COMMENT ON RESPONSES TO THE REPORT:

The effect of defined benefit pension plans on measurement of the cost of capital for UK regulated companies: A report for Ofcom

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SUMMARY

In September 2009 I produced a report "The effect of defined benefit pension plans on measurement of the cost of capital for UK regulated companies". The report investigated whether there is a robust way of adjusting the BT Group asset beta for its pension plan and concluded that there is not. I have been asked by Ofcom to comment on the responses to this part of the consultation.

The difficulties identified in my earlier report included measurement of:

- The beta of pension liabilities;
- Attenuation of the flow-through of risk from the pension plan to shareholders;
- Deviations of share price behaviour from the perfect model assumed by the proposed adjustment formula.

The submissions include new literature, evidence, and opinions on these issues. However, none of the submissions has put forward a method for making the pension adjustment which deals robustly with these issues.

Two different approaches to these measurement problems are suggested in the submissions. One is based on empirical analysis of the relationship between measured asset betas and pension plan characteristics for the FTSE 100 companies. This analysis gives rise to an adjustment to the BT Group asset beta in the range -0.06 to +0.01, depending on the data period used and the estimate of the beta of pension liabilities. The other method is based on building up an estimate from fundamental analysis of the factors which should influence the risk which is passed from the pension fund to shareholders. This gives a much larger adjustment, estimated by Sky as -0.196. In my opinion the "build-up" method based on fundamental analysis cannot deal with many of the important measurement issues. Therefore, if an adjustment is to be used I believe it should be based on the empirical approach.

I have been asked by Ofcom to give my best guess of the size of the pension adjustment to the BT Group asset beta based on all the evidence I have seen. Based mainly on the empirical approach, my best guess of the adjustment which could be applied to the BT Group asset beta is -0.05. However, this is highly uncertain and definitely not robust. In my opinion none of the

measurement issues has been satisfactorily resolved by the new evidence and the size of the adjustment inevitably involves a large degree of judgement.

I have also been asked to discuss the broader context of the way that Ofcom uses the BT Group cost of capital in its estimation of the cost of capital of Openreach. In 2009 Ofcom estimated the Openreach cost of capital using two benchmarks, the BT Group and a range of network utilities. An estimate of the pension adjustment to the BT Group asset beta is one possible input to this process. However, it does not reduce the high degree of regulatory judgment required in making this decision. It gives two extra factors to be considered, the estimate of the pension adjustment and the uncertainty about it. Ofcom will have to consider how this fits into its framework of exercising its regulatory judgment in a single step starting from the unadjusted asset beta of the BT Group.

1. Introduction

In September 2009 I produced a report "The effect of defined benefit pension plans on measurement of the cost of capital for UK regulated companies" ("ICReport1"). ICReport1 concerned the possibility of adjusting the cost of capital of BT to reflect the existence of its large defined benefit ("DB") pension plan. It was published by Ofcom as part of its consultation regarding estimating the cost of capital for use in regulating BT Openreach.

ICReport1 concluded that although it is likely that BT's pension plan increases its measured cost of capital there is no robust way of adjusting the BT Group asset beta for the effect. The size of the adjustment depends on parameters which are not measurable in a reliable way. The measurement issues include:

- Estimating the beta of pension liabilities;
- Estimating the effects of various mechanisms which attenuate the effect of the DB plan on the measured beta of BT, such as the sharing of the risk of the pension plan between BT shareholders and other stakeholders;
- Estimating the extent to which the measured beta of BT immediately and fully reflects variation in the market value of its pension plan.

In addition there is the issue of how to use an adjusted cost of capital in a way that is consistent with operating costs which are affected by the presence of the DB plan.

Ofcom has received several responses to this part of the consultation. Some of these responses comment on ICReport1 but do not suggest how to adjust the cost of capital. Others suggest ways of measuring some of the required inputs to the calculation. Several suggest that further work is required. In my opinion none gives a complete and robust way of estimating the adjustment.

I have been asked by Ofcom to comment on those parts of the responses which relate to ICReport1 and consider how they affect the conclusions expressed there. I have been asked to make these comments in the broader context of the way that Ofcom uses the BT Group cost of capital in its estimation of the cost of capital of BT Openreach. The responses I have been asked to consider are from PwC (for British Sky Broadcasting Group, Cable and Wireless, and Carphone Warehouse), British Sky Broadcasting Group plc ("Sky"), Cable and Wireless, Talk

Talk, and Professor Ian Dobbs (for BT). I have been asked to discuss only those parts which relate to the estimation of the cost of capital of Openreach.

In addition, I have been asked by Ofcom to give my best guess of the size of the pension adjustment to the BT Group asset beta based on all the evidence I have seen, and to discuss how this would fit into the framework Ofcom uses to estimate the cost of capital of BT Openreach.

The remainder of this report is organized as follows. Section 2 discusses the way that Ofcom uses the BT Group cost of capital in its estimation of the cost of capital of BT Openreach. Section 3 discusses additional literature that I did not cover in ICReport1. Section 4 comments on issues raised regarding the pension adjustment. Section 5 comments on other issues raised in the responses. Section 6 summarises the issues regarding measurement of the pension plan adjustment and gives my recommendation. Section 7 discusses further evidence commissioned by Ofcom and gives my opinion of the size of the adjustment to the BT Group asset beta. Section 8 discusses the effect on the estimation of the Openreach cost of capital.

2. Estimating the cost of capital of BT Openreach

Openreach is only about half the BT Group.[1] Therefore, estimating the cost of capital of Openreach is similar to divisional cost of capital estimation. The standard way to do this is to use a pure play industry beta. However, there are no pure play companies with the characteristics of Openreach. So the standard divisional cost of capital estimation procedure is not available. Ofcom has instead used two ways of addressing this problem in its 2005 and 2009 reviews.

In 2005 Ofcom estimated the cost of capital of the copper access network (the precursor to Openreach). It used the following evidence:[2]

- The beta of the BT Group;
- Betas of UK utility companies;
- Betas of US telcos;

[1] Ofcom (2009) A8.74.
[2] Ofcom (2005) para 7.74.

- Cross-sectional analysis of the empirical relationship between betas and business mix;
- Time series analysis of the empirical relationship between betas and business mix for BT;
- The relative income elasticity of line rental versus calls to judge the risk of copper access relative to the rest of BT;
- Fundamental analysis of the risks faced by the copper access business.

On this basis it judged a copper access equity beta of 0.9 relative to a BT Group equity beta of 1.1, i.e. a reduction of 0.2.[3]

In 2009 Ofcom estimated the Openreach cost of capital using two benchmarks. One was the BT Group equity beta, estimated as 0.86 at a target leverage ratio of 35%.[4] The other was a range of network utility equity betas, 0.4-0.7 at a target leverage of 35%.[5] This range was estimated by Brattle based primarily on the betas of United Utilities and National Grid.[6] Using its judgment of the risk of Openreach relative to these benchmarks Ofcom estimated an Openreach equity beta of 0.76 at a leverage ratio of 35%.[7] This is 0.1 below the BT Group beta but above the betas of network utilities. Hence Ofcom's 2009 estimate of Openreach's cost of capital reflected three things:

- Evidence from the asset beta of the BT Group;
- Evidence from the asset betas of network utilities;
- Ofcom's judgement of the risk of Openreach relative to these two benchmarks.

