-term could have a significant impact on cash flows if the cost of debt is much higher than it has been historically. However, for assessing the overall impact on DNOs' cash flows this negative impact needs to be considered in the context of the benefit that the DNOs would enjoy over the low cost existing debt portfolio that will not mature over DPCR5 (also referred to as "embedded debt"). Most of the DNOs' existing debt is fixed rate debt (69%) and has been raised at rates lower than the long-term average rate.

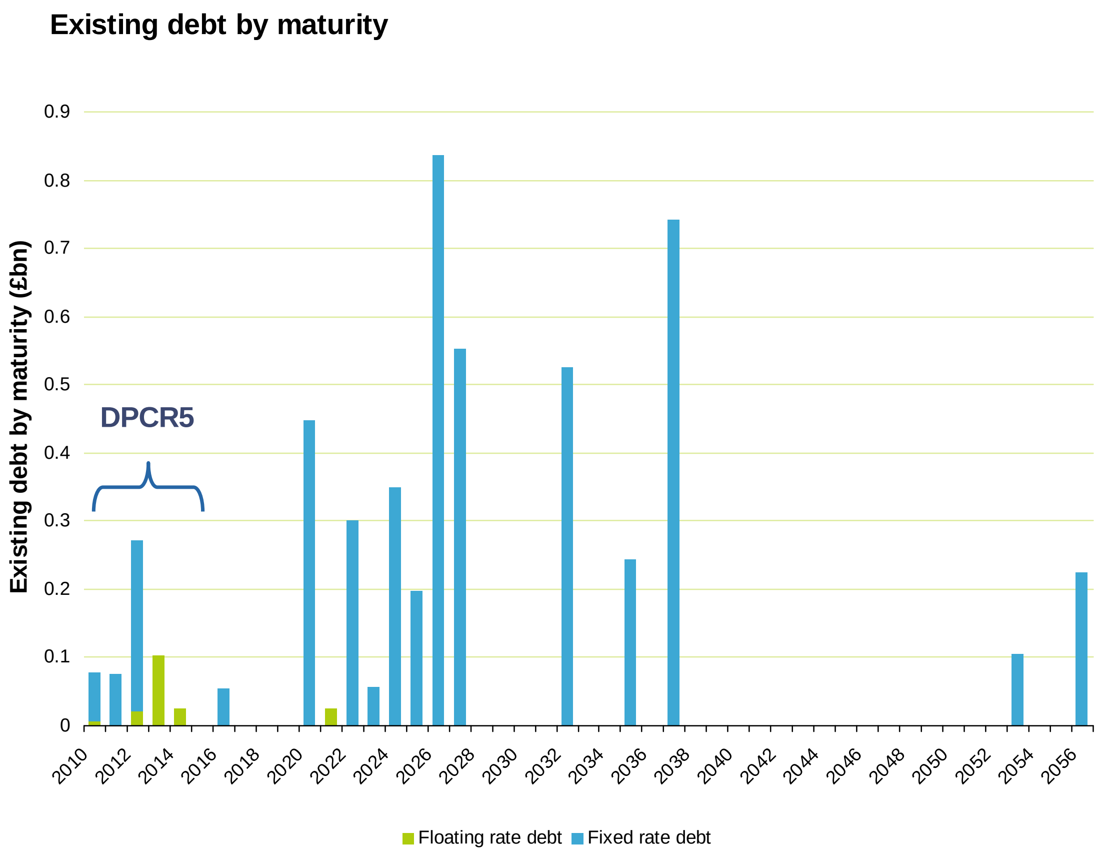
For floating rate embedded debt the DNOs may well also face low rates. There has recently been a sharp decline in the value of Libor, the rate at which banks lend funds to each other, reflecting the BOE's policy of driving its base rate down to a historically low level in reaction to the recession (see Figure 28 below). Libor constitutes a large proportion of the cost of the DNOs' embedded floating rate debt (as spreads were very low when this debt was raised).

Taking all of the above factors into consideration, we consider that even under the current market conditions Ofgem's approach of setting the debt premium and the cost of debt on a long-term basis may remain appropriate, and should allow the DNOs to finance their debt requirements. Moreover this approach would provide regulatory continuity and would ensure that DNOs are incentivised to manage interest rate risk.

However, we acknowledge that credit conditions are unusual, and it is uncertain how they will develop over the course of DPCR5. In a separate paper we consider what options would be available to Ofgem to mitigate the risk of a significant worsening of debt availability and cost (including departing from the long-run approach).

[37]Currently DPCR5 capital expenditure is estimated to be £7.85bn or 65% higher than in DPCR4,: "Electricity Distribution Price Control Review Policy Paper", Ofgem, December 2008, page 93.

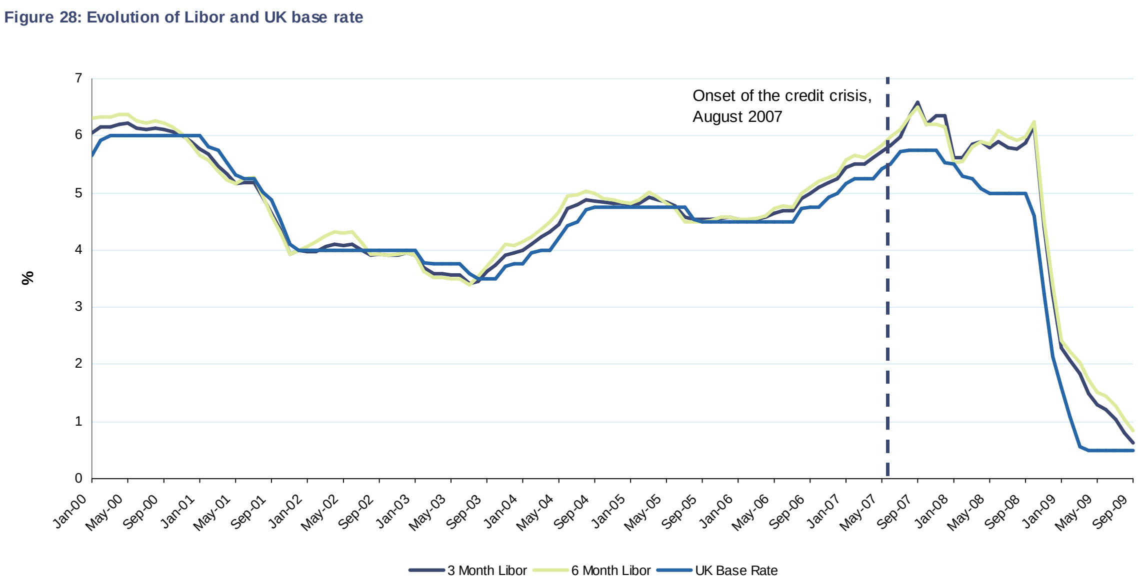
Figure 27: DNOs outstanding debt portfolio



Note: The above chart does not take into consideration debt that matures in 2009.

Source: Regulatory accounts and PwC calculations.

Figure 28: Evolution of Libor and UK base rate



Source: BOE

The results from our analysis are summarised in the table below.

Table 30: Debt premium summary results

Debt premium	Average across comparators' bonds with credit rating A-/BBB+	iBoxx Utilities Index
Spot as of 15/10/09 (%)	1.6	1.7
Approximate 5 year average (since January 2005 - %)	1.5	1.3
Approximate 10 year average (since January 2000 - %)	1.3	1.3

Source: Datastream and iBoxx

Our analysis using the long-term approach gives a figure for the debt premium of approximately 1.3% for DNOs for DPCR5. This is based on the 10 year average spread across comparator bonds and the iBoxx utilities index. However it is important to note that so far we have only examined evidence from secondary markets for debt capital. Spreads evidence derived from corporate bonds traded on the secondary markets typically reflects the debt premium that an issuer would experience if it were to issue a normal bond (that has no additional features such as artificial credit enhancements through wrapping by monolines) at any given point in time, and is therefore only an approximation of the actual spreads on the bonds issued by DNOs. In particular, secondary market data ignores the timing effect, which refers to the practice whereby issuers such as DNOs only access debt markets at certain points in the interest rate life cycle, primarily when it is most advantageous for them, and also ignores the use of financing options such as credit enhancements and securitisation. Evidence on spreads from primary markets does capture the impact of these aspects on spreads. However, despite these limitations, in practice secondary market data are generally used for estimating the debt premium and the cost of debt as this allows for examination of a consistent time series over a long-term period, whereas primary market data is discontinuous, sporadic and usually available only through a limited number of sources. Nevertheless, debt premia calculated using primary market data are a useful cross check to our calculations and therefore we include this in our analysis.

Utility specific primary market evidence

The table below presents an overview of the primary market data that we have considered. Since very limited information was available on utilities in our core comparator set, we have included a few additional companies which we consider are of interest.

Table 31: Launch spreads on selected utilities

Parent	Date of Issuance	Maturity	Tenor (years)	Total Value Issued (£ million)	Launch Rating	Current Rating	Spread to Benchmark
Comparator set							
National Grid	19-Jul-06	01-Aug-16	10	797.3	A-	BBB+	1.27
Eon	21-Sep-07	02-Oct-17	10	3,500	A	A	1.20
Eon	18-Oct-07	30-Oct-19	12	2,150,.5	A	A	1.07
National Grid	18-Feb-08	03-Mar-20	12	396.4	A-	A-	1.70
Severn Trent	04-Mar-08	11-Mar-16	8	700,	A	A	1.59
Eon	23-Apr-08	07-May-20	12	2,500	A	A	1.68
Eon	05-Jun-08	07-May-20	12	400	A	A	1.38
National Grid	08-Jul-08	03-Mar-20	12	74,.7	A	A	1.40
GDF Suez	07-Jan-09	18-Jan-21	12	4,232.7	A+	A+	3.28
Severn Trent	13-Jan-09	22-Jan-18	9	447.6	A	A	2.85
GDF Suez	03-Feb-09	11-Feb-21	12	788.5	A+	A+	2.05
Recent Market evidence (for reference only)							
E.on	17-Mar-09	26-Mar-13	4	750	A	A	1.96
E.on	27-Mar-09	03-Apr-12	3	50	A	A	1.12
E.on	18-May-09	30-Nov-11	2	750	A	A	1.25
E.on	19-May-09	28-Feb-11	2	90	A	A	0.55

Source: Dealogic

Our analysis indicates that in 2006-2007 utilities were able to raise debt finance within a spread range of 1.07%-1.27%. Since then spreads have increased significantly and have been in a range of 1.38%-3.28%. However it is important to note that since January 2009 spreads seem to have decreased. For example, whereas the spread on the GDF Suez bond issued in January was 3.28%, the spread on the bond of the same credit rating and tenor issued one month later was 2.05%. Likewise, the average debt premium on bonds issued by E.ON in May 2009 was 120 basis points (although these were short/medium term bonds with an average maturity of only three years, and for this reason we do not include them in our calculations).

Making sense of this data requires judgement, as calculating an average over a sample of observations that is heavily biased towards post-crisis data would not be meaningful. However, we note that the spreads observed in the first few months of 2009 seem to be unsustainably high, and as mentioned earlier secondary market evidence also points towards a fall in spreads since then. Excluding these gives a range of 1.1% to 1.7% using primary market data.

So far our cost of debt analysis has excluded assessment of transaction fees such as legal fees, bank commission charges and legal trustees' fees. The CC in its cost of debt analysis of Heathrow and Gatwick airport added 15 basis points to the real cost of debt for transaction costs. Likewise, in its recent analysis of Stansted, the CC added 10 basis points for the transaction cost. Considering this, we set out in the next section our view on transaction costs and whether an allowance should be made for them in the allowed cost of debt.

Transaction costs

Transaction costs – in the forms of increased arrangement fees, stricter governance and tighter covenants – have become more important in the recent illiquid credit markets. For corporates, general arrangement fees paid to the lender upon committing to a loan relationship, are now at levels that in some instances represent a 4 to 6 fold increase compared with their level at the height of the credit market boom. It would not be uncommon in the current market for a corporate borrower to pay between 2% and 3% as an arrangement fee for its debt facility (this can increase to 3.5%-4% for highly leveraged transactions). Lenders are also imposing (i) stricter covenants on debt facilities (i.e. requiring borrowers to meet more stringent cash flow and asset cover tests) and (ii) other conditions designed to result in loans having shorter average repayment lives.

Lack of liquidity and the indirect impact on transaction fees is of concern for the DNOs as, given the expected increase in capital expenditure spending in DPCR5, as well as the need to re-finance part of the existing debt portfolio, the DNOs are likely to need to raise significant quantities of finance over the next price control period.

We recognise that DNOs should be compensated for transactions costs, but believe that any compensation should be modelled explicitly as a cost in allowed cash flows, as opposed to adding an uplift in the cost of debt. On this basis we have not included any allowance for transactions costs in our cost of debt.

4.1.3 PwC's recommendations

The table below summarises our debt premia estimates.

Table 32: Summary of debt premia results

Debt premium	Min	Max
Evidence from secondary market (10 year average)	1.3	1.3
Evidence from primary markets	1.1	1.7

Source: PwC analysis

Of the above evidence, we are more inclined to base our recommendation on the 10 year average debt premia calculated using secondary market evidence. This would result in a debt premium recommendation of 1.3% which we consider is too precise to be used for setting the cost of debt under the current uncertain and volatile market conditions. We also note that the evidence from primary markets points towards a wider range with a higher upper end.

Taking these factors into account, we recommend a range of 1.3% to 1.5% for the debt premium for DPCR5. The lower end of our final range is based on the 10 year average debt premia across UK comparators, whereas the upper end of the range is close to the average of recent evidence from the primary markets. Given our range for the RFR, it leads to a real cost of debt range of 3.3%-4.0%.

We recommend using a debt premium of 1.3% - 1.5%, implying a real pre-tax cost of debt range of 3.3% - 4.0%.

5. Gearing

Gearing is the proportion of debt in the capital structure of a company and is normally calculated as the total value of debt as a proportion of the sum of the total value of debt and equity.

5.1.1 Ofgem's approach and regulatory precedents

In DPCR4 Ofgem's regulatory determination assumed a notional gearing level of 57.5% based on a judgment with respect to actual and projected gearing, as well as the DNOs' upstream guarantees.

Figure 29 below summarises results from our regulatory data base. The key aspects to note are:

- Regulators have used gearing ratios that lie within the 10%-60% range. In particular, utility regulators have used gearing levels in regulatory determinations that lie towards the upper end of this range, whereas those used by regulators in other sectors lie towards the lower end;

- When formulating their decisions, regulators generally have had regard to both the actual gearing and notional gearing. For notional gearing, regulators have used levels consistent with a target credit rating of BBB+/A-; and

- Regulators in the utilities sectors have generally calculated gearing as the ratio of Net Debt to regulated asset value (RAV), whereas regulators in other sectors have used the more general definition, the ratio of debt to the sum of debt and equity.

Our gearing analysis for DPCR5 is set out in the following section.

