

Responses to the consultation:

# **Ofcom's approach to risk in the assessment of the cost of capital**

## **PwC response**

August 2004

### **Important Notice**

This document was issued solely to Ofcom for the purposes of assisting it in developing an approach to risk in the assessment of the cost of capital. PricewaterhouseCoopers LLP, its partners and staff neither owe nor accept any duty of care to any third party whether in contract or in tort (including without limitation negligence or statutory duty or howsoever otherwise arising) and shall not be liable in respect of any loss, damage or expense of whatsoever nature which is caused by any third party's reliance upon information derived from the report. If any third party wishes to rely upon the report or information derived therefrom, they do so entirely at their own risk.

## Summary

In June, we delivered our report “Disaggregating BT’s beta” to Ofcom, as part of its consultation on the cost of capital. The key conclusions from our report were:

- “there is sufficient directional evidence for serious consideration to be given to applying disaggregated betas, with the strongest evidence suggesting that a distinction could be made between BT’s information and communications technology (ICT) activities and the rest of BT’s business”;
- “there is weaker, but almost entirely consistent directional evidence to suggest a further disaggregation between the copper access business and the rest of the non-ICT business”; and
- “because of the inherent problems associated with estimation, in our view it seems inevitable that it will be a matter for regulatory judgement whether the directional evidence is sufficient to suggest that disaggregated figures should be applied in practice”.

Ofcom has now received responses to its consultation on the cost of capital, and the responses from BT (including an annex by Professor Cooper) and Telewest in particular comment on our report. This document provides our response to those responses.

Respondents accepted the evidence that BT’s ICT activities have higher systematic risk and the main comments on this area surrounded the precise quantification of this difference.

The evidence for further disaggregation into copper access and the other areas of BT was disputed by respondents. Professor Cooper’s view was that the econometric problems inherent in our analysis meant that any conclusions must be extremely limited and while Telewest agreed that the evidence does support some directional difference in the systematic risk of BT’s differing activities, they argued that little of this evidence was able to quantify these differences in a robust manner. Telewest suggested there was sufficient evidence to justify disaggregating BT’s ICT activities, but making no further disaggregation.

We pointed out in our report that the econometric evidence on the different level of systematic risk for copper access was generally weak and could not be reliably used by Ofcom directly to set the beta to use for copper access activities. However, our opinion of the value of this analysis remains unchanged by the respondents’ arguments, and taken together with the almost entirely consistent qualitative evidence, can be used by Ofcom to inform its judgement of its final selection of the betas to apply in setting BT’s regulated cost of capital.

The only area where a respondent raised new issues that we had not considered were the time series regressions, where Professor Cooper suggested the application of some advanced techniques for dealing with problems of serial correlation and heteroscedasticity. A revised regression produces similar results to our earlier work, and if anything strengthens the statistical tests to produce a more reliable outcome. However, it is not sufficient an improvement to justify strengthening our overall conclusions.

Both BT and Professor Cooper suggested that our evidence was weighted on *a priori* grounds and that we may have introduced bias into, or over-interpreted, our conclusions. We have carefully reviewed our report, and in particular the conclusions we drew, and do not agree with these comments. In the detailed work presented in our report, we went to significant lengths to include all of our analysis, even when inconclusive or contradictory. Where calculations could be performed on a different basis, we presented these alternatives, so that all stakeholders could have access to all of our evidence in forming their own views. In reaching our conclusions we balanced all the evidence with the technical issues faced when

undertaking this type of work, and remain of the view that our conclusions are balanced and supported by the evidence.

# 1 Introduction

Ofcom has received responses to its consultation on the cost of capital, a number of which comment on our report: "Disaggregating BT's beta". This document provides our response to those responses.

As outlined in the summary of this document, the key conclusions from our "Disaggregating BT's beta" report were:

- "there is sufficient directional evidence for serious consideration to be given to applying disaggregated betas, with the strongest evidence suggesting that a distinction could be made between BT's information and communications technology (ICT) activities and the rest of BT's business";
- "there is weaker, but almost entirely consistent directional evidence to suggest a further disaggregation between the copper access business and the rest of the non-ICT business"; and
- "because of the inherent problems associated with estimation, in our view it seems inevitable that it will be a matter for regulatory judgement whether the directional evidence is sufficient to suggest that disaggregated figures should be applied in practice".