None of the betas used by Ofcom to form its judgements in 2005 and 2009 were adjusted for the effect of DB pension plans. Therefore, if it now adjusts the BT Group beta for its pension plan Ofcom will need to consider whether it should also adjust the asset betas of the utility benchmarks for their pension plans. Relative to their operating assets their pension plans are much smaller than BT's.[8] None of the respondents to this consultation has yet argued that any such adjustment should be made. For instance, Sky has used unadjusted utility betas as a benchmark for the adjusted beta of Openreach.[9] Therefore, it is possible that the standard asset

[3] Ofcom (2005) paras 6.100, 7.76, 7.81.
[4] Ofcom (2009) A8.67, Brattle (2009a).
[5] Ofcom (2009) A8.72.
[6] Brattle (2009b).
[7] Ofcom (2009) A8.73.
[8] ICReport1 page 21.
[9] Sky para 4.12.

betas of other utility companies could be used as one agreed benchmark when estimating the Openreach asset beta, regardless of the way that the BT Group beta is adjusted for its pension plan.

Ofcom will also need to decide how any adjustment to asset betas for pension funds affects its judgement of the Openreach beta relative to the two benchmarks of the utility betas and the adjusted BT Group beta. I did not examine this issue in ICReport1. I discuss it in Section 8 of this report.

3. Additional literature

Before discussing the responses, in this Section I discuss literature cited in the responses that was not analysed in ICReport1. Three articles are particularly relevant. Cable & Wireless (2010) cites First Economics (2009), which discusses the betas of Openreach and other regulated companies. Dobbs (2010) cites McKillop and Pogue (2009a), which estimates the impact of DB plans on the observed betas of the FTSE 100 companies. Dobbs also cites Khorasanee (2008), which estimates the discount rate to value DB liabilities.

3.1 The asset beta of Openreach compared to other utilities

First Economics (2009) reports asset betas of various regulated companies, compares them with estimates produced by regulators, and conducts fundamental analysis of these asset betas.[10] This is relevant because I have now been asked to consider the way in which Ofcom uses evidence from utility companies to estimate the cost of capital of Openreach.

Table 3.1 shows the asset betas reported by First Economics.[11] The purpose of its analysis was to assist the CAA in estimating the asset beta of NATS (En Route) plc ("NERL"). NERL is an unlisted company, so estimating its asset beta using utility companies involves issues similar to those involved in estimating the asset beta of BT Openreach. First Economics also reports fundamental analysis of the asset betas of these companies, including BT Openreach. It

[10] All the asset betas are calculated with a standard debt beta of 0.1.
[11] They also report asset betas for airline companies and foreign airports, which I have excluded from the table.

examines three fundamental factors: volume risk, exposure to volume risk via price control, and operating leverage (operational gearing).[12] Table 3.2 shows its analysis.

Table 3.1: Asset betas reported by First Economics (2009)

	Asset beta
Stanstead**	0.61
BT (regulated businesses)**	0.56
Gatwick**	0.52
Electricity DNO's**	0.48
Heathrow**	0.47
Network Rail**	0.46
United Utilities*	0.44
Severn Trent*	0.41
Pennon Group*	0.37
Northumbrian Water*	0.36
National Grid*	0.35

*Estimated by First Economics (Table 3.1 of their report).
**Reported by First Economics based on regulatory reviews (Table 3.2 of their report).

The purpose of this analysis was to assess the asset beta of NERL. First Economics estimated this as 0.5-0.6.[13] It also expressed its opinion about the risk of BT Openreach:

> "*The table shows that NERL appears riskier than all of the other regulated companies, with the possible exception of BT's monopoly activities……Only regulated telecoms businesses, with their moderate income elasticity, pure price cap arrangements, and relatively high 'operational gearing', could conceivably be regarded to exhibit a comparable risk profile to NERL.*"[14]

[12] These are similar to the standard determinants of asset beta, systematic revenue variability and operating leverage (see e.g. Brealey, Myers, and Allen (2008) pp 248-250).
[13] First Economics (2009) page 11.
[14] First Economics (2009) page 8.

Table 3.2: First Economics' analysis of fundamental determinants of asset betas

	Volume risk	*Exposure via price control*	*Operational gearing*
Water	Low	Low to moderate	Low to moderate
Electricity/gas transmission	Low to moderate	Low	Low
Electricity distribution	Low to moderate	Low to moderate	Low to moderate
Rail	Moderate to high	Low	Low
Telecoms	Moderate	High	[High]*
NERL	High	Moderate	High

* First Economics' table does not contain an estimate of the operational gearing of Openreach (measured by the ratio of regulatory asset base to revenue). However, the text makes clear that First Economics considers Openreach to have relatively high operational gearing. Analysis of BT Openreach accounts using the measure applied by First Economics confirms this.[15]

Thus the analysis of First Economics supports Ofcom's conclusion that Openreach has an asset beta above those of water, electricity distribution, electricity transmission, gas transmission, and rail companies. In particular, it is consistent with an estimate of the Openreach asset beta similar to 0.5-0.6, which is First Economics' range for the asset beta of NERL. First Economics calculates an asset beta of 0.56 for Openreach based on Ofcom's assumptions, which falls in the middle of this range.[16] Because this analysis does not make any use of the BT cost of capital it would not be affected by adjusting the BT cost of capital for its pension plan.

3.2 Estimation of the DB adjustment using UK data

McKillop and Pogue (2009a) ("M&P") replicate the analysis of Jin, Merton, and Bodie (2006) ("JMB") using UK data for 2002 to 2006. This is relevant because it gives direct estimates of the parameters of the JMB adjustment as it would apply to the BT Group.

For the FTSE 100 companies M&P test four models of the way in which pension risk affects equity risk. The models are:

(1) Equity risk reflects only the gross size of the DB plan;

[15] On the basis of the 2009 Openreach regulatory accounts, the ratio of regulatory asset base to revenue is 12,051/5,364=2.2. This is similar to the ratio of 1.9 for NERL, which First Economics classifies as high operational gearing.

[16] This is based on an equity beta of 0.8, debt beta of 0.1, and leverage of 35%.

(2) Equity risk reflects only the size of the net funding surplus or deficit;

(3) The JMB model with β_{PL} =0.28;

(4) The JMB model with β_{PL} =0.38.

Their estimates of β_{PL} are based on the beta of 30-year Government bonds, the procedure used by JMB.[17]

The first two of these models are cruder than the JMB model. Both make no allowance for the actual risk of the assets of the pension fund and, therefore, rely on the assumption that a pension fund which has low risk assets has the same effect on the observed equity beta as a fund with high risk assets. The second makes the further assumption that the gross size of the fund does not matter.