Figure 29: Regulatory precedents on gearing

Regulator	Review	Gearing (%)	Comments
ORR (Oct 2000)	Periodic review of Railtrack's access charges: final conclusions	50%	- Calculated gearing as the ratio of debt (D) to debt plus equity (D+E). - ORR used notional gearing that reflected its expectations that Railtrack's gearing levels would increase over the price control. - Used a gearing level that was consistent with a target credit rating of A.
CC (Nov 2002)	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	25%	- Calculated gearing as the ratios of D to D+E. - Used both the book and market value of equity for calculating gearing.
CAA (Feb 2003)	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	25%	- Primarily considered the CC (Nov 2002) decision.
CC (Feb 2003)	Mobile Phone Charges Inquiry	10%	- Used the book value of debt and the market value of equity for calculating gearing. - Used actual gearing levels.
Ofgem (Nov 2004)	Electricity Distribution Price Control Review 4	57.5%	- Calculated gearing as the ratio of net debt to RAV. - Stated DCPR3 as regulatory precedent (assumed 50%). - Considered both actual and notional gearing.
Ofwat (Dec 2004)	Future water and sewerage charges 2005-10	55%	- Calculated gearing as the ratio of net debt to RAV. - Undertook industry benchmarking exercise to calculate target gearing.
Ofcom (Aug 2005)	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	30 – 35%	- Calculated gearing as the ratio of D to D+E. - Considered both actual and notional gearing levels.
CAA (Dec 2005)	NATS Price Control Review 2006-2010 (CP2)	64%	- Calculated gearing as the ratio of net debt to RAV. - Observed that it expected a continual reduction in gearing over CP2 from around 85% (actual level in 2003) to 61% and used the average gearing level of 64% over CP2 for WACC calculations..
Postcomm (Dec 2005)	Royal Mail Price and Service Quality Review	20%	- Calculated gearing as the ratio of net debt to RAV. - Used notional gearing as actual gearing was zero.
Ofgem (Dec 2006)	Transmission Price Control Review, 2007-2012	60%	- Calculated gearing as the ratio of net debt to RAV. - Used actual gearing levels.
Ofcom (Mar 2007)	Mobile Call Termination Statement	10%	- Used the book value of debt and the market value of equity for calculating gearing. - Considered regulatory precedent (Ofcom 2004).
Ofgem (Dec 2007)	Gas Distribution Price Control Review 2007-13	62.5%	- Calculated gearing as the ratio of net debt to RAV. - Although it did consider actual levels, the final range used was consistent with that used in the Transco Price Control (2002).
CAA/CC (Mar 2008)	Economic Regulation of Heathrow and Gatwick Airports (Heathrow / Gatwick)	60%	- Calculated gearing as the ratio of net debt to RAV. - Used a gearing level consistent with a target credit rating of Baa1/BBB+.
CC (Nov 2008)	Stansted Price Control Review (2009-14)	50%	- Calculated gearing as the ratio of net debt to RAV. - Used a gearing level consistent with a target credit rating of Baa1/BBB+.
CAA (Mar 2009)	Stansted Price Control Review (2009-14)	50%	- Primarily based on CC (Nov 2008) decision.

Source: PwC analysis. Further details are provided in Appendix I and V.

5.1.2 PwC's approach

In DPCR4 Ofgem used a notional gearing that reflected its view on the optimal capital structure of an efficient DNO. We agree with Ofgem's previous approach of using a notional rather than actual gearing, since this better incentivises DNOs to optimise their capital structure and manage their interest rate risk. For calculating notional gearing for DNOs, we have considered two alternative approaches:

- Industry benchmarking, which is a "top-down" approach that seeks to evaluate the optimal gearing level by examining the average of the actual observed level of gearing across DNOs; and
- Target credit rating, an approach which focuses on a gearing level that is consistent with a target credit rating.

For our analysis, we have defined gearing as the ratio of net debt to RAV as this is how gearing is typically calculated for regulated utilities. We discuss both approaches in turn below.

Industry benchmarking

For benchmarking, we have examined the actual gearing levels across the UK DNOs. Our results are set out in the table below.

Table 33: DNOs gearing levels

DNO (£,M)	Net debt (£,M)	RAV (£,M)	Gearing to RAV
CN West	670	1,316	51%
CN East	475	1,256	38%
ENW	518	1,191	43%
CE NEDL	397	793	50%
CE YEDL	512	1,026	50%
WPD S Wales	117	692	17%
WPD S West	211	905	23%
EDFE LPN	458	1,156	40%
EDFE SPN	531	874	61%
EDFE EPN	694	1,475	47%
SP Distribution	699	1,388	50%
SP Manweb	549	1,044	53%
SSE Hydro	244	833	29%
SSE Southern	760	1,613	47%
Average	488	1,112	43%
Median			47%
Max			61%
Min			17%

Source: Regulatory accounts

Our analysis indicates that the average gearing level across the DNOs is 43% whereas the overall range across the industry is 17% to 61%. It is important to note that this approach assumes that the average actual gearing level across the industry is representative of the optimal capital structure for the industry. This is likely to be the case if gearing levels across companies are closely aligned together which is clearly not the case for the DNOs, making this approach less useful.

Another limitation of this approach is that in practice gearing is calculated using the book values of net debt and the RAV. This raises an important concern. Using book values results in a gearing estimate that does not reflect the market's forward looking view on the capital structure of the company. This is of particular concern in the case of DNOs which are expected to raise a significant amount of finance over DPCR5. Under the current market conditions, where it is easier to raise finance by issuing equity, DNOs might issue equity to raise capital to meet their financing needs. This means that using book values that do not take into account forward looking expectations might result in a higher gearing level than would be appropriate, and hence unduly lower the overall cost of capital (assuming all other parameters do not change).

Taking into account these caveats, we consider that for the purpose of determining an appropriate gearing level for DNOs that is forward looking, it is more important to focus on the gearing level implied in the target credit rating. This approach is discussed in detail in the next section.

Gearing level consistent with the target credit rating

For this approach we have focused on determining a medium- to long-term average industry gearing that would be consistent with an investment grade credit rating of BBB+/A- (Baa1/A3 using Moody's notation). We have selected this credit rating range as generally this is the minimum rating that the utilities regulators in the UK expect companies to maintain. Furthermore, the financeability analysis that regulators usually undertake as part of the price control review also focuses on determining whether the regulatory settlement would allow an efficient regulated company to maintain a credit rating of BBB+/A-.

We examined guideline ratios published by credit rating agencies Specifically our analysis suggests that Moody's considers a gearing level of 65% to be consistent with a credit rating of Baa1/A3 for UK/European Utilities. In the case of Standard & Poor's (S&P) information was only available for European and Australasian utilities rated A and BBB rather than for BBB+/A- rated utilities. However, since our target credit ratings are a notch higher than the lower end of this range and a notch lower on the upper end, we can formulate a range for BBB+/A- by using the lower end of the gearing range consistent with the BBB rating and the upper end of the gearing range consistent with the A rating[38]. Since, for distribution utilities, S&P considers a gearing range of 55% to 80% to be consistent with a target credit rating of BBB and a gearing range of 40% to 60% to be consistent with a target credit rating of A, using the above approach we translated this into a gearing range of 55% to 60% consistent with our target credit rating range.

Table 34; Gearing range consistent with target credit rating

Comparison gearing range (Distributors)					
Agency	Rating	Mean	Median	Max	Min
Moody's – UK Utilities	Baa1/A3	65%	69%	79%	37%

S&P – US Utilities			
Rating	A	BBB	BBB+/A- (implied)
Transmission utilities	55% - 70%	65% - 80%	65%-70%
Distribution utilities	40% - 60%	55% - 80%	55%-60%
Generation utilities	30% - 40%	35% - 50%	35%-40%
Integrated utilities	40% - 60%	60% - 75%	60%

Source: Moody's EMEA Electric and Gas Utilities Industry Outlook, November 2008,Standard and Poor's International Utility Ratings and Ratios, September 2001 and PwC analysis.

On balance, to formulate our view we have taking into consideration the views of both credit rating agencies. Our proposed range is set out in the next section.

[38] A higher gearing level is consistent with a lower credit rating as it reflects an aggressive capital structure and a higher default risk.

5.1.3 PwC recommendations

For the regulatory determination for DPCR5 we recommend a gearing range of 55% to 65%. This range reflects the views of both credit rating agencies. Again, this is a slightly wider range than typically used, reflecting the uncertainty around gearing levels under the current market conditions

We recommend that Ofgem uses a gearing of 55% to 65% for DPCR5

6. Conclusions on the WACC

Table 35: below sets out our overall WACC estimates for DNOs over DPCR5.

Table 35: PwC proposed WACC for DNOs over DPCR5

	PwC calculations (Low)	PwC calculations (High)	Ofgem's calculations – DPCR4 final decision	Ofgem's calculations – DPCR4 initial decision (Low)	Ofgem's calculations – DPCR4 initial decision (High)
Risk-free rate	2.0%	2.5%	2.6% (implied)	2.25%	3.0%
Equity beta	0.69	1.09	1.0	0.6	1.0
EMRP	4.5%	5.5%	4.9% (implied)	2.5%	4.5%
Gearing	55%	65%	57.5%	50%	60%
Debt premium	1.3%	1.5%	1.5% (implied)	1.0%	1.8%
Cost of equity (post-tax real)	5.10%	8.47%	7.5%	3.75%	7.50%
Cost of debt (pre-tax real)	3.3%	4.0%	4.1%	3.3%	4.8%
WACC (post-tax real)	3.60%	4.84%	4.8%	3.0% (based on individual parameters)	5.0% (based on individual parameters)
WACC (vanilla real)	4.11%	5.57%	5.5%	3.5% (based on individual parameters)	5.9% (based on individual parameters)
WACC (pre-tax real)	5.00%	6.72%	6.9%	4.3% (based on individual parameters)	7.2% (based on individual parameters)

Source: Ofgem's regulatory decisions and PwC analysis

We summarise below our recommended approach to calculating the cost of capital for DPCR5:

- **Methodology for calculating the cost of equity:** We believe that the capital asset pricing model (CAPM) is the most appropriate framework for calculating the cost of equity.

- **Risk-free rate:** Despite some market distortions caused by demand and supply factors, we consider that ILGs provide the best source of evidence on the level of the real RFR. We recommend a range of 2.0% to 2.5% for the RFR for DPCR5. The lower end of the range is broadly consistent with the 5 and 10 year averages for 10 year ILGs. The upper end of the range is consistent with the mid-point level for the real RFR that has generally been used in regulatory determinations since 2000.

- **Equity beta:** We recommend that beta is estimated using a range of comparators including National Grid and UK water companies. We recommend that the Blume adjustment is applied, and although we tested the sensitivity of the beta estimate to a debt beta of 0.1 we ultimately did not include a debt beta in our final WACC calculations. Our equity beta range is 0.7-1.1.

- **EMRP:** A key issue for Ofgem to consider for its DPCR5 determination is whether it believes the EMRP fluctuates in the short-term, and, if so, whether Ofgem would wish to reflect such fluctuations in its determination. If the EMRP is viewed as fluctuating in the short-term, then methodologies such as the Dividend Growth Model (DGM) are relevant to the calculation of the short-term EMRP, and would suggest a relatively high figure for the EMRP based on recent market conditions. Taking a longer-term approach, we consider that a range of 4.5% to 5.5% is appropriate. The upper end of this range is broadly consistent with long-term evidence on the actual excess returns on equities in the UK. The lower end is consistent with regulatory decisions since 2005 and towards the top end of the range used in the most recent regulatory determinations. The range does not include any uplift for any additional returns required for illiquidity risk, which the Bank of England suggests may lie between 0.5 and 1%.

- **Debt premium:** As with the EMRP, if Ofgem decides to use short-term estimates of the debt premium this would result in higher figures than using a longer-term approach. Using a long-term approach, we recommend a range of 1.3% to 1.5% for the debt premium over DPCR5. The lower end of our final range is based on the 10 year average debt premia across UK comparators, whereas the upper end of the range is close to the average of recent evidence from the primary markets. This range does not include any uplift for transactions costs.

- **Gearing:** We recommend a gearing range of 55% to 65%. This range reflects the views of the credit rating agencies on the gearing levels consistent with a credit rating range of A-/BBB+.

Overall our real Vanilla WACC range is 4.1% to 5.6% which is consistent with a real post-tax cost of equity range of 5.1% to 8.5% and a real pre-tax cost of debt range of 3.3% to 4.0%.

Our range is relatively wide, reflecting the high level of uncertainty associated with the cost of capital under current market conditions. Moreover, given these market conditions, we considered at length submissions that suggested a different approach to the calculation of the cost of capital, particularly the EMRP, would be appropriate for DPCR5. Our range is appropriate if Ofgem wishes to set a cost of capital that reflects longer-term conditions. On balance we believe that this is appropriate. We have set out our reasoning in the relevant sections of our report above, but also include a discussion of these issues in Appendix V.

As a cross check of the validity of our WACC calculation Ofgem asked us to undertake a relative risk analysis of the electricity and gas distribution industries. This work is described in the next section.

7. Relative Risk Analysis

7.1.1 Introduction

The main part of our work has been the assessment of a reasonable range for the WACC for DNOs to be used by Ofgem when it decides what WACC to incorporate in its assessment of allowed prices for DPCR5. To calculate this range we have used what we consider to be the appropriate methodologies for calculating the cost of equity, cost of debt and gearing, and have applied these methodologies using our judgement regarding the best available data sources.

The standard methodologies that we have used to calculate the WACC range do not require detailed analysis of the DNOs themselves. Two of the main inputs (the risk-free rate and the EMRP) are generic variables which apply to all businesses. Those inputs that are specific to DNOs (beta, the debt premium and gearing) have been evaluated through benchmarking, rather than through any hands-on analysis of the financial risk associated with the DNOs' businesses in DPCR5.

Whilst this is always the case in any WACC calculation using the standard methodologies, Ofgem asked us to carry out a relative risk analysis, in particular making comparisons between gas distribution networks (GDNs) and DNOs. The aim of this analysis was to consider whether, given the relative riskiness of these two types of businesses regulated by Ofgem, the approach to the WACCs for each appeared consistent. In this analysis we:

- Provide a conceptual framework for the relationship between risk and returns, and hence what in principle the approach should be to setting regulated prices with regard to an allowed return;
- Compare the range for WACC that we have proposed for DPCR5 with those used by Ofgem for DPCR4 and the last GDPCR. This enables us to draw conclusions regarding the relative levels of the WACCs allowed;
- Carry out an analysis of the degree of cash flow volatility associated with DNOs and GDNs in order to comment on the relative extent of the total financial risk to which investors in these businesses are exposed; and
- Draw conclusions regarding the implications for WACC and price cap setting, including recommendations for the approach that Ofgem might adopt in the future.

7.1.2 The conceptual framework for risk and return

Returns and RPI-X regulation

The aim of RPI-X price regulation is to provide, as nearly as possible, the same incentives to invest and rewards for success for businesses with an element of monopoly power as would be the case in an effectively competitive market.