This document responds to three documents in turn. We first address Professor Cooper's detailed annex to BT's response, and then address additional points raised by BT itself. Finally we address Telewest's response which makes some points relevant to our work.

## 2 Response to comments by Professor Cooper

We first respond to the comments by Professor Cooper, who responded as part of BT's overall response His comments were organised as follows:

- i. Difficulties in interpreting the evidence
- ii. Comments on ICT comparators
- iii. Comments on changes to BT's beta
- iv. Comments on the time series analysis
- v. Comments on the cross section analysis
- vi. Use of the evidence

Of the comments within these sections:

- a number were not new but were already made in our report;
- a number we do not agree with, and we explain our reasons below; and
- a number raise additional points that are worth our further consideration.

### 2.1 Difficulties in interpreting the evidence

In general we provided evidence on disaggregating BT's beta using a wide range of possible calculation methods, and econometric approaches. Our intention was to be transparent in disclosing the full detail of our work in order to allow stakeholders to interpret the full weight of our evidence for themselves. The following section headings represent the summary of each of Professor Cooper's points, in regard to the difficulty in interpreting the evidence. Each point is explained more fully in his document<sup>1</sup>. We believe that this is an appropriate approach to considering his analysis.

#### 2.1.1 "The measure of beta used as the principle evidence for each test differs between the tests"

We presented different measures of betas calculated using daily, weekly and monthly data, because each is frequently used by cost of capital practitioners. Each test used and reported these different measures of beta in a consistent manner.

However, in selecting principal evidence and the beta method on which we place the most weight for each test it was appropriate to consider the exercise that was being carried out. For example, when comparing betas across companies, it is interesting to look at a range of methods for estimating beta, typically using a longer time period for greater stability, but when conducting time series analysis it is more useful to look at a beta measured over a shorter time period, since this is better for capturing changes over time. This is why some of our principal evidence placed more weight on a particular method of calculating beta.

Our cross sectional evidence used the full range of evidence and its conclusions were drawn from all three beta estimation methods: *"Regardless of which measure of beta is used, estimated asset betas are highest for ICT activities and lowest for the fixed network business"* (PwC page 34). For our time series evidence we dropped the monthly method of calculating beta because it is smoothed by the long time period (five years) used in its estimation, which means that any changes in systematic risk will not be rapidly picked up in the beta estimate. Of the weekly and daily betas, the standard errors on the regressions were better for the weekly estimate than for the daily estimate<sup>2</sup>. Cost of capital practitioners do use a range of

---

<sup>1</sup> Professor Ian Cooper, 2005, *Comments on the document: Disaggregating BT's beta by PwC*

<sup>2</sup> Professor Cooper also asks how we deal with the day of the week problem. We carry out our beta regressions from a Friday to a Friday to minimise this effect (which is most prevalent on a Monday (Paudyal, 1995). As we are more interested in the changes to beta over time, rather than the level *per se* the day of the week problem is of less importance to us.

methods to estimate beta, and we feel justified in allowing the statistical tests from the econometrics to influence the selection of our principal evidence. We believe that this was an appropriate approach to take in this analysis.

#### **2.1.2 “The measures of beta are inconsistent with those used in the analysis performed by Brattle for a closely related purpose”**

Both our report and the analysis of the Brattle Group used a range of beta estimates and there is overlap between us; for instance, we both drew upon beta calculated using 1 year of daily data in our analysis. However, Brattle concluded that its preferred window of estimating beta is two years, whereas we used a wider range from one year to five years, on a daily, weekly and monthly basis.

While our two studies are clearly related, they have different purposes. The Brattle Group study assessed which particular measure of beta will provide the best forward-looking indicator of the degree of correlation between BT’s returns and those of the market whereas our study assessed whether there is a discernable difference in the systematic risk across BT’s activities. The former required a more detailed assessment of the evidence from current methods of calculating betas, whereas our study required the use of a broad range of measures to ensure that any findings were robust, regardless of the method of estimating beta. For our study the consistency of any results was of greater importance than a particular beta method to focus upon. Given that the range of different betas calculated by Brattle (e.g. comparing a one year to a two year basis) is smaller than ours, we do not think that using Brattle’s preferred beta would materially change our results, nor do we think that in principle the two different studies conducted by ourselves and Brattle should have necessarily used the same measures of beta.