For each model M&P run a panel regression with controls for other variables, such as growth and leverage, which may be correlated with both the size of the pension fund and the measured beta. The models are estimated by the regression:[18]

$$\beta_{E+D} = a + bPRi + cCONTROLS + \varepsilon \qquad (1)$$

Where β_{E+D} is the standard asset beta, *CONTROLS* are various control variables, and *PRi* is the measure of pension risk, given by:

$$\text{PR1} = \frac{PL}{D+E}$$

$$\text{PR2} = \frac{PA - PL}{D+E}$$

$$\text{PR3} = \text{PR4} = \beta_{PA}\frac{PA}{D+E} - \beta_{PL}\frac{PL}{D+E}$$

Table 3.3 shows the results of their analysis.[19] The coefficient b measures the extent to which actual asset betas reflect the pension fund risk. The naive JMB model implies that the coefficient b should be equal to 1.0 in the last two rows of the Table.

[17] Although M&P use a beta of 0.28-0.38 for pension liabilities, they use a beta of 0.175 for bonds in the pension asset portfolio, which is inconsistent.
[18] Variable definitions are given in ICReport1.
[19] They also report another statistical version of the multivariate regression using a Fama-MacBeth adjustment, but in McKillop and Pogue (2009b) they rely on the Rogers adjustment. The Rogers method is generally better. The issues are discussed in Petersen (2009).

Table 3.3: McKillop and Pogue results (multivariate specification, Rogers adjustment)

Pension risk measure	Coefficient b	T-statistic	R^2
PR1: Size of pension fund	0.0460	1.92	37.87%
PR2: Pension surplus	-0.1761	-0.50	36.98%
PR3: JMB measure with β_{PL} =0.28	0.3777	1.51	37.57%
PR4: JMB measure with β_{PL} =0.38	0.1997	0.56	36.98%

The quality of fit of the four models, measured by R^2, is almost independent of the specification. Approximately 37% of the variation in asset betas is explained by the regression regardless of the way that pension risk is measured.[20] In fact the crudest specification, PR1, does best. Thus, on the basis of this empirical analysis there is effectively no way to choose between these models or between the different estimates of β_{PL} when the JMB procedure is used in approaches 3 and 4.[21]

The coefficients in the JMB regression are statistically significantly lower than 1.0 but not statistically different from zero. The naïve JMB model assumes that pension risk feeds through one-for-one to the asset beta. However, the estimated coefficients imply attenuation of 62%-80% of the risk.[22] The other statistical specification used by M&P implies attenuation of 68%-74%.

Although these four models give virtually identical fits to the data, they have different implications for the effect of pension risk on any individual firm. Table 3.4 shows the base case data for BT used in Table 2 of ICReport1. Table 3.5 uses this data to calculate the four M&P variables PR1-PR4. It then applies the estimated regression coefficients from Table 3.3 to calculate the magnitude of the pension adjustment to the asset beta resulting from applying each model to BT.[23]

[20] Most of this is a result of the control variables. When the pension variables are used alone they explain only about 15% of the variation.
[21] This indeterminacy is very similar to the result of the JMB analysis discussed on page 18 of ICReport1.
[22] The degree of attenuation is 1.0 minus the coefficient. For PR3 attenuation is 1.00-0.38=0.62. For PR4 it is 1.00-0.20=0.80.
[23] These adjustments measure only the partial effect of the pension variable in the regressions. Applying the complete regression models to BT would require the use of the control variables and constant terms as well as the pension term.

Table 3.4: Base case assumptions for BT Group used in ICReport1

E	D	PA	PL	Beta PA
11,140.42	7,081.83	29,353.01	33,326.00	0.41

Table 3.5: Adjustments to the BT Group asset beta using McKillop and Pogue regression coefficients and β_{PL} with base case assumptions from Table 3.4

	(1) Pension risk measure	(2) Regression coefficient	(3)=(1)*(2) Asset beta adjustment
PR1	1.829	0.046	-0.084
PR2	-0.218	-0.1761	-0.038
PR3	0.149	0.3777	-0.056
PR4	-0.034	0.1997	0.007

The resulting adjustments to the asset beta range from a decrease of 0.084 for PR1 to an increase of 0.007 using the JMB model with β_{PL}=0.38 (i.e. PR4). For the first two models, which do not require an estimate of β_{PL}, the adjustment decreases the asset beta by 0.08 and 0.04. For the two JMB models the adjustment to the asset beta is -0.06 or +0.01, depending on the assumed level of β_{PL}.

In summary, the McKillop and Pogue analysis implies that the adjustment to the asset beta of the BT Group is between -0.08 and +0.01, depending on the specification. This does not allow for uncertainty in parameter estimation, which would increase the range further. The JMB adjustment is highly attenuated and also sensitive to the assumption of the beta of pension liabilities. These points are emphasised by the authors in their conclusions:

> "*In general terms, our analysis also indicates that for FTSE 100 companies, over the 2002-2006 period, pension plan risk does feed into firm equity and debt risk. This suggests that the market views the assets and liabilities of the company pension scheme as part of the assets and liabilities of the firm itself. Having made this point it is also the case that there is some sensitivity to model specification and the adjustment techniques utilized. More specifically, we note that the measure of pension risk proposed by Jin et al (2006) can result in quite divergent findings influenced by only relatively small variations in the assumed value of the systematic risk of the pension liabilities. Where the correct sign was obtained, with respect to this measure, it was*

also apparent that the resultant estimate was significantly lower than one, raising doubt about the hypothesised 1-to-1 relationship between pension risk and capital structure. This in turn raises the spectre that there may be a weakness in the informational efficiency of markets which may be caused by shadows cast on the market by the plethora of accounting rules and actuarial assumptions."

3.3 Estimating the beta of salary-linked liabilities

Dobbs (2010) cites a paper by Khorasanee (2008) which estimates the beta of the relationship between real wage growth and the stock market using annual data for 1946-2005. This is relevant because one factor influencing the beta of pension liabilities is the relationship between real wages and stock market returns.

Khorasanee estimates a very high correlation between stock market returns and subsequent real wage growth ($\rho_{MV} = 75\%$).[24] However, the standard deviation of real wage growth (σ_S) is only 2.4% per annum whereas the standard deviation of the stock market (σ_M) is 21% per annum. As a result Khorasanee's estimate of the beta of a salary-linked asset is 0.086, given by:

$$\beta = \frac{\sigma_S}{\sigma_M} \rho_{MV} = (0.024/0.21)*0.75 = 0.086 \qquad (2)$$

In my opinion this estimate is an underestimate of the beta of a real salary-linked liability. It reflects the standard deviation of real wage growth (σ_S), whereas it should reflect the standard deviation of the present value of an asset linked to future real wages. A large part of actual stock market betas appears to derive from variation in discount rates.[25] This is not included in Khoranasee's estimate. Including this factor would increase the beta. When the stock market is high and real wage growth is expected to be high the discount rate will be low. That will mean that the proportional increase in the PV of a salary linked asset is greater than the growth in expected real wages. As a result, the volatility of the PV will be greater than the volatility of the rate of growth of real wages. Therefore, the beta of the present value of a claim linked to real wages is likely to be higher than the figure of 0.086 reported by Khoranasee. However,

[24] This is measured by regressing real wage growth on contemporaneous and lagged stock market returns.
[25] See, for example, Campbell and Mei (1993).

there is no accepted model for deriving the beta of a present value based on the beta of a macroeconomic variable analysed in this way.