In effectively competitive markets, through the process of competition and entry/exit, prices are forced to settle at the level where (1) efficiently incurred costs are covered, with, in addition, (2) just sufficient margin to allow investors to earn returns which reward them for their investment but no more. Economists refer to this competitive benchmark as "normal" profitability. Lower profits would not be sustainable in the medium- to long-run as re-investment would not be incentivised. Firms would exit, driving prices and profits back up to the normal level. Higher, or "supernormal" profits, would only be possible in markets that were not competitive, for example due to barriers to entry. In competitive markets high profits would encourage entry, driving prices down. In competitive markets, therefore, firms earn normal profits.

To mimic the competitive outcome through RPI-X price cap regulation, regulators set price caps in advance for a five year period, based on expected sales volumes, with the intention of (1) covering forecast efficiently incurred costs and (2) providing a normal return on investment. The WACC is used as the basis for the calculation of what constitutes a normal profit. It is calculated using market data on returns actually achieved by investors in the market. This approach implicitly assumes that in the market as a whole competition is effective, so that actual achieved returns are a good indicator of the minimum level of returns required to incentivise investors and provide them with a normal return.

Components of return

In textbook competitive markets artificial assumptions such as instantaneous costless entry and exit and infinite numbers of homogeneous minimum-scale suppliers guarantee that all firms will always earn normal profits. In real world competitive markets such returns are not guaranteed, but over time an averagely efficient company can expect to earn normal returns in the form of the WACC. In the short- to medium-term, because of different degrees of efficiency or success, companies can earn either subnormal or supernormal profits. In other words, in real world markets investors are exposed to risk.

The normal return expected by investors, and observed in the market, therefore includes a component reflecting the exposure to risk associated with investment. It also includes a "time preference" component relating to the reward demanded by the average investor to compensate for the delay between an investment being made and returns being received, regardless of risk (this is why there is generally a positive return on a risk-free investment such as the purchase of UK ILGs).

Return on debt

Accordingly, the normal return on debt (or cost of debt) includes a pure time preference component (the risk-free rate) and a component relating to risk (the debt premium). The latter is needed to compensate debt providers for their exposure to default risk.

Return on equity

Similarly, the normal return on equity (or cost of equity) comprises the risk-free rate plus a risk premium. Using the CAPM methodology, the latter is the product of the EMRP and the investment's equity beta.

The equity beta is the only component of the cost of equity which is bespoke to the type of investment being considered. Beta is a measure of the degree to which returns on a particular investment are correlated with returns on the market as a whole. If an investment was not correlated with the market at all the risk premium would be zero and there would be no mark-up for risk – in other words, the only risk recognised in the CAPM is risk correlated with the market. This is referred to as systematic risk.

The reason for this can easily be demonstrated by creating a portfolio of equities and observing the calculated variability in returns. Individual equities often exhibit a great deal of variability in returns, but by combining them in a portfolio the overall variability is reduced. This is because when some investments in a portfolio perform badly others perform well, dampening fluctuations in the portfolio as a whole. In a well-diversified portfolio, the only risks to which an equity investor remains exposed are the systematic risks which are associated with most or all investments simultaneously. These systematic risks are generally associated with the performance of the economy. Risks which are specific to particular investments do not affect the investor as these cancel each other out – those investments that under-perform due to specific risk factors are offset by those that out-perform.

The higher the beta of an investment, the higher the indication of systematic risk exposure and hence the higher the expected or required return on equity:

- Investments which exhibit greater correlation with the economic situation (e.g. highly cyclical demand) have higher betas;

- Higher financial gearing increases the equity beta. A higher proportion of debt finance makes an equity investment more risky (all other things equal) because equity is rewarded through cash flows net of payments on debt. More debt amplifies any underlying exposure to systematic risk; and

- Similarly, higher operational gearing (i.e. a bigger proportion of fixed costs) also amplifies any underlying exposure to systematic risk because equity is rewarded from cash flows net of payments for fixed costs.

Systematic and specific risks

A key point from the above is that the WACC derived using CAPM includes an uplift only for the risk associated with systematic risk factors – it includes no compensation for the specific risks associated with investments.

This is despite specific risks being quantitatively more important for most businesses than systematic risks. It can seem counterintuitive to many that some of the biggest risks facing a business appear to be ignored in financial economic theory, and that genuinely risky ventures appear to be expected to yield only a modest normal return (the WACC).

True expected cash flows

The answer to this conundrum often lies in a mismatch between the precise nature of the theory and its commercial interpretation. The theory suggests that specific risks do not affect the WACC because in a portfolio under- and out-performance can be expected to offset each other, eliminating specific risk exposure. Note that in this analysis, risk is defined as "variability". In financial economics, out-performance is as much a contributor to risk as is under-performance. In common commercial usage, risk is often used to refer only to the downside.

The observation that under- and out-performance are self-cancelling is only possible where, for each investment in a portfolio, there is symmetry of the possible variability about the expected outcome for each individual investment. If, for example, an investor made investments on the basis that generally there was more downside on each investment than upside (e.g. the investor bought shares at a high price relative to the expected value of future cash flows) then it would be unreasonable to expect there to be sufficient out-performance on some investments to offset under-performance on others.

So underpinning the diversification theory is an assumption that investors consider all risks (specific as well as systematic) carefully, and do not invest where the probability-weighted downsides exceed the upsides.[39] For the WACC theory to hold, all investments must be made at a fair value reflecting true expected cash flows, with the probability-weighted upsides matching the probability-weighted downsides.

There are many instances in commercial life where this does not accord with what is commonly done. Venture capitalists, for example, tend to target returns well above any normally computed cost of capital. This is because they are not targeting returns against a true expected outcome – they are targeting the returns needed in the event that the venture is successful. On this basis the probability weighted downside is significantly higher than the probability weighted upside and it is important that the outcome should indeed be well above the WACC – only if this is the case is there the prospect that the investment can be expected to achieve the WACC on a true expected cash flow basis.

Indeed, high specific risk projects can exhibit low systematic risk and hence have a low WACC. Start-up venture capital businesses are likely to carry significant specific risk – the basic success of the core "idea" or business model may be uncertain, the management unproven, the establishment of the venture yet to be completed, the existence of demand for the product unclear. Whilst it might also be exposed to systematic risk (it might be easier to be successful in a strong economy than a weak one) overwhelmingly the risks are likely to be specific. So venture capital businesses can have low WACCs, despite investing in risky ventures and targeting high returns for individual investments.

Treatment of specific risks

Continuing the theme of counter-intuitive outcomes, the theory also suggests that investors should be indifferent between investments which differ substantially in terms of total risk exposure, as long as they exhibit the same degree of systematic risk.

In calculating the cost of equity, only the beta is used as the basis for differentiating returns on different types of investment. The beta only reflects systematic risk. So if two investments have the same beta, the cost of equity is the same, even if one exposes equity investors to substantially greater specific, and hence total, risk.

The reason for this is that in a well-diversified portfolio of equity investments specific risks simply do not matter as they can be expected to self-cancel. They are therefore irrelevant to the calculation of a required return – investors cannot expect a return to compensate for a risk that they simply do not face. Whilst intuitively it might seem logical that, faced with two investments with the same systematic risk and expected

[39] Naturally investors would prefer to invest where the upsides exceed the downsides but in well-functioning markets this should not be possible as demand for such opportunities would be high, raising the price and hence reducing the available returns to a point where the upside is balanced by the downside.

cash flows an investor would prefer the one with the lower specific risk, the theory does not discriminate between them.

This result is based on the observed self-cancelling of specific risks in a portfolio. In this regard the degree of specific risk of individual investments does not matter. An investment which exhibits a high degree of variability of cash flows due to specific risks can make an important contribution to the self-cancelling of specific risks by offsetting other high specific risk investments in the portfolio.

There is a possible counter to the standard theory where specific risks could cause extreme asymmetric outcomes. A highly (specific) risky investment could have the possibility of swinging between extremely positive cash flows and large negative ones. In the former case the result would simply be high returns for the equity investors. In the latter case the investment could go into financial distress. This has transactions costs and other difficulties that may result in an asymmetrical outcome, with the downside outcome being more extreme than the upside[40].

For specific risks to be ignored in the calculation of the cost of equity for a particular investment it is therefore important that either such extreme downsides do not exist, or that the costs associated with financial distress are incorporated into the true expected cash flows for the investment.

Conclusions on conceptual framework

The theoretical underpinnings of the concept of normal profitability and the derivation of the WACC Have implications for the use and interpretation of WACC in the context of RPI-X regulation:

- WACC is a fair return on investment in DNOs as long as the cash flows used in the models used to derive price caps also include true expected cash flows, in the sense that on a probability-weighted basis the upsides are equal to the downsides;
- Specific risks should only be taken into account in the calculation of true expected cash flows. They are not relevant to the calculation of WACC; and
- This assumes that there are not asymmetric outcomes associated with specific risks.

We will return to the implications of these for the practical calculation of price caps in the concluding paragraphs of this section. But before we do we next look at evidence for the compatibility of our WACC estimate with those used previously by Ofgem for DNOs and GDNs, and then we consider evidence on the total cash flow volatility of DNOs compared with the GDNs. This will help us to form a complete picture of the risk profile of DNOs and GDNs, and enable us to conclude on the efficacy of our WACC estimates and Ofgem's overall approach to setting an allowed return.

7.1.3 WACC Calculations

The conceptual framework section has explained why the WACC is the appropriate rate of return under certain conditions relating to the cash flows used in conjunction with the WACC to calculate price caps. In this section we cross-check the WACC range we have identified for the DNOs in DPCR5 by comparing it with the WACCs set by Ofgem in the last Gas Distribution Price Control Review (GDPCR) and in DPCR4.

The table below compares our proposed WACC for DPCR5 with that allowed for in GDPCR and DPCR4.

Table 36: Cost of capital comparison

[40] We noted earlier that the Fama-French three-factor model includes a term for the book-to-market ratio, implying that companies in financial distress where the book-to-market value increases can be expected to have a higher cost of equity.

	DPCR 5 (Low)	DPCR 5 (High)	GDPCR	DPCR 4
Risk free rate	**2.0**	**2.5**	2.5 (implied)	2.6 (implied)
Equity beta	**0.69**	**1.09**	1 (implied)	1 (implied)
EMRP	**4.5**	**5.5**	4.8 (implied)	4.9 (implied)
Gearing	**55%**	**65%**	62.5%	57.5%
Debt premium	**1.3**	**1.5**	1.1 (implied)	1.5 (implied)
Cost of equity (post tax real)	**5.10**	**8.47**	7.25	7.5
Cost of debt (pre tax real)	**3.3**	**4.0**	3.55	4.1
WACC (vanilla real)	**4.11**	**5.57**	4.94	5.55

A simple comparison of the WACC figures in the table suggests that the figures used previously by Ofgem are broadly consistent with our range for DPCR5. This is broadly indicative that (1) there has been consistency in the treatment of the DNOs between DPCR4 and DPCR5 and (2) our view of the WACC for the DNOs seems to be in line with the earlier view taken by Ofgem with respect to GDNs.

However, it is not possible to draw definitive conclusions from this simple comparison because of differences in:

- Estimation technique – for example Ofgem used the CAPM framework as well as wider market evidence including data on the aggregate returns on equity method whereas our analysis for DPCR 5 is based solely on the CAPM framework;
- Views – cost of capital analysis allows a degree of subjectivity and judgement in choosing comparators, the relevant time period for analysis (e.g. definitions of long-, medium- and short-term averages of interest rates/years to maturity, etc.) and reliance on regulatory precedents; and
- Timing – the analyses under comparison have been undertaken at different points in time (2004, 2006 and 2009). In particular, our estimate for DPCR5 has been prepared after the onset of the credit crisis in August 2007.

Therefore, in addition to this simple comparison we have also considered our own view of the WACC for GDNs now, on the same basis as the WACC range we have derived for DNOs for DPCR5. This analysis eliminates differences in estimation techniques, timing and views, and therefore any difference in the cost of capital for DNOs and GDNs would be due purely to identified differences in exposure to systematic risk.

To undertake this analysis we considered evidence for differences in systematic risk associated with electricity and gas distribution. We used our analysis of international comparators (set out in section 3.4 and restated in the table below) which shows that gas and electricity asset betas are very similar.

Table 37: International comparator asset betas

	5 year monthly –adjusted betas (debt beta 0.0 – 0.1)
Primarily Electricity Distribution (ED)	0.29 – 0.32
Primarily Electricity Transmission (ET)	0.40 – 0.43
Primarily Electricity Networks (EN)	0.24 – 0.27
Over all range electricity	**0.24 – 0.43**
Primarily Gas Distribution (GD)	0.60 – 0.61
Primarily Gas Transmission (GT)	0.26 – 0.45
Primarily Gas Networks (GN)	0.26 – 0.37
Overall range for Gas	**0.26 – 0.45**

Note we have excluded EGNs from our analysis for this comparions

Source: Datastream and PwC calculations.

The overall range for electricity tabulated above (including distribution, transmission and networks) is 0.24-0.43 and for gas (including transmission and networks) is 0.26-0.45. In general, betas for gas companies are slightly higher than those for electricity companies, both in the case of the overall range, and when comparing individual category sets i.e. GT relative to ET and GN relative to EN. The exception is gas distribution, where the GD beta is roughly twice the ED beta range.

However, as stated earlier we believe it is appropriate to disregard the GD beta. This is because our analysis shows that the asset beta of our sole GD company (Nicor) has historically been very volatile, perhaps the result of higher operational leverage or due to reasons related to vertical integration.

The equity betas are also affected by the level of gearing, but given the similarities of the businesses and the evidence in the table of similar assets betas, we have no reason to believe that there should be any differences in gearing. Since the risk-free rate and EMRP are market based parameters that do not differ between businesses, this means that, based on this limited analysis, we have no reason to believe that the cost of equitiy should differ between DNOs and GDNs, although the evidence might suggest that the WACC for GDNs should be slightly higher than for DNOs.

Comparison of cash flow volatility

The analysis of the WACC necessarily examines evidence only for differences in systematic risk. In this section we look at evidence on cash flow risk as a whole, including specific risk as well as systematic risk. In this way we seek to provide an assessment as to the relative total risk exposure between DNOs under proposals for DPCR5 and DPCR4, and between DNOs and GDNs. In conjunction with our earlier conceptual framework, this assessment can be used to comment on the overall approach to building a WACC return into the price cap settlement.

7.1.4 Volatility analysis

This section looks at risks evident from fluctuations in historic cash flows and is based on data taken from a number of sources[41]. It provides a high level quantitative assessment of the volatility of operating expenditure (OPEX), capital expenditure (CAPEX) and revenue. This analysis draws heavily upon Ofgem's Relative Risk Analysis (RRA (2006)) undertaken at the time of GDPCR.

[41] In particular, we have sourced revenue and cost data from companies' regulatory accounts and historical cost and allowance figures from the regulatory reporting packs (RRPs).