#### **2.1.3 “The tests used by PwC are inconsistent with those used by Brattle”**

Again, the cross section and time series analysis we conducted differed from the analysis carried out by Brattle, and in particular some of the required statistical tests were different. Whilst some tests were of a similar type they were carried out differently, for example using different breakpoints. This selection of breakpoints, as noted by both Professor Cooper and the Brattle Group, is subjective and can lead to biased results, but where we used breakpoints we have sourced these breakpoints from external points of reference, such as market volatility or specific events, like the terrorist attacks on September 11<sup>th</sup> 2001. We are still of the opinion that each test was relevant to the analysis that we were conducting.

#### **2.1.4 “PwC appears to weight evidence on *a priori* grounds”**

The purpose of our study was to assess the evidence for disaggregating BT’s beta, with no preconceived ideas as to what evidence we would find. This is why we looked at the “first principles” assessment of BT’s systematic risks. Following our initial qualitative evidence gathering we formed the opinion that the systematic risk for BT’s access services could be lower than that for the remainder of the group. This then set the hypothesis for the more quantitative analysis that followed and we found that some quantitative evidence did support this hypothesis, but other evidence did not. We placed great emphasis on ensuring that the conclusions we reached were balanced, and were backed up by the qualitative and quantitative evidence. We went to significant lengths to include all of our analysis, even when inconclusive or contradictory. Where calculations could be performed on a different basis, we presented these alternatives, so that all stakeholders could have access to all of our evidence in forming their own views. Because none of the quantitative analysis was, in our view, sufficiently robust to provide direct numerical evidence of disaggregated betas, we did not include any figures in either the conclusions or summary sections of our report. We therefore reject the assertion that the evidence was weighted on *a priori* grounds and still maintain the opinion that the conclusions are supported by the evidence.

### **2.1.5 “It is not clear how the samples used for analysis have been chosen”**

Samples of companies were chosen for the ICT pure-play comparators and for the cross section analysis. Selection of comparators is always a somewhat judgemental process. We found that BT’s ICT activities do not sit within a well defined industry grouping and therefore focussed on identifying a number of good comparators in order to provide sufficient evidence to show that the risks of ICT activities were different to BT’s other activities.

For the cross section analysis we required a significant number of companies that cover the full range of BT Group’s activities. We aimed to obtain over 50 companies to give the sample sufficient depth, so that we were able to rely on the regression statistics. We used Bloomberg’s industry classification to identify companies that had a significant activity matching at least one of BT’s activities, and this was refined by excluding certain comparators that did not meet certain thresholds, for example, requiring at least one year of trading history to enable a sensible beta calculation. We also cross-checked Bloomberg descriptions with the financial statements for each company, to make sure that we captured the correct mix of activities. In our study we concentrated primarily on OECD countries, with a special focus on the EU region, as companies from that area show the highest similarities to BT. We believe that this approach to choosing comparators was reasonable and appropriate to the analysis undertaken.

### **2.1.6 “Different measures of the same thing are used in different parts of the analysis”**

Professor Cooper questions why we have used different measures for the same thing, and provides an example of the revenue weights used in the cross section analysis and the book and market values used in the time series analysis. While it would have been ideal to use the same basis of measuring the weights of divisions within companies in both analyses, we were limited in the information available. Whereas detailed information was available for BT, there was limited financial information for the comparable companies we used<sup>3</sup>. This data availability restricted the basis for measuring division size to turnover, when we would ideally have used true value weights. In this case, better information was available for the time series analysis carried out on BT’s beta, and it was sensible to use better data, rather than be constrained to use data consistent with our other analyses.

### **2.1.7 Conclusion**

Our analysis covers a range of technical issues. We appreciate that this is a technical subject and interpretation can be difficult. By providing a full presentation of our results, including sensitivities, different model specifications and using different methods for calculating beta, we hoped that stakeholders would be better able to interpret our results.

We remain of the opinion that where different or apparently inconsistent tests have been used, there is either good reason for this, or were we to re-run tests and/or scenarios then this would not markedly alter our results. We therefore remain of the view that our overall approach was appropriate given the objectives of the analysis and the constraints of the available data.