Also, the beta measures only the part of β_{PL} arising from the correlation between real wage growth and the stock market. It does not include the part of the beta of pension liabilities arising from their long-term nature, which is the measure of β_{PL} used by JMB and M&P.

3.4 Additional literature: Summary

The additional literature cited by the responses is helpful in three ways. The paper by First Economics examines the asset betas of Openreach and other utilities and gives a judgment of relative risk based on fundamentals. This analysis is consistent with the Openreach asset beta used by Ofcom in its 2009 review. The paper by McKillop and Pogue gives empirical estimates of the impact of pension funds on asset betas using UK data for 2002-2006. This analysis implies an adjustment to the BT Group asset beta in the range -0.08 to +0.01. The paper by Khoranasee shows that there is a high correlation of 0.75 between real wage growth and stock market returns.

4. Issues raised regarding estimation of the pension adjustment

In this Section I discuss the issues raised by the responses regarding estimation of the pension adjustment. In Sections 5 I discuss other significant issues related to the cost of capital.

4.1 The overall adjustment for the pension fund

Only Dobbs and Sky give estimates of the overall adjustment to the asset beta. Dobbs' base case is that there should be no overall adjustment to the asset beta of the BT Group.[26] This derives mainly from an assumption that β_{PL} is similar to the beta of the pension assets. I discuss β_{PL} in Section 4.3 below. In this Section I discuss Sky's estimate of the overall adjustment.

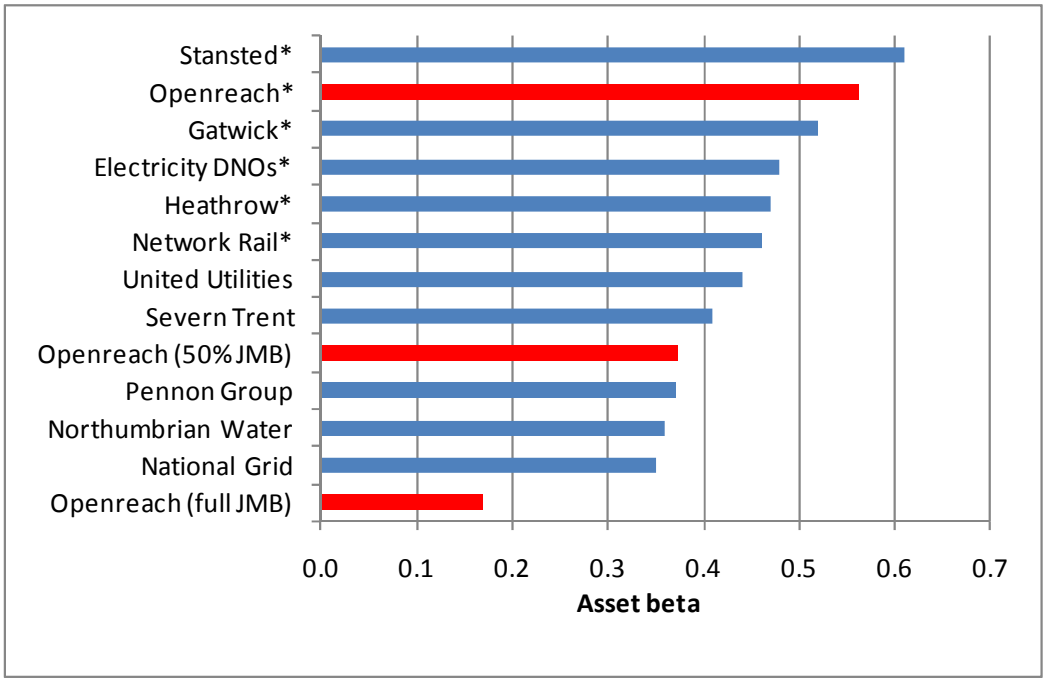
[26] Dobbs Table 2.

Sky's base case is β_{PL} equal to 0.175 and a 50% attenuation factor. This results in a decrease of 0.196 in the BT Group asset beta. This may be compared with the range -0.08 to +0.01 estimated based on the empirical analysis of M&P. On that basis it looks very large. Sky estimates a similar reduction, 0.190, in the Openreach asset beta. Starting from the asset beta estimated by Ofcom Sky applies this adjustment and derives an adjusted asset beta for Openreach of 0.372.[27] This is 0.263 lower than its estimate of the unadjusted asset beta of the BT Group.[28]

Sky's adjusted Openreach asset beta may be compared with the utility company asset betas I discussed in Section 3.1 above.[29] Figure 4.1 below reproduces Sky's comparison. From its analysis Sky concludes that 50% of the JMB adjustment is reasonable because:

> *"A 50% JMB adjustment would move Openreach from near to the top of the range to near to the bottom, but still well within the range of plausible values."*[30]

Figure 4.1: Sky analysis of the JMB adjustment applied to Openreach



[27] Sky para 4.9. For BT 0.635-0.439=0.196. For Openreach 0.562-0.372=0.190.
[28] 0.635-0.372=0.263.
[29] Sky para 4.12.
[30] Sky para 4.12.

Sky's conclusion is very different to that reached by Ofcom based on a comparison of the risk of Openreach and other utilities. Ofcom has concluded that Openreach is riskier than network utilities, including United Utilities. In contrast, Sky says that Openreach's operating asset beta (0.372) is significantly below that of United Utilities (0.44). Sky's conclusion also contradicts that of First Economics, on whose data its comparison is based. First Economics concludes that:[31]

> "*Only regulated telecoms businesses, with their moderate income elasticity, pure price cap arrangements, and relatively high 'operational gearing', could conceivably be regarded to exhibit a comparable risk profile to NERL.*"[32]

First Economics' estimate of the asset beta of NERL is 0.5-0.6. Sky's estimate for Openreach is 0.372, far below this range.

The issue here is a comparison between the risks of Openreach and utility companies. This can be judged without reference to any procedure for adjusting the risk of the BT Group for its pension fund. Ofcom's range for the equity beta of network utilities is 0.4-0.7 at a leverage ratio of 35%. This corresponds to a range of asset betas of 0.295-0.490.[33] If Ofcom is confident that the asset beta of Openreach lies above this range there is no room for a pension adjustment of the size estimated by Sky in addition to the adjustment made by Ofcom to the BT Group asset beta.