Our analysis covers all of the GDNs and DNOs regulated by Ofgem. Ideally, to assess the degree of cash flow volatility associated with DNOs and GDNs in order to comment on the relative total financial risk faced by investors, we would have preferred to compare the cash flow volatility of DNOs and GDNs over the same recent time period under a static regulatory regime. However, since the most recent GDPCR was implemented in early 2008 this would have provided only two years' data for comparison. We have therefore extended this back to include a further two years of OPEX data, giving us data for OPEX for 2005-06 to 2008-09 inclusive. We have been unable to extend the dataset for Revenue and CAPEX for GDNs due to a lack of accurate figures in the public domain.

Approach to volatility analysis

A standard approach to volatility analysis for non-regulated businesses is to measure revenue and cost volatility as the standard deviation of actual amounts compared with an historical average, where the historical average could either be assumed to be constant over time or vary in line with an assumed trend.

We used a slightly amended approach in our assessment of volatility for the DNOs and GDNs. For regulated businesses like these, the volatility to which they are exposed is under- or over-recovery against the allowed values for revenue and costs embodied in the regulated price cap decision. In this sense, volatility is best measured as the standard deviation of actual amounts compared with the values determined in the regulatory decision, rather than compared with some historical average.

A complicating factor for regulated businesses is the extent to which any exposure to cash flow volatility is dampened through any sharing factor or pass-through element, for example for non-controllable costs. For example, if some cost elements within OPEX are subject to an automatic pass-through provision, then the business would not be exposed to cash flow volatility associated with any fluctuation in these elements of OPEX. We have not adjusted for this in our high level analysis, although it would in principle be possible to undertake a much more detailed analysis, understanding the underlying reasons for fluctuations in costs, and identifying those where pass-through or other arrangements mitigate the risk for the DNOs and GDNs.

Because we were unable to do this, in addition to analysing total cash flow volatility, we have also looked specifically at the degree of cost pass-through in the arrangements for DPCR4, DPCR5 and the latest GDPCR.

To analyse the relative risks faced by DNOs and GDNs, we assessed the volatility of the three cash flow elements on the basis of deviation from the regulatory allowance, and assessed whether the volatility metrics for DNOs and GDNs are statistically different from each other. Specifically, we use a two-tailed statistical F-Test to test the null hypothesis that the cash flow volatility faced by investors in DNOs and GDNs is similar.

Results of volatility analysis

The tables below detail the average annual volatility for each of the three cash flow variables across the DNOs and GDNs. As noted, volatility is measured as the standard deviation of actual outturn versus regulatory allowance, and the averages across all DNOs and GDNs for each year have been calculated and included in the tables.

Table 38: OPEX, CAPEX and REVENUE Volatility

Average annual volatility – DNOs						
	DNOs			GDNs		
Time Period	OPEX	CAPEX	REVENUE	OPEX	CAPEX	REVENUE
2005-06	11.3%	12.4%	6.5%	8.5%	~	~
2006-07	13.7%	12.1%	4.2%	11.9%	~	~
2007-08	8.1%	16.6%	7.4%	10.0%	15.6%	8.2%
2008-09	9.0%	22.9%	12.6%	6.0%	11.3%	15.0%

Source: RRPs and regulatory accounts

A simple comparison of volatilities over time shows DNOs' CAPEX to be the most volatile variable among our sample. Revenues, for both GDNs and DNOs, have also proven to be more volatile in the most recent year. On first glance, volatility appears to be higher for DNOs than GDNs. However, to test whether this apparent observed difference in volatility between DNOs and GDNs is statistically significant, we conducted an F-test. We tested the three variables at the 1% and 5% levels of significance. The results are tabulated below.[42]

Table 39: Results

	GDNs(σ_g)	DNOs (σ_e)	F Value (5%)	F Value (1%)	Test Statistic	Significant at 5%?	Significant at 1%?
OPEX	4.9%	11.5%	5.9	14.3	5.4	No	No
CAPEX	8.4%	12.3%	5.9	14.3	2.2	No	No
REVENUE	3.1%	7.3%	5.9	14.3	5.3	No	No

Source: RRPs and regulatory accounts

The analysis shows that the cash flow volatility proxied by the relative volatility in the variables is not statistically significantly different. Therefore, on this basis the cash flow volatility faced by investors across GDNs and DNOs is broadly similar[43].

It is recognised that this analysis has a number of limitations and associated caveats. These should be borne in mind when forming any firm conclusions:

- The assessment of cash flow volatility (taking OPEX, CAPEX and revenue independently) does not take into account any correlations between these expenditure categories which may impact the overall riskiness of the operators' returns. For example, a portion of OPEX (or CAPEX) is likely to be discretionary and so could potentially be reduced in the event of a CAPEX (or OPEX) over-run, helping to smooth the overall cash outlays in a given year (or, indeed, there may be scope for deliberate trade-offs between CAPEX and OPEX). If such negative correlations exist then an assessment of the absolute volatilities in these expenditure items may overstate the overall riskiness of the operators' returns. To the extent that the relationships between the various expenditure categories differ substantially between DNOs and GDNs, the analysis could lead to an erroneous conclusion regarding the relative risk of the two sectors.

- The dataset that underpins our analysis is based on headline cost and revenue lines and extends only over a few years. In order to draw more robust conclusions it would be necessary to use a more granular cost and revenue breakdown over a longer time period. This would enable a fuller recognition of particular cost and revenue drivers, and allow any necessary normalisation to the data.

- Whilst we are trying to draw conclusions regarding the implications for WACC and price cap setting for DPCR5, our quantitative analysis by its very nature uses historic data. Although in some circumstances the past is a reasonable indication of the future, there have been events in the recent past (e.g. structural changes in the GDN sector) and changes proposed in the future (e.g. adaptations to the regulatory regime proposed for DPCR5) that make this inference less robust.

- As noted, we have examined total cash flow volatility, with no allowance made for volatility associated with expenses subject to pass-through arrangements.

Taking these limitations into account, whilst we believe that our quantitative analysis yields some high level insight into the relative volatility of cash flows between DNOs and GDNs, caution needs to be exercised in interpreting the results.

To supplement this analysis, therefore, we have undertaken a qualitative assessment of risk exposure embedded within the regulatory determinations (for example through the incentive mechanisms). For regulated business such as DNOs and GDNs that face very limited demand risk because of the nature of the

[42] A more detailed methodology for the F-Test is set out in the appendix.
[43] It is noted that at the 6% significance level both OPEX and Revenue volatility differs across the two sectors.

services they provide and their monopoly positions, these risk exposures are important drivers of the cash flow risk faced by investors. Additionally, it has an advantage over the quantitative analysis by being forward looking. The next section discusses the comparative assessment of risk exposure embedded in the price controls in more detail.

7.1.5 Risk exposure under the regulatory frameworks

This section outlines our comparative assessment of risk exposure of GDNs and DNOs under the different regulatory regimes. We look in turn at different components of the regimes and compare first the relative treatment for the DNOs between DPCR4 and that currently proposed for DPCR5, and second the relative treatment between the last GDPCR and DPCR5.

Exposure to network investment expenditure risk

Expenditure on replacing, upgrading or extending the existing network infrastructure is controlled according to the allowances set by Ofgem during the price control review period. The regulatory mechanisms employed are intended to incentivise the operators to aim for greater efficiency in achieving lower costs against allowances, while ensuring that this is not achieved through artificially inflated cost forecasts.

DPCR4 compared with DPCR5: The incentive mechanism has been altered slightly between DPCR4 and DPCR5, with a movement from a “Sliding Scale” mechanism to an “Information Quality Incentive” (IQI) framework. These work along similar lines, the latter being an enhancement of the former. The Sliding Scale used in DPCR4 took the gap between Ofgem’s baseline allowance (found using benchmarking techniques) and the DNO’s forecast expenditure, and set an actual allowance based on a mark-up to the baseline of a proportion of the difference. Each company’s incentive strength (the proportion of under- or over-performance on costs to which it is exposed) then relates directly to the proximity of the forecast to the baseline, with those forecasting relatively lower costs being allowed to retain as much as 40% of any cost savings, whilst those forecasting relatively high costs retaining as little as 20%. In addition, companies with lower forecasts can potentially achieve a higher return than the cost of capital should they not spend over their allowance. Thus there are incentives for both efficiency and low, accurate forecasts. The IQI mechanism proposed for DPCR5 works in a very similar way, the principle adjustment being that the incentive strengths resulting from the matrix have been shifted to give a range of 30-50%[44]. This represents an increased risk exposure under the new proposals. An alternative, steeper incentive structure with a range of 25-55% is also under consideration.

GDPCR compared with DPCR5: The GDPCR framework also makes use of the IQI mechanism for both CAPEX and REPEX, using an incentive strength range of 20-40% as in the previous DPCR4 sliding scale mechanism[45]. Hence, the DPCR5 proposals also represent a higher level of risk faced by DNOs than for GDNs under the existing arrangements.

Exposure to controllable operating costs

Costs associated with the everyday operations of the business (with the exception of costs deemed non-controllable as outlined below) are directly regulated by Ofgem on the basis of fixed allowances. The associated incentives encourage operators to strive for greater efficiency in lowering expenditure.

DPCR4 compared with DPCR5: During DPCR4, operators have been fully rewarded for/exposed to all efficiency savings or under-performance costs associated with controllable OPEX. Under the new DPCR5 plans, however, controllable OPEX will be treated under the IQI mechanism, implying a significant reduction in firms’ exposure using the 30-50% range as discussed above.

GDPCR compared with DPCR5: In the GDPCR framework the system was identical to that in DPCR4, with the GDNs being fully exposed to all over- or under-performance.

Exposure to non-controllable operating costs

Ofgem characterises certain operating costs as non-controllable under the regulatory framework. These costs include business rates on network assets, regulator license fees, transmission exit charges and depreciation, among others.

[44] The matrices for the IQI and sliding scale mechanisms are reproduced in the appendix.
[45] See IQI matrix in the appendix.

DPCR4 compared with DPCR5: Being, as defined, outside of the control of the operator, DPCR4 allows these costs to be expensed on a 100% pass-through basis, such that the operators bear none of the risk associated with volatility in these cost items. DCPR5 proposes to continue with this system of pass-through, implying no change to the existing risk exposure[46].

GDPCR compared with DPCR5: Non-controllable operating costs are treated identically in the GDPCR as for DPCR4 and DPCR5.

Exposure to fault costs

Fault costs are those incurred in repairing unanticipated faults in the network, both in terms of increased operating costs required to get the infrastructure back on-line, and capital expenditure as necessary to replace and repair faulty equipment.

DPCR4 compared with DPCR5: Under DPCR4, fault costs are treated alongside controllable operating costs and as such are subject to the same incentive strength (implicitly 100%). In the DPCR5 proposal, however, they fall under the IQI system and therefore firms face only a 30-50% exposure to the risk of over- or under-performance against fault cost allowances.

GDPCR compared with DPCR5: In GDPCR, the same DPCR4 approach of treating fault costs as controllable operating costs was adopted, implying a 100% exposure level.

Exposure to indirect costs

Other costs associated with the operations of the business which are unattributable to a specific cost driver are referred to as indirect costs, and in some cases are treated separately from operational costs.

DPCR4 compared with DPCR5: It is not clear to what extent DNOs are exposed to indirect costs. As an estimate we note that during the DPCR4 period, 62% of indirect costs related to operating costs, the remaining 38% relating to capital expenditure. As noted above, overall CAPEX exposure is 20-40% through the sliding scale. Using the figures from the publicly available DPCR4 model, we observe that the controllable portion of total OPEX is around 81-86%. Applying these figures together results in an estimated range of 57.8-68.5% exposure for indirect costs in DPCR4. The proposed blanket application of the IQI mechanism in DPCR5 includes indirect costs, with the exception of business support costs, and hence these will be subject to a 30-50% exposure level. The excepted business support costs include CEO costs, HR, insurance, finance and regulatory costs and specifically defined other costs. It is proposed that for these cost items DNOs would be symmetrically liable for 100% of any savings or over-spend. Under DPCR4 these costs were not treated separately from other indirect costs.

GDPCR compared with DPCR5: It has not been possible to ascertain the ratio of indirect costs attributed to CAPEX and OPEX under the GDPCR mechanism. We therefore assume the same split as that used in DPCR4: 38% to CAPEX and 62% to OPEX. Calculating from this we find a value of 70-77% volatility exposure under GDPCR. Comparing this to the 30-50% in the DPCR5 proposals, this implies that exposure is significantly higher in the existing gas regulation regime.

Exposure to distributed generation costs

Distributed generation costs, applicable only within the electricity distribution industry, refer to expenses generated through the connection of new generation capacity to the existing network.

DPCR4 compared with DPCR5: In both DPCR4 and the DPCR5 proposals, there is an 80% pass through of costs relating to such connections, implying an exposure level of 20%. The new guidelines make minor alterations to the specific variables subject to this pass through, but they are unlikely to have any material effect on risk exposure.

Exposure to pensions costs

DNO and GDN pension contributions and deficit repayment obligations are included within the regulatory framework.

[46] We have assumed that the same items are treated as non-controllable under all regulatory regimes.

DPCR4 compared with DPCR5: The mechanism used in DPCR4 was fairly simple and involved an effective short-term pass through rate of 0%, rising to 100% in the medium-term, since all efficiently incurred spending above or below the allowance will be compensated for in the following price control period. Hence the long-term exposure of an efficient DNO is zero, though there may be incentives in terms of short-term cash flow benefits. The accumulated deficit allowance is calculated on a company-by-company basis. In DPCR5 it has been suggested that some changes might be made to this system, specifically that it might be appropriate for shareholders to bear a small portion of the risk associated with pension costs. No decision has been made but the most recent consultation suggested two risk sharing options (50:50 or IQI ratios) for ongoing liabilities based on an ex-ante allowance and a potential reopener on deficit costs based on tracking the PPF 7800 index. Ofgem points out that its current model of zero exposure is out of line with other UK utilities regulators.

GDPCR compared with DPCR5: Under the GDPCR regulations the pension cost exposure of GDNs is in line with that of DNOs operating under the existing DPCR4 framework.

Exposure to losses and leakage incentives

Losses/leakage regulatory mechanisms employed by Ofgem are intended to incentivise the operators to reduce losses by undertaking the appropriate investments, increasing operational efficiency and by undertaking measures to reduce theft across the networks.