## **2.2 Comments on ICT comparators**

Professor Cooper agreed with our finding that the systematic risk of BT’s ICT activities is higher than that of the remainder of BT’s activities. He did have a number of points of detail, which he believed reduced the robustness of our conclusions. The following points follow the points set out in Professor Cooper’s document.

---

<sup>3</sup> BT, through the requirement to publish separate regulatory segmented accounts, provides much more publicly available information than many of the international telecommunications companies used in our comparator set.

### 2.2.1 “Beta estimates have not been adjusted to be optimal forecasts”

The high beta values for the ICT comparators were, in part, attributed by Professor Cooper to the lack of adjustment to our betas. We presented all of our beta estimates on a “raw” basis, that is, as direct outputs from OLS regressions, and without subsequent adjustments. These adjustments are sometimes included by providers of beta information; for example Bloomberg provides the option of making this adjustment by quoting both a raw beta and an adjusted beta.

Professor Cooper did not provide his rationale as to why the raw beta should be adjusted, but such adjustments are often justified on the work of Blume<sup>4</sup>, Vasicek<sup>5</sup> and others who have shown that estimated betas are subject to error, are not stationary over time and have a tendency to move towards 1. This work is used to support adjustment of estimated betas towards 1.

This adjustment is often used to adjust a single historic beta estimate for forward looking purposes, but there are other approaches used to minimise estimation errors. One commonly used approach is to estimate beta by obtaining a larger sample of betas from comparable companies in the same industry group. This is based on the premise that betas actually tend towards their industry average beta rather than 1, and is further explored in Martin Lally’s critique of Blume and Vasicek adjustments<sup>6</sup>. This makes conceptual sense. Any industry that is characterised by inherently high or low risk attributes should contain companies with betas on average above or below 1<sup>7</sup>.

We agree that this is a contentious point with no correct answer and many reputable data providers, like the LBS, do provide betas on an adjusted basis. However, given the type of analysis we were carrying out and the fact that we were using broad samples of comparable companies we did not consider it necessary to make any adjustment<sup>8</sup>. For our time series analysis, any mean reversion should be apparent in the raw data, so again it is preferable to work with the raw data.

Regardless of whether the adjustment is made or not, the purpose of providing the ICT comparators is to show that BT’s ICT activities are of different systematic risk to its other activities, and the betas we presented provided robust evidence of this. Even by taking a typical Blume adjustment of a one third weighting towards one, our average ICT equity beta of 2.04 becomes 1.7. This is still significantly higher than BT’s group beta on all current beta measurement bases and close to Telewest’s analysis of the betas for ICT comparators. Telewest’s example was based on the UK “computer services” industry, and Telewest concluded that a figure of 1.8 was representative of ICT systematic risks. Therefore the lack of an adjustment in our analysis does not impact on the conclusions we draw from it. Furthermore we note that our conclusion with regard to ICT activities was directional only – we did not include any figures in either the conclusions or summary sections of our report.

### 2.2.2 Implausibly high beta

Professor Cooper stated that our asset beta evidence for ICT comparators might be implausible, because the figures were higher than any other figures contained in LBS’ Risk Measurement Service. We agree that the betas are high, but ICT activities are likely to have a very high level of systemic risk, as they supply predominantly corporate customers for large,

---

<sup>4</sup> Blume, M.E., 1971, On the assessment of risk, *Journal of Finance* 26, 1-10 and Blume, M.E., 1975, Betas and their regression tendencies, *Journal of Finance* 30, 785-799.

<sup>5</sup> Vasicek, O., 1973, A note on using cross-sectional information in Bayesian estimation of security betas, *Journal of Finance* 28, 1233-1239.

<sup>6</sup> Lally, M. 1998, ‘An Examination of Blume and Vasicek Betas’, *The Financial Review*, vol.33, pp. 183-198.

<sup>7</sup> The presence of cross-correlation in error terms of betas across an industry could mean that a wide sample may still be a biased forward looking estimate. An example of this is how utility betas declined during the TMT boom, but this specific factor was considered in our analysis through the use of dummy variables.