4.2 Procedures for estimating the pension adjustment

I now discuss the way the pension adjustment is estimated and the robustness of the adjustment. In ICReport1 I concluded (1) that there is no robust way of adjusting the asset beta of the BT Group for its pension risk, and (2) the adjustment is probably downwards but its size is highly uncertain. If the JMB approach is used, the inputs required are β_{PL} and the attenuation factor. In ICReport1 I examined various approaches to estimating these parameters

[31] See Section 3.1 above.
[32] First Economics (2009) page 8.
[33] I have used a debt beta of 0.1 to be consistent with the asset betas First Economics reports.

and concluded that there is no reliable way to estimate them. Some submissions have now provided estimates of these parameters, which I discuss in this Section.

4.3 Estimating β_{PL}

Only Sky and Dobbs give estimates of β_{PL}. Both are based on the beta of nominal gilts. Sky uses a US figure from JMB (0.175) and Dobbs bases his estimate (0.45) on a UK figure from M&P. Neither conducts their own empirical analysis to make an estimate. Both use an asset beta of 0.41-0.42. Since the pension adjustment depends primarily on the difference between the betas of the pension assets and liabilities, the different estimates of β_{PL} give very different implications for the size of the adjustment.

Dobbs uses an β_{PL}=0.45 in his "illustrative calculation".[34] This is based on the higher end of the range estimated by M&P from the beta of nominal gilts (0.28-0.38). That estimate is for the period 2002-2006. Dobbs adds the beta of real wages estimated by Khoranasee (0.086). In my opinion Dobbs' estimate does not address all the measurement issues, including the following:

- The BT asset beta used is for 2007-2009.[35] The value of β_{PL} used is measured for 2002-2006. The two measures should be consistent.
- The pension liabilities are real, not nominal.
- The Khoranasee estimate measures the beta of real wage growth, not the beta of the present value of real wages.
- The beta of real wages should be applied only to that part of the pension liability which is exposed to real wage increases, not the entire pension liability.

Sky uses β_{PL}=0.175, the lower of the two estimates used by JMB based on the beta of nominal US Treasury bonds. Sky says it would increase this estimate if longevity and salary growth are correlated with movements in the market.[36] In my opinion Sky's estimate does not address all the measurement issues, including the following:

[34] Dobbs Table 2.
[35] ICReport1 page 21.
[36] Sky para C.16.

- Even if the beta of government bonds is used as a benchmark, it is sensitive to the measurement period and method. For instance, JMB report two estimates, 0.175 and 0.45. If the higher estimate were used it would give a negative pension adjustment.[37]
- The JMB estimate used by Sky is for the US. UK estimates may be different. For instance the McKillop and Pogue estimates of β_{PL} are higher than the US estimate used by Sky.[38]
- Salary growth is correlated with the market. Khoranasee shows that this correlation is very high.[39]

The above measurement issues were stated in ICReport1 as reasons why I do not believe that there is a robust way of estimating β_{PL}. For instance, there is a wide difference between the estimates used by Sky (0.175) and Dobbs (0.45), even though both use the beta of government bonds as a benchmark. The responses have not changed my view that there is no simple and robust method of addressing the above issues.

4.4 Estimating the attenuation factor

Sky and PwC estimate the attenuation factor based on a "build-up" method, which estimates the components using fundamental analysis.[40] PwC's range for the overall factor is 38%-61% and it concludes that: "*Overall a figure nearer 38% seems more plausible…*".[41] Sky's estimate is 50%.[42] Dobbs refers to the McKillop and Pogue estimate of 62%-80% derived from empirical data on UK asset betas.[43] Both the PwC range based on build-up analysis and the range based on empirical analysis of asset betas are quite wide, but they do not overlap.

PwC's analysis is similar to Sky's. The PwC analysis is more detailed, so I use it as the main basis of my discussion. The components of the PwC estimate are shown in Table 4.1 below.

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[37] ICReport1 page 24.
[38] Section 3.2 above.
[39] Section 3.3 above.
[40] Talk Talk says that the factor will be less than 50% but does not provide any analysis (Talk Talk para 100).
[41] PwC para 40.
[42] Sky pages 21-23.
[43] Dobbs page 18.

Table 4.1: PwC's estimate of the attenuation factor

Risk sharing with	*Low estimate*	*High estimate*
Pension insurance schemes	0%	0%
Scheme members and employees	14%	31%
Customers and suppliers (through regulation)	0%	15%
Government (taxes)	28%	28%
Aggregate attenuation through risk sharing	38%	61%
Attenuation through imperfect market response	0%	0%
Overall attenuation	*38%*	*61%*

Both PwC and Sky assume that certain factors cause no attenuation:

- They assume that the present value of future wage costs is unaffected by a growing pension deficit.[44]
- They assume that the present value of pension liabilities is unaffected by default risk.[45]

Regarding the first of these effects, there is evidence that the financial well-being of a firm significantly affects the level of its future wage costs (e.g. Hanka (1998)). Regarding the second, it is commonly assumed that the present value of DB pension liabilities is affected by default risk.[46] Neither of these effects can decrease the amount of attenuation. If they are material they can only increase the attenuation factor. In my opinion, these effects are likely to be material but there is no simple way of estimating them.

Both PwC and Sky also assume that there is no imperfection in the share price response to fluctuations in the value of the pension plan.[47] To support its view, PwC states that analysts follow BT's pension risk closely. However, that does not necessarily mean that the week-to-week or month-to-month variations in the share price (which influence the measured beta) evolve in the way the JMB model assumes. For instance, when BT announced its pension recovery plan the share price fell 8% even though the announcement was made along with

[44] PwC para 25 footnote 20.
[45] PwC mentions default risk in Appendix IV but does not include it in its calculations. It could be included either in the attenuation factor or in the beta of pension liabilities.
[46] For instance, Ralfe (2010) paras 12.7-12.8.
[47] PwC para 20 and Appendix 1. Sky does admit the possibility of such an effect (Sky C.16(c)).

quarterly results slightly ahead of analysts' expectations.[48] This suggests that the link between the share price and the net value of the DB plan is more complex than assumed by the JMB model. For this factor there is no simple way of estimating it. If it is material it will increase the attenuation.

The attenuation factors which PwC and Sky include are tax, risk sharing with beneficiaries, and risk sharing through regulation. I agree with the structure of the PwC analysis, whereby the tax adjustment is made only after the other factors have been included.[49] Both use a tax factor of 28%, with which I agree.

PwC's range for risk-sharing with scheme members is 14%-31%.[50] Sky's estimate is 5%.[51] Both are based on a comparison of the present value of reductions in benefits with the pension deficit. PwC estimates that a total PV of £1.4 billion was actually saved in the period leading up to April 2009, whereas Sky says that a saving of £1 billion is a theoretical future possibility to which it attaches a probability of 50%.[52] Sky compares the saving with the Triennial funding valuation deficit of £9billion, whereas PwC uses both that figure and the deficit of £4 billion reported in the 2009 Annual Report.[53] In my opinion the range of estimates for this factor, from 5% to 31%, illustrates the difficulty of estimating stock market attenuation based on fundamental analysis of this type.