DPCR5 compared with DPCR4: Under DPCR4, the target losses levels, where losses were defined as the difference between the estimated volume of electricity entering and exiting the system, were set on an ex-ante basis for each DNO at the start of the price control. Any under- or out-performance was either penalised or reward by Ofgem at the rate of £48/MWh (the incentive strength). One of the concerns during DPCR4 was the manner in which losses were calculated. Ofgem's guidance allowed a degree of subjective interpretation leading to differing approaches, and sometimes markedly different results. Under DPCR5 Ofgem intends to make several changes to the incentive mechanism. Ofgem intends to modify the definition, laying out a much more clearly defined measurement approach that it considers to be more appropriate. This would eliminate any out-performance which was more a function of measurement as opposed to being underpinned by operational efficiency. It is proposed that the incentive strength be increased to £60/MWh, and Ofgem intends to limit DNOs' exposure by introducing a cap and collar.[47] Overall, it is unclear whether the DNOs' overall exposure has increased or decreased under the new modified incentive mechanism proposed to be in place in DPCR5 relative to that in DPCR4. While the introduction of the cap and collar reduces the exposure, a higher incentive strength and more tightly defined measurement criteria are likely to increase exposure.

DPCR5 compared with GDPCR: The leakage incentive mechanism under GDPCR is broadly similar to the losses incentive mechanism under DPCR5. The main difference is the exposure under the cap and collar mechanism. While GDNs' exposure is 10%, DNOs' exposure under DPCR5 is still to be determined at the time of reporting. We can therefore not conclude whether DNOs under DPCR5 face a higher or lower exposure compared to GDNs..

Exposure to transmission exit incentive

Transmission exit costs, applicable only within the electricity distribution industry, refer to charges paid by the DNOs to National Grid in relation to the financing and operating costs of equipment and infrastructure that connects the distribution network to the transmission network (the transmission exit point).

DPCR5 compared with DPCR4: Under DPCR4, all transmission exit charges are passed through to the customers, implying that the DNOs have no exposure. However, Ofgem considers that having a straight pass-through mechanism does not incentivise DNOs to manage these costs. Under the proposed DPCR5 mechanism, Ofgem intends to separate out controllable and non-controllable costs. Non-controllable costs would still be passed-through in full to the customer. However, for controllable transmission exit costs, Ofgem proposes to set ex-ante allowances along with a cap/collar that would limit DNOs exposure to 20%. This suggests that DNOs would face a higher risk under the proposed mechanism than during DPCR4.

Exposure to the Innovation Funding Initiative

[47] Ofgem's initial proposal is that the cap and floor will be calculated for each DNO as plus or minus 0.5% of the DNO's DPCR4 average annual units distributed (MWh), multiplied by the new loss incentive value (£60/MWh), multiplied by five.

The Innovation Funding Initiative (IFI) is designed to encourage research and development aimed at improving the efficiency of the network.

DPCR5 compared with DPCR4: In DPCR4, for costs related to the IFI Ofgem set a pass-through rate of 70-90% of costs up to the cap, where the cap was determined as 0.5% of regulated revenue. Costs above the cap had an exposure rate of 100%. The proposed IFI scheme for DPCR5 is very similar to that for DPCR4, with the exception that the pass-through rate is a flat rate of 80% (which is equal to the average over DPCR4). However, we do not expect this to have any significant impact on exposure given the discretionary nature of the expenditure.

DPCR5 compared with GDPCR: The IFI in place under the current GDPCR is the same as that proposed for DPCR5, and hence the risk exposures are also equivalent.

Exposure to guaranteed standards of performance

Ofgem sets several ex-ante performance standards that it expects regulated companies to meet over the price control. If network operators fail to meet these standards, they are required to provide cash compensation to customers in line with specified criteria set out in the regulatory framework. For example, under the general standards of performance (GSOP) DNOs are required to inform customers at least 2 days ahead of a planned interruption. Failing that they have to pay £22/£20 to domestic/non domestic customers.

DPCR5 compared with DPCR4: The main difference between the GSOP in DPCR4 and DPCR5 is that under the proposed new price control Ofgem intends to introduce a new performance standard which relates to the quality of service provided in relation to new connections. Specifically, this will entitle customers to compensation if they do not receive the appropriate standard of service in relation to several aspects such as connection quotes and energisation of new connections. If the proposed GSOP does not entail any caps or collar, DNOs would have 100% exposure to all claims being made under this mechanism. In this case, since the GSOP only entails downside risks and no upside, it could be argued that the proposed mechanism would increase the overall risk faced by DNOs.

DPCR5 compared with GDPCR: As in electricity, the GSOP under the GDPCR only poses downside risks. However, given the industry-specific nature of these mechanisms, we consider that it is not possible to compare the risk exposure under each in a meaningful way.

Exposure to the Interruption Incentive Scheme

The Interruptions Incentive Scheme (IIS), applicable within electricity only, is designed to encourage DNOs to improve their performance in relation to the number of interruptions in the supply (customer interruptions – CI) and the duration of these interruptions (customer minutes lost – CL). In particular, the incentive scheme consists of symmetric annual rewards and penalties, the realisation of which depends upon how each DNO performs against its ex-ante targets for each metric.

DPCR5 compared with DPCR4: In DPCR4, the proportion of revenue exposed under the scheme was 1.2% for CI and 1.8% for CL. The proposed exposures under DPCR5 are 0.8% for CI and 2.2% for CL. Although the DPCR5 exposures are slightly different compared to DPCR4, we do not consider that this would have a material impact on the overall risk.

Exposure to tax

The tax allowance that Ofgem builds into the allowed revenue is determined using the corporate tax rate in place at the time of the review and Ofgem’s forecast of companies’ profits.

DPCR5 compared with DPCR4: The DPCR4 regulatory framework did not include a mechanism that would adjust the allowed revenues for changes in the corporation tax rate after the price control has been set, implying that DNOs had 100% exposure to changes in the tax rate. However, for DPCR5, Ofgem has proposed at the time of writing to introduce a tax trigger that if breached would lead to a re-opener. The threshold levels currently under consideration are either a movement of 1 percentage point in the corporate tax rate or a change in the tax rate that has an impact on DNOs cash flows equivalent to, or higher than 0.5% of the allowed revenues. In comparison to DPCR4, the proposed framework limits DNOs exposure to movements in the tax rate.

DPCR5 compared with GDPCR: As the GDPCR is similar to DPCR4, DNOs have a lower exposure under the proposed mechanism compared to GDNs.

Exposure mitigants – protections and reopeners

Under the current regulatory framework, DNOs and GDNs can request a reopener to the price control if certain costs deviate significantly from the allowance (such as those they are exposed to under the 2004 Traffic Management Act) or for a broader range of reasons as a result of which they consider that under the existing regulatory settlement they would no longer be able to meet their statutory duties / obligations despite being efficient. The latter is referred to as the disapplication clause.

DPCR5 compared with DPCR4: The mitigant mechanisms in place are the same in DPCR4 and DPCR5. Hence the limit to risk exposure are also equivalent.

DPCR5 compared with GDPCR: For GDPCR, the mechanism in place is the same as that under DPCR4 and DPCR5. Hence the limit to risk exposure are also equivalent.

Overall Exposure

There have been a number of changes to the regulatory regimes, some of which have decreased the exposures of the companies and others that have increased the risk. The tables below summarise our results.

Table 40 – Difference in risk (DPCR 5 compared with GDPCR)

Business Risk Variable	Exposure to under-/over-performance		Relative exposure of DNOs vs. GDNs (Directional steer)
	DPCR 5	GDPCR	
Capital Expenditure (Networking Investment)	30-50%, although 25-55% under consideration	20-40%	↑
Fault Costs	30-50%	100%	↓
Operating Expenditure	30-50%	100%	↓
Non-controllable OPEX	0%	0%	↔
Indirect Costs – Other	30-50%	70-77%	↓
Indirect Costs - Business Support	100%	70-77%	↑
Pensions	Some risk sharing exposure - Ongoing consultation.	0% where efficiently incurred	↑
Losses and leakages incentives	TBC	10%	TBC
Transmission exit incentive	20%	N/A	N/A
Innovation Funding Incentive	20% up to the cap	20% up to the cap	↔
Guaranteed Standards of Performance	100%	100%	↔
Interruption incentive scheme	3%	N/A	N/A
Tax	<100%	100%	↓
Exposure mitigating mechanisms : *Disapplication clause and other specific costs-related reopeners*	0%	0%	↔

Source: Regulatory documents

Table 41 – Difference in risk (DPCR 5 compared with DPCR 4)

Business Risk Variable	Exposure to under/over performance		Relative exposure of DNOs under DPCR4 and DPCR5 (Directional steer)
	DPCR 5	DPCR 4	
Capital Expenditure (Networking Investment)	30-50%, although 25-55% under consideration	20-40%	↑
Fault Costs	30-50%	100%	↓
Controllable OPEX	30-50%	100%	↓
Non-controllable OPEX	0%	0%	↔
Indirect Costs – Other	30-50%	57.8-68.5%	↓
Indirect Costs - Business Support	100%	57.8-68.5%	↑
Pensions	Some risk sharing exposure - Ongoing consultation.	0% where efficiently incurred	↑
Losses and leakages incentives	TBC	100%	TBC
Transmission exit incentive	20%	0%	↑
Innovation Funding Incentive	20% up to the cap	10-30% up to the cap	↔
Guaranteed Standards of Performance	100%	100%	↔
Interruption incentive scheme	3%	3%	↔
Tax	<100%	100%	↓
Distributed Generation	20%	20%	↔
Exposure mitigating mechanisms : *Disapplication clause and other specific costs-related reopeners*	0%	0%	↔

Source: Regulatory documents

It is difficult using this high level approach to give a definitive quantitative assessment as to the relative risk exposure between different price controls, especially when considering cross-sector comparisons, and it would be necessary to perform a deeper, more numerical analysis in order to draw any firm conclusions.

This said, we believe the reduction in OPEX exposure in the proposed DPCR5 regime compared with DPCR4 is an important and significant one, and that it might be considered that this alone results in an overall reduction in risk exposure relative to DPCR4 and GDPCR. While the proposals include a modest increase in CAPEX exposure this is not a change of a similar magnitude to that associated with including OPEX in the IQI mechanism where it had previously not been included under the Sliding Scale. The DPCR5 regime also marks a reduction in indirect cost exposure (with the exception of a small portion treated as business support) compared with both GDPCR and DPCR4, lending further weight to the suggestion that overall exposure has decreased.

Of those cost variables which we consider to be significant in magnitude and likely to have a material influence on overall risk exposure, the only other one which may see a sizeable change in risk exposure is pension costs, exposure to which is likely to rise given the current intention to share savings and over-runs of ongoing liabilities with customers. This may be sufficient to further offset the reduction in OPEX exposure, though it is our view that the DPCR5 proposals represent an overall reduction in the level of risk exposure faced by DNOs when compared to previous regimes.

7.1.6 Conclusions on relative risk

The analysis we have performed on relative risk analysis has been high level, intended to provide a broad cross-check of our conclusions on WACC, and to provide guidance on the relationship between risk and allowed return which Ofgem could use in future work. Our results are therefore directional rather than absolute, and intended to help inform decisions and future work.

Based on the conceptual framework discussed above and our analysis, we conclude for an averagely efficient company the following:

- The WACC approach to setting allowed returns is the appropriate one. However, WACC is the minimum theoretically acceptable return, and can appear low in commercial appraisal terms.

- Allowing a WACC return is only appropriate where the probability-weighted downside risks are offset by probability-weighted upside opportunities – the cash flows used in regulatory price cap modelling should be true expected cash flows. WACC would therefore be inadequate as a return if added on to a cost base which was set on an aspirational basis or based on positive outcomes for particular cost uncertainties.

- Empirical analysis has found that WACC rises for companies nearing financial distress. Hence, even if the cash flow downsides and upsides are symmetric on a probabilistic basis, there may be an argument for allowing a higher return or factoring in extra downside costs to reflect the asymmetric impact of extreme downsides compared with upsides.

- The RPI-X plus WACC approach was originally designed to be applied to companies with extremely certain cash flows. For such companies a WACC margin would provide a sufficient cash buffer for efficiently managed companies to be unlikely to be exposed to extreme downside problems. If this has not changed then this undermines any argument for a return above WACC.

- Within the WACC methodology, investors are not exposed to specific risks so there is no return for exposure to such risks. This implies that any “de-risking” of regulated businesses (e.g. by allowing a greater degree of pass-through of costs) which reduces exposure to specific risks will have no effect on WACC and hence allowed return.

- De-risking of systematic cost risks in theory could actually increase WACC. Costs which exhibit systematic risk increase (decrease) when the economy expands (contracts), which is when revenues increase (decrease). Hence, allowing pass-through of such costs in prices will result in an amplification of cyclical swings in net revenue, which should in principle increase WACC. Businesses with high systematic risk exposure have net revenue or cash flows that trend up and down relatively excessively over the economic cycle. Costs which exhibit systematic risk dampen overall systematic risk: by moving up when the economy expands they dampen the upwards movement in net revenue or cash. Effectively they contribute to a reduction in operational gearing. If DNOs were to be allowed to pass through such costs, this would restore the gap between revenue and cost to what it would have been were the costs not systematically risky, thus eliminating this dampening effect and increases overall systematic risk exposure and beta.

- Given the preceding points, there is no advantage from a WACC point of view in de-risking. This does not mean that de-risking is not worthwhile. Some specific risks are highly asymmetrical (e.g. the risk that the tax rate will increase). In principle this should be dealt with by including probability-weighted cash flows, which in the tax example should include the possibility of a tax increase in the future. Were this not to materialise, consumers would have paid higher prices to cover a risk which the DNOs could not be incentivised to control. There is merit in allowing pass-through to avoid building in higher costs which may or may not materialise.

- In addition, if there are asymmetric impacts of downsides compared to upsides then reducing exposure to these through de-risking would also allow overall prices to be lower until and if such downsides were to materialise.

- Based on a high level comparison of the WACCs for DPCR4 and the last GDPCR with the range we propose for DPCR5, we believe that there is little difference in the underlying WACCs and that this is appropriate. If anything, the evidence suggests that the GDN WACC may be slightly higher than that for DNOs.

- Based on an assessment of historic volatility of cash flows, we have found no statistically significant difference in volatility between DNOs and GDNs. However, there are major limitations to this analysis, and the evidence suggests that the DNOs may face more cash flow volatility than the GDNs.

- We have compared the extent to which the regulatory regimes reduce the exposure of GDNs and DNOs to particular risks, for example by allowing cost pass-through. We found that the proposals for DPCR5 appear to reduce risk exposure for DNOs, both compared to DPCR4 and compared with the arrangements in the last GDPCR.

- This may be sensible given the evidence of somewhat higher cash flow volatility for DNOs compared with GDNs, and given the increased uncertainty associated with current market conditions. However, this is subject to the theoretical considerations above.

- Considering all of the evidence, it is difficult to make a definitive assessment of the relative riskiness of the different regimes. We believe that the latest DPCR5 regulatory framework proposals create a less risky environment than gas distribution and than electricity distribution under DPCR4, but it is difficult to assess whether this difference is material.

Based on this we recommend the following:

- Ofgem should undertake cash flow analysis to ensure that price determinations are based on true expected cash flows. We understand that Ofgem has undertaken some Monte Carlo simulation analysis, however, we have not been privy to the extent of this work.

- The same analysis could identify upward movements in expected costs associated with particular risk factors and consider to what extent it would be appropriate to deal with these through pass-through de-risking arrangements rather than through a higher price cap per se.