<sup>8</sup> For increased accuracy, Blume’s 1971 work can be used to show how the scale of the adjustment (the weighting towards one) should be reduced as the sample size is increased.

discretionary, technological, projects. The demand for these ICT projects is likely to be heavily dependent upon wider economic factors and the general strength of the UK economy.

Part of the reason why the figure seems high is the different position on whether to use adjustments, as discussed above.

As stated above, our high betas were also supported by the beta analysis provided by Telewest. We do not therefore think that our ICT beta estimates were implausibly high.

### **2.2.3 “It is not clear how the comparison companies have been chosen”**

See paragraph 2.1.5 for our view on this issue.

### **2.2.4 “The estimate of the adjustment to get the beta of the access business is made using revenue weights. The correct weights to use are value weights”**

Professor Cooper commented on our illustration that used revenue weights to disaggregate BT’s group beta into ICT and non-ICT parts. We agree that ideally we would have used true value weights, but without a separate valuation (e.g. a detailed discounted cash flow analysis or separate market listing) of the ICT part of BT’s business this was not possible. Professor Cooper suggested that because the discount rate applied to the ICT part of the business was higher based on our analysis, the value weight should be lower than the revenue weight. We were aware of this point when we produced our report, and took it into account when considering whether a revenue weighting, in the absence of valuation figures, would be a helpful indicator of the relative importance of the ICT activities. We concluded that the higher discount rate was only one of many factors that would influence the relationship between revenue and value – for example, also of importance would be market perceptions of the likely relative faster growth in ICT revenues compared to the remainder of BT’s revenues, which by itself would suggest it should attract a higher value weight than revenue weight. We investigated the enterprise to revenue multiples<sup>9</sup> of our cross section comparators and BT, and because they were not conclusively dissimilar<sup>9</sup> across the different activity areas, including ICT, we used the revenue weights for our illustration. We therefore believe that our approach was appropriate given the available data.

### **2.2.5 Conclusion**

Professor Cooper considered that our analysis of ICT comparators was *“the only robust piece of evidence in the econometric analysis provided by PwC”*, but that there were *“several significant weaknesses that reduce[d] the robustness of the conclusions drawn”* (Cooper page 7). We agree that the ICT analysis does show that BT’s ICT activities do have higher risk than the rest of BT. We do not agree that the weaknesses Professor Cooper suggested reduces its robustness; it is not clear that the betas should be adjusted and the use of weights is an issues of application rather than questioning the validity of our conclusion.

## **2.3 Comments on the cross section regression**

Professor Cooper stated that our cross section regression analysis revealed little information additional to that revealed by the ICT pure-play comparators. This, too, was our principal conclusion from this section. However, the regression analysis does also raise some additional insight about the nature of other non-fixed telephony activities; in particular, mobile activities and other telecoms activities appear to have a beta higher than that for fixed activities. While the standard errors on the regression coefficients may not provide conclusive evidence of this, we do take this evidence as useful directional support for our other work. The following sub-sections provide our response to the points that Professor Cooper thinks impact the interpretation of our analysis.

---

<sup>9</sup> The Enterprise Value to Revenue multiples for the ICT comparators ranged from 0.39x to 2.11x, with BT’s at 1.36x (Source: Bloomberg, latest financial year end)

### 2.3.1 “A method that gives a beta that conflicts with the BT group beta has serious problems”

We agree that the fact that BT’s predicted beta is not close to BT’s actual beta in some of the regressions should be taken into account in drawing conclusions from the analysis. We investigated this fact when we carried out the regressions and it is not unsurprising given that an observed beta moves around considerably, so the observed estimate has the potential drift away from its modelled expected value. Because of the estimation error of the betas, which we use as our explanatory variable, it is understandable that the cross section regression will have predictive errors. This is why our conclusions from the cross section regression were based upon a wide sample of companies, so any estimation error from the beta of one company is diluted by the size of the sample and we can make conclusions from the whole sample on the relative risks of different activities. We do not consider this to undermine the limited conclusions we drew from this analysis.

### 2.3.2 Omitted key variables

Professor Cooper stated that our work did not include any allowance for the nature of the regulatory regime. We used regional dummy variables as a proxy for the differences between regulatory regimes across different regions. We found that the Americas dummy was statistically insignificant and our emerging countries dummy was only significant in one of the regressions.