To measure the attenuation of beta arising from sharing with scheme members would require a measure of the change in the market's view of the present value of the net deficit combined with the change in its expectation of the present value of the part of this that will be covered by members of the pension fund. Although PwC's calculation measures variables that are related to this there is no way of telling whether these represent the market's view and whether they include the entire change in the present value of benefits resulting from the deficit.

[48] Can BT plug UK's largest pension deficit? *This is Money* website, 11 February 2010.
[49] PwC para 36.
[50] PwC Appendix V.
[51] Sky paras C.11 and C.15.
[52] PwC paras A26-A28 and Sky para C.11.
[53] PwC para A26.

PwC says says that regulatory attenuation could be up to 15%.[54] This is based on two numbers. 30% of BT's employees are involved in providing regulated wholesale services combined with the "conservative" assumption that the market thinks that there is a 50% chance of pass-through. The probability assumption looks reasonable but also cannot be verified by stock market evidence.

Overall Sky's and PwC's estimates based on fundamental analysis using the build-up approach give attenuation of between 38% and 61%. Before Ofcom could use such an approach it would be necessary to understand why this is so different to the empirical approach used by McKillop and Pogue, which gives a range of 62%-80%. One possible explanation is that the factors which PwC assumes have zero effect do have some effect, although it is not measurable.

The differences between these ranges casts doubt on the robustness of the JMB method. However, in my opinion if the JMB approach is to be used it would be better to use an empirical estimate of the entire attenuation effect based on actual asset betas rather than an estimate based on a build-up of components each of which is measurable only very indirectly.

5. Other issues raised in the responses

In this Section I discuss some other issues raised in the responses regarding the cost of capital.

5.1 Analogy with the disaggregation procedure used for copper access

Sky makes an analogy between adjusting BT's cost of capital for its pension plan and the method used to estimate the copper access cost of capital in 2005.[55] However, there are three important differences between these situations:

- The copper access disaggregation was based on a large amount of evidence from stock market betas. For the pension fund adjustment the relevant evidence from stock market betas is much more limited. For instance, the method suggested by Sky uses a proxy based on government bonds to estimate the beta of pension liabilities and does not use stock market data to estimate the attenuation factor.

[54] PwC paras 29-34.
[55] Sky para 4.3.

- The theoretical model linking the asset beta of a division to the asset beta of a group is widely accepted and used. In contrast, the theoretical model linking the asset beta of a company to the characteristics of its pension plan is not widely accepted and used.
- The output of the copper access disaggregation was an estimate of the beta of the regulated entity. Even if the pension fund adjustment is applied to the BT Group, a further adjustment will be needed to get the asset beta of the regulated entity.

In my opinion these differences are substantial and there is no direct analogy between the two situations.

5.2 Adjusting operating costs to be consistent with the adjusted cost of capital

PwC says that if scheme members bear pension risk they may also demand higher wages or higher levels of pension benefits than if they did not bear such pension risk.[56] It says that "*If the asset beta was reduced to its true operational level, but no adjustment were made to remove these additional pension risk related costs in setting regulated prices … prices would be higher than would be the case for a notional company without a pension scheme*".[57] In my opinion this analysis is based on an inappropriate comparison. When the cost of capital is adjusted for the presence of the DB scheme the comparison ought to be between the company as it is with the DB scheme and the same company without a DB scheme. Instead, PwC makes a comparison between a company with a DB scheme which has risk-sharing and the same company with the same DB scheme but no risk-sharing.

To illustrate the difference, consider the following three scenarios:

Scenario 1: The company with a DB scheme and risk-sharing (i.e. the actual company).

Scenario 2: The same company with no DB scheme.

Scenario 3: The same company with the same DB scheme but no risk-sharing.

PwC says that employees seek higher wages in Scenario 1 than in Scenario 3. This forms the basis of the analysis in paragraphs 41-56 of its report. However, if the cost of capital is adjusted to eliminate the effect of the DB plan, then the relevant scenario is Scenario 2 (not Scenario 3). In Scenario 2 employees will seek higher wages than in Scenario 1. A DB pension scheme has value to employees even if they share in some of its risks.

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[56] PwC para 44.
[57] PwC para 47.

Therefore, if the cost of capital is reduced to eliminate the effect of the DB plan the level of operating costs should be assumed to be higher rather than lower. Wages are likely to be higher in Scenario 2 than in Scenario 1. In contrast, PwC states that wages will be lower because it compares Scenario 3 with Scenario 1. A simple way of expressing the same point is that a change which lowers the cost of capital (eliminating the DB plan and the risks it transfers from employees to shareholders) is likely to raise the cost of labour. In contrast, PwC's analysis implies that BT could reduce the costs of both capital and labour by eliminating its DB plan.

5.3 Can the JMB adjustment give implausibly low estimates?

PwC questions whether the JMB approach can give implausibly low estimates.[58] In ICReport1 gave examples of adjusted asset betas of 0.228 for Boeing, 0.24 for BT and 0.17 for Stagecoach.[59] PwC denies that these estimates are implausible because, it claims, there is no benchmark against which to judge that conclusion. I disagree with this. These estimates can be judged against the asset betas of the many companies which do not have DB plans and operate in industries similar to these companies. Against that benchmark they are implausibly low, representing levels of asset beta that are not observed in reality for such companies. As a further illustration Sky derives an asset beta for Openreach of 0.182 using the full JMB adjustment.[60] Against the benchmark of other utility asset betas this looks implausible.[61]

5.4 Other benchmarks for the cost of capital of Openreach

C&W provides another comparison between the cost of capital of Openreach/copper access and other utilities. It compares Ofcom's estimates with those of other regulators and concludes that "*BT's cost of capital is higher than the utilities*" and that "*The gap is more than can be rationally expained (by factors such as increased competition).*"[62] However, its comparison is based on pre-tax nominal figures for BT and a mixture of pre- and post-tax real figures for other utilities. Therefore, as presented the comparison is not appropriate.

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[58] PwC para 12 footnote 14.
[59] ICReport1 pages 9 and 22.
[60] Sky para 4.9.
[61] Sky para 4.12.
[62] C&W (2010) para 7.2.

Table 5.1 below shows the figures reported in Table 7.2 of C&W's report.[63] In addition, the bottom two rows of the table provide cost of capital estimates for Openreach/copper access calculated in all relevant ways so that appropriate comparisons can be made.[64] Using the appropriate figures for comparison the costs of capital of the copper access network estimated in 2005 and Openreach estimated in 2009 are generally either similar to or below the appropriate comparison figures in C&W's table. Hence, C&W's conclusion that "BT's cost of capital is higher than the utilities" is not a correct interpretation of these data.