- De-risking reduces any incentive for DNOs to manage such risks, and does not reduce WACC. However, it avoids the need for prices to be higher to reflect a risk that may not materialise and may not be controllable by the DNO.

- The Monte Carlo simulation analysis could also identify the probability of extreme downside scenarios which could result in financial distress for DNOs and dislocation for customers. Ofgem should consider whether an uplift in allowed revenues would be justified to reflect such risks and reduce the likelihood of distress.

Appendix I – Regulatory precedents

Table 42: Details of regulatory precedents

Regulator	Review	Date
Office of Rail Regulation	Periodic review of Railtrack's access charges: final conclusions	October 2000
Competition Commission	BAA plc: A report on the economic regulation of the London airports companies (BAA Q4)	November 2002
Civil Aviation Authority	Economic Regulation of BAA London Airports Q4 (Heathrow & Gatwick Q4)	February 2003
Competition Commission	Mobile Phone Charges Inquiry	February 2003
Office of Gas and Electricity Markets	Electricity Distribution Price Control Review 4	November 2004
Office of Water Services	Future water and sewerage charges 2005-10	December 2004
Office of Communications	Ofcom's approach to risk in the assessment of the cost of capital (BT copper access network)	August 2005
Civil Aviation Authority	NATS Price Control Review 2006-2010 (CP2)	December 2005
Postal Services Commission	Royal Mail Price and Service Quality Review	December 2005
Office of Gas and Electricity Markets	Transmission Price Control Review, 2007-2012	December 2006
Office of Communications	Mobile Call Termination Statement	March 2007
Office of Gas and Electricity Markets	Gas Distribution Price Control Review 2007-13	December 2007
Civil Aviation Authority	Economic Regulation of Heathrow and Gatwick Airports (Heathrow / Gatwick)	March 2008
Competition Commission	Stansted Price Control Review (2009-14)	November 2008
Civil Aviation Authority	Stansted Price Control Review (2009-14)	March 2009

Appendix II – Calculating equity and asset betas

Summary

In choosing a beta de-levering/re-levering formula to use in estimating the WACC an assumption must be made about the degree of certainty around future debt tax shields. Treating companies' future debt tax shields as certain is generally not a realistic assumption to make. A more reasonable assumption is that future debt tax shields are uncertain, consistent with companies having active debt management policies (although the first year's debt tax shields might, perhaps, be considered as certain).

This assumption points to the Harris and Pringle beta de-levering/re-levering formula, being the appropriate formula to use in all beta de-levering/re-levering calculations. The formula is as follows:

$$\beta_e = \frac{\beta_a}{(1 - G)} \tag{1}$$

where:

β_e is the company's equity beta;

β_a is the company's asset beta; and

G is the level of gearing

It is noted that formulae above assumes a debt beta (β_d) of zero. Moreover, the same formula is used for de-levering the comparable company betas as is used for re-levering the target company beta, and that the comparable companies have similar gearing and tax rates as the target company, the target company equity beta estimate should not be particularly sensitive to the choice of beta de-levering/re-levering formula.

Background

The beta input required for the CAPM is an equity beta (β_e). Equity betas reflect the "riskiness" of shareholder returns that arises as a result of fixed debt servicing commitments (i.e. the effects of financial leverage or gearing) as well as the underlying riskiness of the firm's assets. The latter is measured as an asset beta (β_a). Only equity betas are "observed" in the market place, through statistical analysis of share price behaviour for companies whose shares are actively traded. Since financial leverage varies between companies the preferred, and indeed conventional, approach to estimating the equity beta based on comparators is as follows:

- Obtain equity beta estimates for a sample of listed companies that are considered comparable to the company being considered;
- Obtain financial leverage details for the comparator companies;
- "De-lever" the comparators' equity betas to arrive at their asset beta estimates (formulae for doing this are discussed below). This step removes the influence on beta arising from variations in comparators' financial leverage;
- Having regard to the comparators' asset betas, make an assessment of the asset beta appropriate for the "target" company being considered; and
- "Re-lever" the assessed asset beta for the level of gearing being assumed for the target company, to arrive at an assessed equity beta for that company (the formula used is generally the reverse of that applied in the "de-levering" process).

Formulae for De-levering/Re-levering Betas

Fundamentally the asset beta of a company is a weighted average of that company's equity beta and its debt beta. Estimation of debt betas is problematic, so current practice among most practitioners and many academics is to assume that companies' debt betas have a value of zero. This simplifies the relationship between the equity beta and the asset beta, but three issues still need to be considered in determining the appropriate formula to use. These issues are:

- The company's effective corporate tax rate (T_C);
- The effect of investors' taxes on the value (if any) of the tax shield arising from the use of debt; and
- The effect of the company's debt management policy on the value of the debt tax shield.

The Hamada Formula

Under a classical tax system (i.e. one where dividends are paid from company earnings after corporate tax, and are then subject to personal taxes at the investor level) and where the company adopts a passive debt management policy (i.e. the future debt servicing schedule is assumed to be known with certainty at the valuation date), then the appropriate formula for relating equity and asset betas is:

$$\beta_e = \beta_a \left[1 + (1 - T_C) \frac{D}{E} \right] \qquad (2)$$

where:

D is the market value of the company's debt; and

E is the market value of the company's equity.

The above formula is known as the "Hamada" formula[48] and is widely used by practitioners and academics. However, the assumption that the company's future debt servicing schedule is known with certainty is questionable. For example, in the face of changes to its enterprise value a company is likely to adjust its level of debt in order to maintain a target leverage ratio.

The Harris and Pringle Formula

Where all of the company's future debt tax shields, including those arising in the first period, are treated as uncertain or risky then analysis by Harris and Pringle (1985) provides the following relationship between the equity beta and asset beta:

$$\beta_e = \frac{\beta_a}{(1 - G)} \qquad (3)$$

The above formula is known as the "Harris and Pringle" formula and is derived from different assumptions to the Hamada formula. If the company is expected to maintain a target leverage ratio through time (i.e. it has an active debt management policy), but with total firm value evolving with uncertainty, then it follows that the future debt servicing schedule is uncertain. Typically this assumption is more realistic than the alternative of assuming that the future debt servicing schedule is known with certainty. This means that in most circumstances the Harris and Pringle formula will be more appropriate than the Hamada formula.

The Miles and Ezzell Formula

Miles and Ezzell (1985) derive a beta de-levering/re-levering formula that assumes that the tax shield on debt is certain for the first period (i.e. the first year), but thereafter is uncertain. These assumptions fall between those of Hamada and of Harris and Pringle so, as to be expected, the resulting formula falls between formulae (2) and (3) above. The Miles and Ezzell formula is:

$$\beta_e = \beta_a \left[1 + \left(1 - \frac{r_f T_C}{1 + r_f} \right) \frac{D}{E} \right] \qquad (4)$$

where:

r_f is the risk-free rate of return.

The formulae that we have used for levering and de-levering betas is:

$$\beta_e = \frac{(\beta_a - \beta_d * G)}{(1 - G)}$$

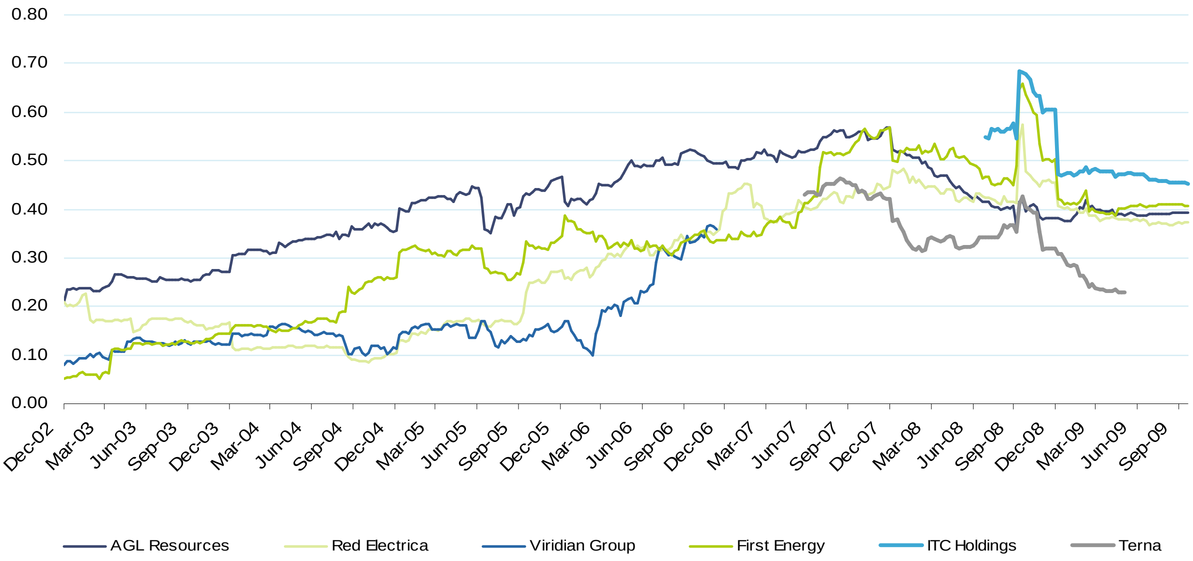
This above formulae is a generalized version of Harris and Pringle Formulae that explicitly takes into account a debt beta in levering and de-levering calculations.

Appendix III – Asset beta analysis

For reference, in this appendix, we set out figures showing the evolution of 2 year daily and 3 year weekly unadjusted asset betas of our international comparators. We did not include these charts in Section 3.4 (where we presented the evolution of monthly betas) as we consider them to be less relevant for our analysis (for reasons we have discussed in Section 3.4).

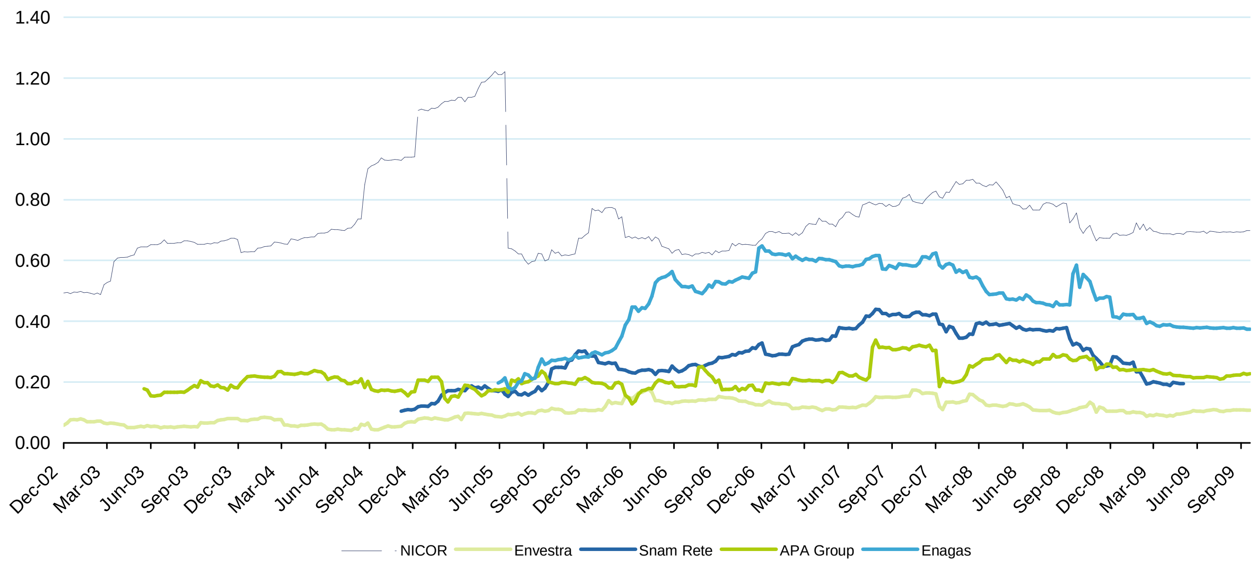
Weekly betas

Figure 30: International electricity comparators, evolution of 3 year unadjusted weekly asset beta



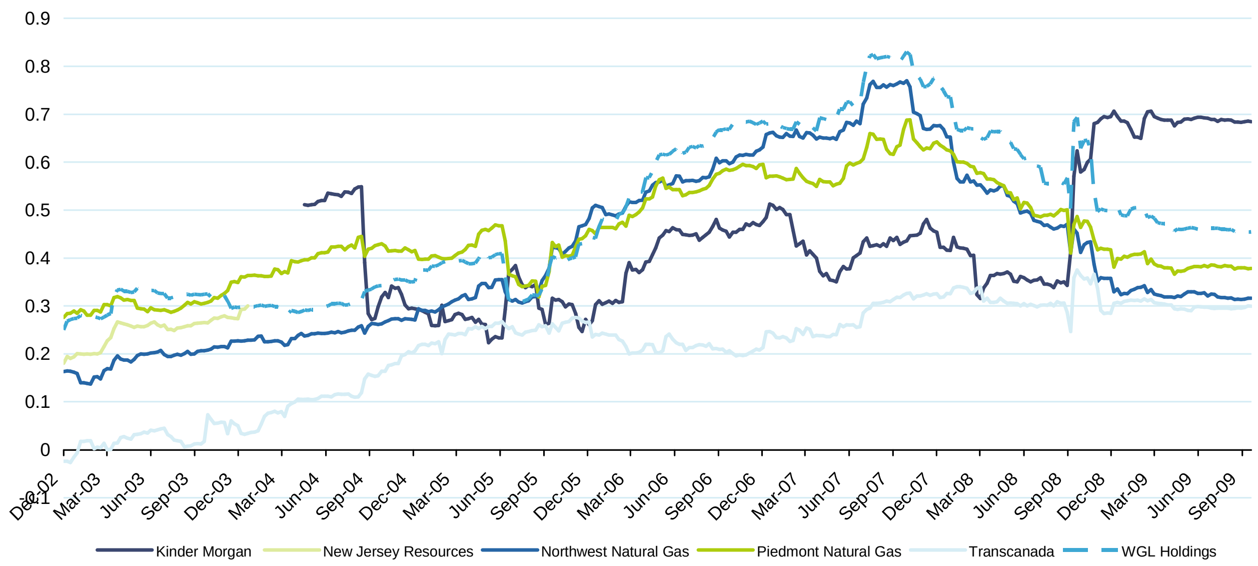
Source: Datastream and PwC analysis.

Figure 31: International gas distribution and transmission comparators, evolution of 3 year unadjusted weekly asset beta



Source: Datastream and PwC analysis.

Figure 32: International gas networks, evolution of 3 year unadjusted weekly asset beta



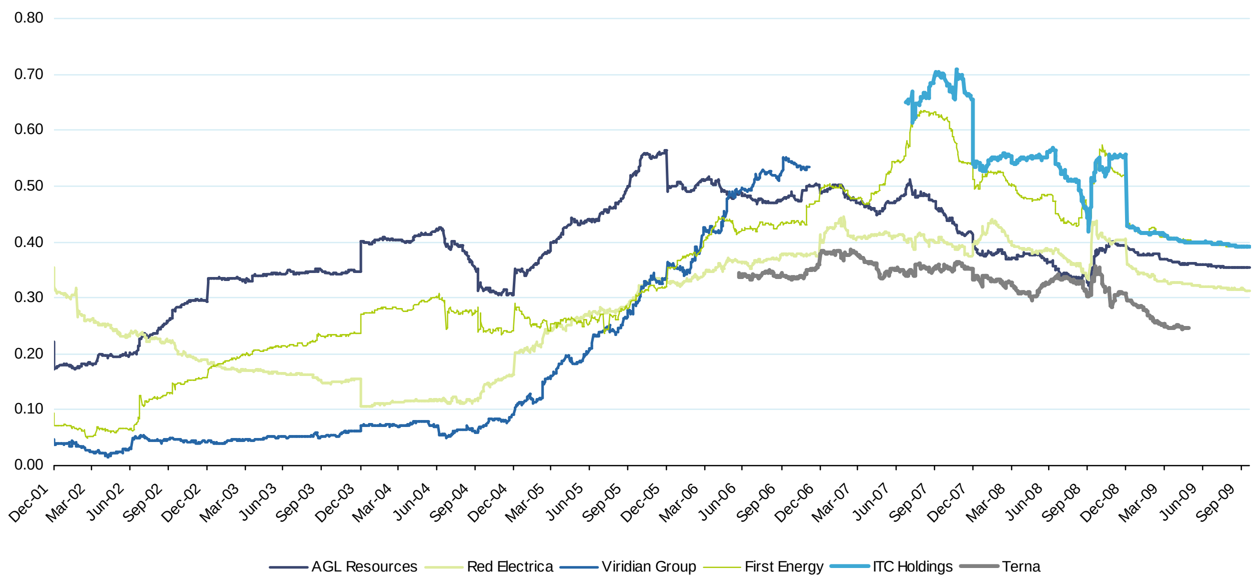
Source: Datastream and PwC analysis.

Figure 33: International all networks, evolution of 3 year unadjusted weekly asset beta

Source: Datastream and PwC analysis.

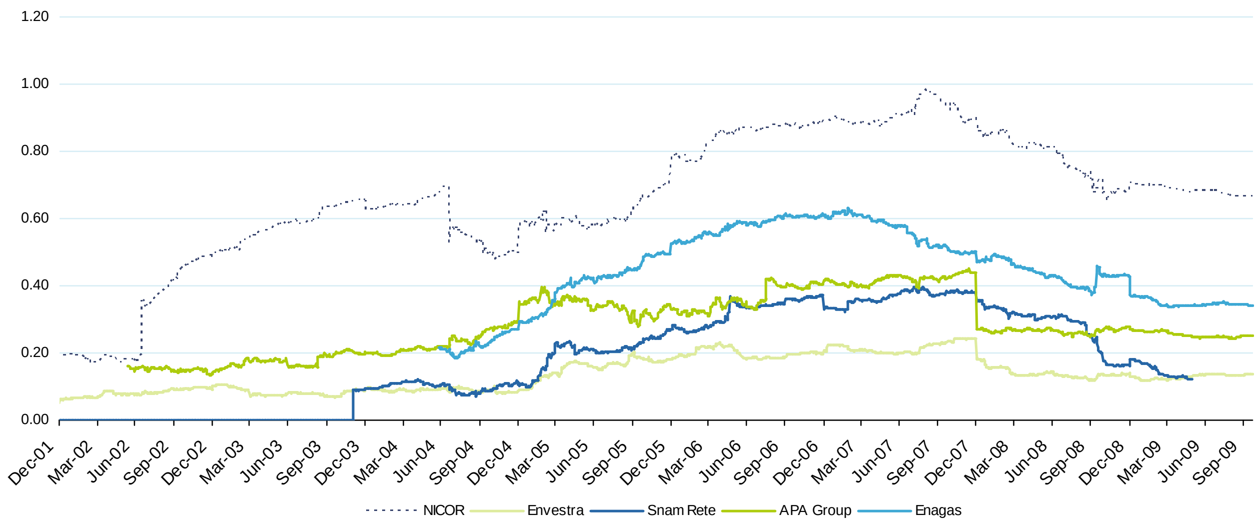
Daily betas

Figure 34: International electricity comparators, evolution of 2 year unadjusted daily asset beta



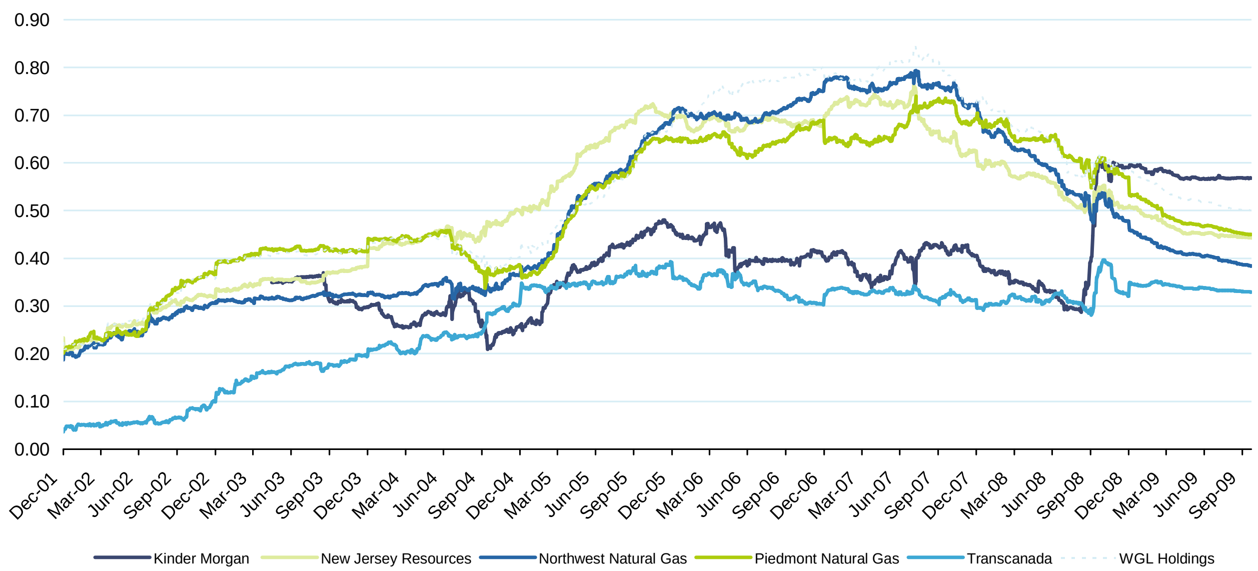
Source: Datastream and PwC analysis.

Figure 35: International gas distribution and transmission comparators, evolution of 2 year unadjusted daily asset beta



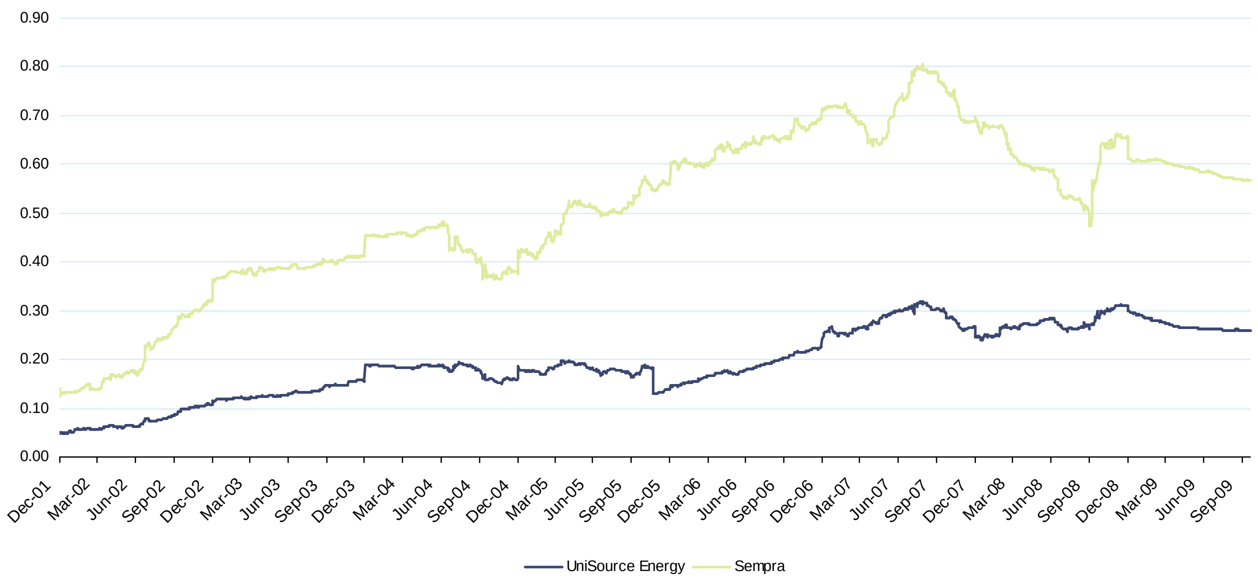
Source: Datastream and PwC analysis.

Figure 36: International gas networks, evolution of 2 year unadjusted daily asset beta



Source: Datastream and PwC analysis.

Figure 37: International all networks, evolution of 2 year unadjusted daily asset beta



Source: Datastream and PwC analysis.

Appendix IV – Notes on the relative risk analysis

F-Test methodology

To conduct the two-tailed F-test, we required several input factors as follows:

- The two figures for testing, which are the average standard deviations in Gas and Electricity distribution for each metric, σ_g and σ_e.
- The Test Statistic is the variance (σ^2) of the higher of either σ_g or σ_e, taken as a fraction of the variance of the lower. We do this to ensure that the test statistic is greater than 1
- The sample sizes for our dataset. In Gas, we have 5 operators, in Electricity 14. Hence n_g=5, n_e=14
- The F Value takes our confidence level, p, and our sample sizes as its inputs and is calculated =FINV(p%, (MAX(n_g, n_e)-1), MIN((n_g, n_e)-1)

If, under the conditions of our test, the test statistic derived from our variables exceeds the F value determined for our sample sizes, we can conclude that there is a difference significant at the confidence level set.

Incentive Mechanism Matrices

We have reproduced the matrices for the GDPCR and DPCR5 'IQI' mechanisms, and for the Sliding Scale used under DPCR4, below.

Figure 38: Proposed DPCR5 IQI Matrices

DNO:Ofgem ratio	100	105	110	115	120	125	130	135	140
Incentive rate	50.0%	47.5%	45.0%	42.5%	40.0%	37.5%	35.0%	32.5%	30.0%
Allowed expenditure	100.00	101.25	102.50	103.75	105.00	106.25	107.50	108.75	110.00
Additional income	2.50	1.84	1.13	0.34	-0.50	-1.41	-2.38	-3.41	-4.50
90	7.50	7.19	6.75	6.19	5.50	4.69	3.75	2.69	1.50
95	5.00	4.81	4.50	4.06	3.50	2.81	2.00	1.06	0.00
100	2.50	2.44	2.25	1.94	1.50	0.94	0.25	-0.56	-1.50
105	0.00	0.06	0.00	-0.19	-0.50	-0.94	-1.50	-2.19	-3.00
110	-2.50	-2.31	-2.25	-2.31	-2.50	-2.81	-3.25	-3.81	-4.50
115	-5.00	-4.69	-4.50	-4.44	-4.50	-4.69	-5.00	-5.44	-6.00
120	-7.50	-7.06	-6.75	-6.56	-6.50	-6.56	-6.75	-7.06	-7.50
125	-10.00	-9.44	-9.00	-8.69	-8.50	-8.44	-8.50	-8.69	-9.00
130	-12.50	-11.81	-11.25	-10.81	-10.50	-10.31	-10.25	-10.31	-10.50
135	-15.00	-14.19	-13.50	-12.94	-12.50	-12.19	-12.00	-11.94	-12.00
140	-17.50	-16.56	-15.75	-15.06	-14.50	-14.06	-13.75	-13.56	-13.50
145	-20.00	-18.94	-18.00	-17.19	-16.50	-15.94	-15.50	-15.19	-15.00

DNO:Ofgem ratio	100	105	110	115	120	125	130	135	140
Incentive rate	55.0%	51.2%	47.5%	43.7%	40.0%	36.2%	32.5%	28.7%	25.0%
Allowed expenditure	100.00	101.25	102.50	103.75	105.00	106.25	107.50	108.75	110.00
Additional income	2.50	1.77	0.94	0.02	-1.00	-2.11	-3.31	-4.61	-6.00
90	8.00	7.53	6.88	6.03	5.00	3.78	2.38	0.78	-1.00
95	5.25	4.97	4.50	3.84	3.00	1.97	0.75	-0.66	-2.25
100	2.50	2.41	2.13	1.66	1.00	0.16	-0.87	-2.09	-3.50
105	-0.25	-0.16	-0.25	-0.53	-1.00	-1.66	-2.50	-3.53	-4.75
110	-3.00	-2.72	-2.62	-2.72	-3.00	-3.47	-4.12	-4.97	-6.00
115	-5.75	-5.28	-5.00	-4.91	-5.00	-5.28	-5.75	-6.41	-7.25
120	-8.50	-7.84	-7.37	-7.09	-7.00	-7.09	-7.37	-7.84	-8.50
125	-11.25	-10.41	-9.75	-9.28	-9.00	-8.91	-9.00	-9.28	-9.75
130	-14.00	-12.97	-12.12	-11.47	-11.00	-10.72	-10.62	-10.72	-11.00
135	-16.75	-15.53	-14.50	-13.66	-13.00	-12.53	-12.25	-12.16	-12.25
140	-19.50	-18.09	-16.87	-15.84	-15.00	-14.34	-13.87	-13.59	-13.50
145	-22.25	-20.66	-19.25	-18.03	-17.00	-16.16	-15.50	-15.03	-14.75

Figure 39: GDPCR IQI Matrix

GDN:Ofgem ratio	100	105	110	115	120	125	130	135	140
Efficiency incentive	40.0%	37.5%	35.0%	32.5%	30.0%	27.5%	25.0%	22.5%	20.0%
Additional income	2.50	1.97	1.38	0.72	0.00	-0.78	-1.63	-2.53	-3.50
Allowed expenditure	100	101.25	102.5	103.75	105	106.25	107.5	108.75	110
Actual expenditure									
70	14.50	13.69	12.75	11.69	10.50	9.19	7.75	6.19	4.50
80	10.50	9.94	9.25	8.44	7.50	6.44	5.25	3.94	2.50
90	6.50	6.19	5.75	5.19	4.50	3.69	2.75	1.69	0.50
100	2.50	2.44	2.25	1.94	1.50	0.94	0.25	-0.56	-1.50
105	0.50	0.56	0.50	0.31	0.00	-0.44	-1.00	-1.69	-2.50
110	-1.50	-1.31	-1.25	-1.31	-1.50	-1.81	-2.25	-2.81	-3.50
115	-3.50	-3.19	-3.00	-2.94	-3.00	-3.19	-3.50	-3.94	-4.50
120	-5.50	-5.06	-4.75	-4.56	-4.50	-4.56	-4.75	-5.06	-5.50
125	-7.50	-6.94	-6.50	-6.19	-6.00	-5.94	-6.00	-6.19	-6.50
130	-9.50	-8.81	-8.25	-7.81	-7.50	-7.31	-7.25	-7.31	-7.50
135	-11.50	-10.69	-10.00	-9.44	-9.00	-8.69	-8.50	-8.44	-8.50
140	-13.50	-12.56	-11.75	-11.06	-10.50	-10.06	-9.75	-9.56	-9.50