Table 5.1: Figures from C&W Table 7.2 with appropriate BT comparisons

	Nominal			*Real*		
	Vanilla	*Post-tax*	*Pre-tax*	*Vanilla*	*Post-tax*	*Pre-tax*
Cable and Wireless Table 7.2						
Ofwat Final Determination (2010-2015)				5.1%		
Gas Distribution Price Control (2007)				4.94%		
Electricity Distribution Price Control (2004)					6.9%	
Royal Mail Price Control (2006-2010)						8%
BT copper access network (2005)			10%			
BT non-copper access network (2005)			11.4%			
Comparison figures from Ofcom condocs						
BT copper access network (2005)	7.6%	7.0%	10.0%	5.1%	4.5%	7.5%
BT Openreach (2009)	8.0%	7.3%	10.1%	6.1%	5.4%	8.2%

5.5 Is the difficulty of making the pension adjustment relevant?

PwC states that exercising judgement and making an adjustment for the effect of the DB plan is better than not doing so, regardless of the uncertainty of the adjustment.[65] Sky says that the difficulty of making an adjustment is not a reason to avoid it.[66] In my opinion, if an estimate of the pension adjustment is used it should be the best guess, as PwC and Sky say. However, the weight given to the estimate should reflect the accuracy with which the adjustment is estimated.

[63] "Vanilla" means that the rate is after tax but the tax deduction for debt is not included.
[64] The calculations are given in Appendix 1 of this report.
[65] PwC para 15.
[66] Sky para 4.3.

Talk Talk says that two benchmarks, the BT Group and Utility companies, can be used to estimate the asset beta of Openreach.[67] It says that disaggregating the BT Group asset beta involves "two relatively difficult to determine adjustments". These are the adjustment for the pension scheme and the relative risk of Openreach compared with the BT Group. I agree with this comment. The use of two such judgemental adjustments should affect the relative weight one gives to the estimate derived from the BT Group asset beta.

6. Measuring the pension adjustment: Issues raised by the responses

If the pension adjustment is used, the main measurement issues are summarised by Sky:

> (1) *Narrowing down the range of uncertainty for the pension risk attenuation/flow-through parameter*;[68]
>
> (2) *Narrowing down the estimate of* β_{PL};[69]
>
> (3) *Narrowing down the estimate of* β_{PA};[70]
>
> (4) *Investigation of "damping" mechanisms*;[71]
>
> (5) *Further benchmarking analysis*.[72]

I agree with this summary. In this Section I give my opinion as to the appropriate method of addressing each issue.

(1) *Narrowing down the range of uncertainty for the pension risk attenuation/flow-through parameter and* (2) *Narrowing down the estimate of* β_{PL}.

It is difficult to separate the attenuation factor from β_{PL}. The empirical results of both JMB and M&P fail to distinguish empirically between different combinations of these two parameters. Also, particular factors such as the possibility that default risk could pass risk from the pension fund to pensioners can be captured by either a higher β_{PL} or a greater degree of attenuation.

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[67] Talk Talk (2010) paras 94-95.
[68] Sky C.17 (a).
[69] Sky C.17 (b).
[70] Sky C.17 (b).
[71] Sky C.17 (c).
[72] Sky C.17 (d).

Therefore, estimation of the attenuation factor must be combined with a consistent procedure to estimate β_{PL}, and should not be considered in isolation.

The beta of the pension liabilities, β_{PL}, should reflect the factors I discussed in Section 4.3. In my opinion there is no simple robust way of measuring this and it is inevitable that only a relatively broad range can be determined.

The attenuation factor should measure the proportion of the systematic risk arising from the pension plan that does not show up in the measured share price beta. My suggestion is that Ofcom should use direct empirical estimates based on updating the McKillop and Pogue study. These estimates have the advantages:

- They are based directly on empirical evidence about asset betas rather than elements built up using indirect evidence;
- The attenuation factor is estimated in a way that is associated with a particular assumption about β_{PL};
- Given the uncertainty about β_{PL}, the relationship can be estimated using alternative values of β_{PL} to obtain a range for the total adjustment to the asset beta.

The alternative is to estimate the attenuation factor using the build-up method. This places a heavy burden on fundamental analysis where there is little or no stock market evidence to support the judgments made.

(4) *Investigation of "damping" mechanisms.*

In my opinion there is no simple way of determining whether share prices respond to pension values with no damping. However, the empirical method of estimating the attenuation factor deals directly with this issue. Any damping is implicitly included in the estimated attenuation factor.

(3) *Narrowing down the estimate of* β_{PA}.

The beta of BT's pension assets can be resolved as a matter of fact by examining the actual portfolio of the BT pension fund.

(5) *Further benchmarking analysis.*

I have discussed benchmarking using other utility companies in Sections 3.1, 4.1, and 5.4 above.

In summary, I believe that the main weight should be given to empirically-based estimates of the pension adjustment. In my opinion, the measurement difficulties of the build-up approach are so great as to make evidence based on it unreliable.

7. Further evidence and my best guess of the size of the adjustment

The study by McKillop and Pogue discussed in Section 3.2 above uses data from 2002 to 2006. Ofcom commissioned the authors to update the study using the most recent available data by extending the period to 2008. The results are given in Gallagher, McKillop, and Pogue (2010). Table 7.1 summarizes the regression results. These may be compared with Table 3.3 above, which is based on 2002-2006 data.

The revised estimates of β_{PL} are 0.28 and 0.30. The first is the same as model PR3 and the results for β_{PL}=0.30 are in the row labelled PR5. The other rows give the results for the other four specifications discussed in Section 3.2 above using the extended data set. Table 7.1 confirms the features of the results discussed in Section 3.2 above:

- the quality of fit of all the models is similar;
- the degree of attenuation is high;
- the coefficients of the JMB model are statistically insignificantly different from zero.

Table 7.2 shows the size of the adjustments if the models are applied to the BT Group using the base case assumptions from Table 3.4 above. Table 7.2 also shows the results based on the Fama-MacBeth adjustment for comparison. The effect of the extended data set can be seen by comparing column (4) with column (2). It changes the estimated adjustments only slightly. When the Fama-MacBeth method is used (columns (3) and (5)) there is also little change if the JMB models PR3 and PR4 are used. However, there is a larger change if PR1 and PR2 are

used. For those models the size of the adjustment is also very sensitive to whether the Rogers or Fama-MacBeth procedure is used. If the JMB adjustment is used the Table confirms the sensitivity of the adjustment to β_{PL}.