Figure 40: DPCR4 Sliding Scale

DNO:PB Power Ratio	100	105	110	115	120	125	130	135	140
Efficiency Incentive	40%	38%	35%	33%	30%	28%	25%	23%	20%
Additional income	2.5	2.1	1.6	1.1	0.6	-0.1	-0.8	-1.6	-2.4
as pre-tax rate of return	0.200%	0.168%	0.130%	0.090%	0.046%	-0.004%	-0.062%	-0.124%	-0.192%
Rewards & Penalties									
Allowed expenditure	105	106.25	107.5	108.75	110	111.25	112.5	113.75	115
Actual Exp									
70	16.5	15.7	14.8	13.7	12.6	11.3	9.9	8.3	6.6
80	12.5	11.9	11.3	10.5	9.6	8.5	7.4	6.0	4.6
90	8.5	8.2	7.8	7.2	6.6	5.8	4.9	3.8	2.6
100	4.5	4.4	4.3	4.0	3.6	3.0	2.4	1.5	0.6
105	2.5	2.6	2.5	2.3	2.1	1.7	1.1	0.4	-0.4
110	0.5	0.7	0.8	0.7	0.6	0.3	-0.1	-0.7	-1.4
115	-1.5	-1.2	-1.0	-0.9	-0.9	-1.1	-1.4	-1.8	-2.4
120	-3.5	-3.1	-2.7	-2.5	-2.4	-2.5	-2.6	-3.0	-3.4
125	-5.5	-4.9	-4.5	-4.2	-3.9	-3.8	-3.9	-4.1	-4.4
130	-7.5	-6.8	-6.2	-5.8	-5.4	-5.2	-5.1	-5.2	-5.4
135	-9.5	-8.7	-8.0	-7.4	-6.9	-6.6	-6.4	-6.3	-6.4
140	-11.5	-10.6	-9.7	-9.0	-8.4	-8.0	-7.6	-7.5	-7.4

Appendix V – Current market conditions

Introduction

During the course of our work we were aware of submissions by the DNOs or their advisers (the Submissions) that suggested that the cost of capital should be significantly higher for DPCR5 than it had been in DPCR4.

The Submissions suggested that the recent unusual market conditions – the high cost and limited availability of credit, the dramatic fall in share prices, and the recession – indicated that the cost of capital had risen.

As the main body of our report indicates, we believe that if a longer-term approach to the cost of capital is taken, the evidence suggests that it has not changed significantly since DPCR4, although the range of uncertainty is wider than normal and there may be a case for raising prices to cover illiquidity and transactions costs.

In arriving at this conclusion we considered the evidence on recent capital market trends, for example in our discussion of the overall approach to the cost of equity (Sections 3.1 and 3.2), in reviewing the level of the EMRP (Section 3.5) and in our discussion of the debt premium (Section 4.1).

However, in order to set out clearly how we came to our conclusion regarding our approach to the cost of capital in the current market circumstances, in this Appendix we set out the key challenges posed by the DNOs and their advisers, and set out our response.

DNO submissions

The key points made by the DNOs and their advisers were as follows:

- Point 1 – It is clear from evidence from the Dividend Growth Model (DGM) and Implied Volatilities (IVs) that the cost of equity has increased significantly with the credit crunch and recession.
- Point 2 – It is clear from observed yields that the cost of debt has increased, so the cost of equity must also have increased.
- Point 3 – There is evidence that the recession will persist, so the increased cost of capital will also persist, and this needs to be taken into account by Ofgem.
- Point 4 – Whilst this suggests a departure from Ofgem’s past approach of calculating the cost of capital on a long-term basis, this is justified because market and economic conditions are so unusual – this is the first significant recession experienced since RPI-X regulation was established in the UK.

Taken together, Points 1 and 2 suggest that the current cost of capital is higher than it was in DPCR4, and indeed higher than the long-run value.

Point 3 suggests that this elevated level will persist and therefore will be relevant for at least some part of the next price control period – i.e. it is not a temporary phenomenon of no relevance to Ofgem's price setting decision. One submission we saw suggested that Ofgem should set an overall WACC for DPCR5 that is a weighted average of the current higher WACC and the lower long-term WACC, with the weight for the higher WACC being the proportion of DPCR5 that would be likely to be subject to the current higher WACC conditions. This proportion, it was argued, would depend on the length of the recession.

With regard to Point 4, we agree that the current recession is more severe than any experienced since the first wave of privatisations in the UK in the 1980s, and has specific characteristics (the financial services crisis, the credit crunch) which make it important to conduct a full consideration of its possible effects on the cost of capital. Ofgem should consider whether these special circumstances justify any departure from its previous approach to setting the cost of capital.

Assessment

Starting first with Point 1, we discussed the use of DGM and IVs evidence on the cost of equity in the main body of the report. On IVs we concluded that due to data limitations IVs are unreliable as a medium- to long-term source of evidence on the cost of equity.

Use of the DGM does indeed suggest that at least some of the recent falls in share prices may be associated with a higher cost of equity, and in particular a higher equity market risk premium (EMRP). However, use of the DGM results in estimates of the EMRP that are inevitably volatile. Share prices can and do move dramatically and rapidly in either direction. Under the DGM framework such price movements are taken to imply that there have been dramatic and rapid revisions in dividend expectations and/or dramatic and rapid revisions in the cost of equity.

Where the market index is being considered, average dividend growth expectations should reflect only systematic factors. One would not expect these to change dramatically and rapidly – they will reflect changes in the macroeconomic outlook which generally evolves gradually with the release of new data or commentary. So the DGM relies heavily on changes in the cost of equity to explain dramatic and rapid stock market index movements. An underlying implication of the DGM, therefore, is that the EMRP is a volatile figure, which is indeed what we conclude if we use the DGM to calculate it.

The first issue that arises is whether in principle the EMRP and the cost of equity can be expected to fluctuate as rapidly and significantly as the DGM suggests. It certainly seems possible in principle that the average returns required by equity investors could move up and down in response to short-term events affecting perceptions of, and attitudes to, equity risk.

However, we note that the generally accepted approach to calculating the EMRP of using very long-run historic trends in actual equity returns implies that, over the long-run at least, the EMRP can be expected to be a stable figure. The highly respected Dimson, Marsh and Staunton (DMS) dataset, for example, uses 109 years of historic data to infer the forward-looking EMRP today. This approach inherently assumes that the EMRP (as a required or expected return) is a long-run concept – what happened in 1900 is a guide to the returns equity investors expect in 2010 and beyond.

As the Submissions we saw use both the DMS and DGM approaches we infer that they accept the long-term stability of the EMRP (DMS approach), but also attach importance to short-term fluctuations (DGM approach). This is also consistent with advocating that Ofgem use a weighted short-term/long-term WACC.

We cannot rule out in principle the possibility that the long-term EMRP is stable, but that it fluctuates around this level in the short-term. However, we do not believe that the EMRP is as volatile even in the short-term as the DGM would suggest.

First, the DGM bases its inferences on share price movements. This is likely to be unreliable as a source of information on changes in the EMRP. Some of the more extreme fluctuations in share prices are probably associated not with changes in either the cost of equity or dividend growth forecasts at all, but other non-fundamental factors such as market sentiment and speculation.

Second, even if observed share price movements were reflective of fundamental changes in required equity returns, basing a cost of equity estimate on short-term movements in share prices is problematic in the context of Ofgem's need to set a cost of equity for a 5 year period. Share prices can change quickly, implying a change in the cost of equity. Ofgem could set a high cost of equity for DPCR5, only for share prices to recover and the EMRP implied by the DGM to fall, even before the start of DPCR5. When using historic equity returns data to infer the long-run EMRP, DMS warn that many decades of data are needed to eliminate distortions caused by significant periods of over- or under-performance in actual returns. Using share prices to estimate the EMRP in the short-term creates a high level of uncertainty.

Third, Ofgem has not changed the cost of equity to reflect short-term conditions in the past. Arguably there have been occasions when Ofgem's cost of equity was much higher than that implied by applying the DGM to share prices.

We therefore cannot rule out in principle the approach implicit in the Submissions of a long-run cost of equity that fluctuates in the short-term, but we have concerns about the extent of such fluctuations, the reliability of short-term share price information as the basis for evaluating these fluctuations, and the practicality and consistency of Ofgem adopting this approach in preference to its past practice of calculating the cost of equity on a long-term basis.

Furthermore, there are two related paradoxes apparent in the Submissions:

- Paradox 1 – Whilst required equity returns are up (Points 1 and 2 of the Submissions), available equity returns are low because of the recession (Point 3).

- Paradox 2 – Whilst we are in a period when the EMRP is currently high compared to its long-term average (Points 1 and 2), because we are in a recession (Point 3), when in future years we will use the DMS database to infer the long-term EMRP, this period will likely be one of poor returns which will provide evidence of a lower, not a higher, EMRP.

Paradox 1 has implications for how Ofgem might wish to react. If the Submissions are right, then currently equity investors expect low returns (Point 3) but have high requirements (Points 1 and 2). These can only be reconciled by a sharp fall in share prices, to bring the price of equity in the secondary market down to a level which will allow the higher required cost of equity to be achieved despite the recession's impact on forecast dividend growth. This is what the DGM posits.

However, we note in passing that generally periods of recession have overall been associated with low equity returns, not high ones (hence Paradox 2). Setting this aside, if the Submissions are right and the EMRP is a volatile figure, the reductions in share prices that have occurred will allow equity investors to have an expectation of achieving the increased returns they desire in the future despite the recession (if this was not the case there would be reduced demand for equities and share prices would fall further until it was the case).

However, the higher returns available after the fall in share prices will not compensate equity investors for the share price falls themselves. Over the course of a recession we would expect most companies to generate less profits than normal, implying low returns to equity investors over the whole recession. Whatever the expectations or requirements for returns (the EMRP and cost of equity), a recession is a period of under-performance of actual returns. It is precisely because actual returns can under- or over-perform that there is an additional return for bearing the risk associated with equities (the EMRP).

Furthermore, Ofgem is setting a cost of equity to be applied to a RAV, not a stock market valuation. The RAV is maintained by Ofgem at a stable level compared with share prices. To allow a higher return on the RAV would be to allow equity investors in DNOs to earn returns not generally available in the market. An alternative would be to allow a return on equity (utility share prices have fallen, although by less than other shares). But this would be a significant change in the structure of regulation, and the RAV was introduced to avoid the complicated circularity issues implied by setting a return on share prices.

It is not at all clear, therefore, how Ofgem should set prices if the Submissions are right and the cost of equity fluctuates in the short-term.

Furthermore, by maintaining a long-term EMRP and cost of equity approach, in conjunction with a stable RAV and forecasts that take into account sales volume movements, Ofgem arguably offers relatively stable revenue to DNOs. This in itself reduces risk, and thus tends to weaken any link with any volatile short-run EMRP.

Finally, with regard to Point 2, it is clearly the case that in any given WACC calculation the cost of debt must be lower than the cost of equity. But this does not imply that if the spread on debt increases this must necessarily imply an increase in the associated cost of equity:

1. If the gap between the cost of equity and the cost of debt prior to the increase was greater than the increase in the debt spread then the apparently higher cost of debt would not be a constraining factor on the cost of equity.

2. There is just as much logic in arguing that if the cost of equity is calculated as being below the (now apparently higher) cost of debt then the latter should be reduced, as there is in arguing that the cost of equity should be increased. It is not clear why the cost of debt, and not the cost of equity, should be the constraining figure when the two figures appear to be incompatible.

With regard to (2), we suspect that the reason the cost of debt is treated by the Submissions as the constraining figure is that it is felt that this can be observed directly empirically whereas the cost of equity is estimated from economic models such as the CAPM. Therefore, following this logic, priority should be given to the “empirical” figure (the cost of debt) above the “modelled” figure (the cost of equity).

If this is the reason, this is a false premise. What we observe empirically is not the cost of debt, which should be an expected return to debt investors, but a promised payment which might or might not be made in full. Where debt margins increase this is a sign of increased default risk and/or increased disutility associated with being exposed to default risk. If there has been any increase in the chance of default then, at least in part, an increase in the promised yield does not feed through directly into an increase in the expected returns on debt.

The most extreme examples of this effect occur when considering the cost of capital for companies near to financial distress. In these cases the observed, promised return on debt is far removed from the actual, expected cost of debt. Raising the cost of equity because of the observed high spread on debt in such cases would result in an inappropriately high cost of capital[49].

With regard to Points 3 and 4 we accept that the current market conditions are unusual and warrant particular consideration by Ofgem. However, poor market and economic conditions do not necessarily point unequivocally to a higher cost of capital. For example, it is not clear that recessionary conditions per se imply a higher cost of equity. The cost of equity is related to volatility rather than the absolute rate of growth. In addition, given the recession there are some aspects of market conditions that might suggest the cost of capital is actually lower:

- As discussed above, actual returns are likely to be lower in a recession. Using the historic returns approach this would be indicative of a lower EMRP.

- In principle the risk-free rate (RFR) may be lower. The RFR represents the extra return investors require for postponing consumption for a year. In part this is based on expectations of economic growth – if I expect to be wealthier in a year’s time, I need an extra return for foregoing consumption now as I am shifting consumption from a time when I am relatively poor to a time when I am relatively wealthy. If growth expectations fall due to a recession this tendency is reduced and the RFR might be expected to be reduced.

The Bank of England Base Rate is at an all-time low of 0.5%, dragging down other interest rates including Libor. For those with money to invest the returns available in the market are generally low, and this might be argued to constrain the returns demanded on equities.

Research published by McKinsey & Company in December 2008 concluded that, whilst there was a lack of availability of short-term capital, the cost of capital itself had not increased in previous recessions, and in fact “was remarkably stable” through stock market fluctuations such as the tech bubble of 2000.[50]

[49] See for example the case of Colt Telecom Group at http://www.hmcourts service.gov.uk/judgmentsfiles/j1486/colt_telecom_v_insolvency_act.htm, paragraph 100 onwards.
[50] Available at http://www.mckinseyquarterly.com/Corporate_Finance/Capital_Management/Why_the_crisis_hasnt_shaken_the_cost_of_capital_2269?gp=1

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