Table 7.1: McKillop and Pogue updated results (multivariate specification, Rogers adjustment)

Pension risk measure	Coefficient b	T-statistic	R^2
PR1: Size of pension fund	0.0515	2.06	34.93%
PR2: Pension surplus	-0.1374	-0.47	33.95%
PR3: JMB measure with β_{PL}=0.28	0.3448	1.63	34.53%
PR4: JMB measure with β_{PL}=0.38	0.1031	0.37	33.76%
PR5: JMB measure with β_{PL}=0.30	0.4140	1.59	34.62%

Table 7.2: Adjustments to the BT Group asset beta using McKillop and Pogue regression coefficients with base case assumptions from Table 3.4 (calculations in Appendix 2)

	(1)	(2)	(3)	(4)	(5)
		2002-2006		*2002-2008*	
Pension measure	β_{PL}	*Rogers*	*Fama-MacB*	*Rogers*	*Fama-MacB*
PR1: Size of pension fund	NA	-0.084	-0.114	-0.094	-0.174
PR2: Pension surplus	NA	-0.038	-0.107	-0.030	-0.131
PR3: JMB	0.28	-0.056	-0.048	-0.051	-0.041
PR4: JMB	0.38	0.007	0.009	0.003	0.005
PR5: JMB	0.30			-0.047	-0.038

In my opinion, this analysis confirms the opinion expressed in ICReport1 that there is no robust method for estimating the pension adjustment. The estimates in Column (4) range from -0.094 to +0.003. The estimates using the JMB model range from -0.056 to +0.003 depending on the data period and estimate of β_{PL}. However, Ofcom has asked me to give my best guess of the size of the pension adjustment to the BT Group asset beta based on all the evidence I have seen, and to discuss how this would fit into the framework Ofcom uses to estimate the cost of capital of BT Openreach.

My judgement is based on the following opinions and observations:

- In my opinion the estimate of the attenuation factor should be based on empirical analysis not the build-up method;
- In my opinion the estimates based on models PR1 and PR2 should be given little weight because they have no strong theoretical underpinning and they ignore the betas of pension assets and liabilities;
- In my opinion the assumptions of PR4 (β_{PL} = 0.38 and attenuation of 90%) both represent the upper end of the possible ranges. Therefore, the pension adjustment based on them, zero, is the minimum decrease in the beta, not the central estimate.
- If I had to make a single guess I would use -0.05. This is consistent with the estimate using the JMB method based on data for 2002-2008 based on β_{PL} = 0.28-0.30. The associated empirical estimate of the attenuation factor is 59%-66%.[73]
- The figure for β_{PL} of 0.28-0.30 has been estimated by Gallagher, McKillop, and Pogue based on the beta of gilts in a manner consistent with the procedure used by JMB. In my opinion it is also broadly consistent with the beta of a long-term default free indexed claim plus other factors including real wage growth and default risk (assuming default risk is included in β_{PL} and not in the attenuation factor).
- The attenuation factor of 59%-66% is estimated from empirical data and so includes various factors as they appear in the empirical data. It is also consistent with the top of the range for the attenuation factor estimated by PwC.

Although my best guess of the adjustment which should be applied to the BT Group asset beta is -0.05, this is highly uncertain and definitely not robust. The range of estimates in Table 7.2 is wide and takes no account of parameter estimation risk, which makes the range even wider. As I discussed in ICReport1, there is significant uncertainty about β_{PL}, the attenuation factor, and whether stock market betas respond in the perfect way JMB assume. In my opinion none of these issues has been satisfactorily resolved by the new evidence and the size of the adjustment inevitably involves a large degree of judgement.

[73] Table 7.1 gives the coefficients for PR3 and PR5 as 0.34 and 0.41. 1.00-0.34=0.66. 1.00-0.41=0.59.

8. The effect on estimating the cost of capital of Openreach

I have not been asked to estimate the asset beta or cost of capital of Openreach. However, in this section I comment on the use of the pension adjustment to the BT Group asset beta in that broader context.

In my opinion the following considerations arising from the pension adjustment should affect the use of the adjusted BT Group asset beta in estimating the cost of capital of BT Openreach:

- If Ofcom makes the pension adjustment to the BT Group asset beta it will then need to make a further adjustment for the relative risk of Openreach. A procedure involving two such significant judgemental adjustments is unusual in my experience.
- In using this evidence Ofcom should take into account both the size of the adjustment and the uncertainty with which it is estimated.

Given the procedure it used in 2009, Ofcom has to judge the asset beta of Openreach relative to the asset betas of the BT Group and network utilities. An estimate of the pension adjustment to the BT Group asset beta is one possible input to this process. However, it does not reduce the high degree of regulatory judgment required in making this decision. It gives two extra factors to be considered, the estimate of the pension adjustment and the uncertainty about it. Ofcom will have to consider how this fits into its framework of exercising its regulatory judgment in a single step starting from the unadjusted asset beta of the BT Group.

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Appendix 1: Calculations of the BT figures in Table 5.1

	(1) **Ofcom 2005 Copper access**	(2) **Ofcom 2009 Openreach**
Inputs		
EMRP	4.50%	5.00%
Equity beta	0.9	0.76
RF	4.60%	4.50%
Debt premium	1.00%	3.00%
Tax rate	30.00%	28.00%
Leverage	35.00%	35.00%
Inflation	2.50%	1.90%
Nominal costs of equity and debt		
RE	8.7%	8.3%
RD	5.6%	7.5%
Nominal WACC		
Vanilla nominal	7.6%	8.0%
Post-tax nominal	7.0%	7.3%
Pre-tax nominal	**10.0%**	**10.1%**
Real WACC		
Vanilla real	5.1%	6.1%
Post-tax real	4.5%	5.4%
Pre-tax real	7.5%	8.2%

Sources:
(1) Ofcom (2005) paras 8.15 and 8.20.
(2) Ofcom (2009) paras A8.8 and A8.105.

Appendix 2: Calculations of the figures in Table 7.2

Rogers method

2002-2006 data

	(1) Pension risk measure	(2) Regression coefficient	(3)=(1)*(2) Asset beta adjustment
PR1	1.829	0.0460	-0.084
PR2	-0.218	-0.1761	-0.038
PR3	0.149	0.3777	-0.056
PR4	-0.034	0.1997	0.007

2002-2008 data

	(1) Pension risk measure	(2) Regression coefficient	(3)=(1)*(2) Asset beta adjustment
PR1	1.829	0.0515	-0.094
PR2	-0.218	-0.1374	-0.030
PR3	0.149	0.3448	-0.051
PR4	-0.034	0.1031	0.003
PR5	0.113	0.4140	-0.047

Fama-MacBeth method

2002-2006 data

	(1) Pension risk measure	(2) Regression coefficient	(3)=(1)*(2) Asset beta adjustment
PR1	1.829	0.0625	-0.114
PR2	-0.218	-0.4912	-0.107
PR3	0.149	0.3217	-0.048
PR4	-0.034	0.2576	0.009

2002-2008 data

	(1) Pension risk measure	(2) Regression coefficient	(3)=(1)*(2) Asset beta adjustment
PR1	1.829	0.0951	-0.174
PR2	-0.218	-0.6004	-0.131
PR3	0.149	0.2741	-0.041
PR4	-0.034	0.1382	0.005
PR5	0.113	0.3417	-0.038