Regulatory regimes have been converging across the world<sup>10</sup>, increasingly moving away from rate of return regulation so we suspect that the regulatory regime does not have as big a distorting impact on cross-country beta comparisons as it once did. We therefore believe that our work takes account of the potential impact of differences in the regulatory regimes and do not agree that we have omitted a key variable.

### 2.3.3 “PwC regresses the beta on the revenue mix of the companies rather than the proportions of value”

As explained in section 2.2.4, the information readily available restricted us to the use of revenue weights. However, as referred to in footnote 58 of our report, we experimented with adjusting our revenue shares to get an estimate of the true value proportions by running a two-step estimation model, although we did not set out the results in the report. In the first step we regressed the enterprise value/ revenue multiple (EV/REVENUE) of our cross sectional data on the simple revenue proportions to obtain corresponding revenue multiples for the different business segments. To estimate enterprise value shares of different business units we applied these multiples to our original divisional revenue shares.

STEP 1: Intermediate regression:

$$\frac{EV_i}{REVENUE_i} = a_1sfix_i + a_2smob_i + a_3sysint_i + a_4other_i + \varepsilon_i \quad i = 1 \dots N$$

where

ai: revenue multiples of the different segments i=1..4

ε: error term

N: number of companies in the sample

---

<sup>10</sup> Harmonised European legislation has imposed a consistent regulatory regime across EU nations and similar regulation has often been adopted by other countries around the world. In the US the cost of service basis of regulation has been significantly replaced with incentive based regulation, which is far closer to the UK model. This evolution was reviewed by Tardiff and Taylor in ‘Aligning Price Regulation with Telecommunications Competition’, 2003.

STEP 2: Regress beta values on new estimated value shares, generated by the following formula:

$$\begin{aligned} \text{ssfix} &= \hat{\alpha}_1 \text{sfix} \hat{R}, & \text{ssmob} &= \hat{\alpha}_2 \text{smob} \hat{R}, \\ \text{ssother} &= \hat{\alpha}_3 \text{sother} \hat{R}, & \text{ssysint} &= \hat{\alpha}_4 \text{sysint} \hat{R} \end{aligned}$$

,where  $\hat{R}$  is the estimated EV/REVENUE shares from the Step 1 regression.

The second step regression equation is similar to our reported regression:

$$\beta_i = \alpha_1 \text{ssfix}_i + \alpha_2 \text{ssmob}_i + \alpha_3 \text{ssysint}_i + \alpha_4 \text{sother}_i + \varepsilon_i \quad i = 1 \dots N$$

Using this methodology the general conclusions of the cross section analysis remain valid. As the cross-sectional analysis was only an indicative assessment on the relative size of the different parts of integrated telecommunications companies we choose to rely on the less sophisticated and more straightforward methodology in our report.

#### Results of the 2-step beta disaggregation analysis

	MonthlyL	MonthlyG	WeeklyL	WeeklyLR	WeeklyG	DailyL	DailyG
<b>smob</b>	<b>0.908</b>	<b>1.019</b>	<b>0.895</b>	<b>0.895</b>	<b>0.722</b>	<b>0.922</b>	<b>0.748</b>
s.e	(.141)	(.202)	(.128)	(.082)	(.116)	(.112)	(.106)
<b>sfix</b>	<b>0.484</b>	<b>0.388</b>	<b>0.351</b>	<b>0.351</b>	<b>0.256</b>	<b>0.226</b>	<b>0.231</b>
s.e	-0.326	-0.47	-0.297	-0.288	-0.269	-0.26	-0.245
<b>sysint</b>	<b>2.213</b>	<b>3.009</b>	<b>1.916</b>	<b>1.916</b>	<b>1.678</b>	<b>1.68</b>	<b>1.59</b>
s.e	(.226)	(.326)	(.206)	(.332)	(.186)	(.181)	(.17)
<b>sother</b>	<b>1.253</b>	<b>1.773</b>	<b>0.755</b>	<b>0.755</b>	<b>0.889</b>	<b>0.812</b>	<b>0.949</b>
s.e	(.23)	(.331)	(.209)	(.263)	(.189)	(.183)	(.173)
<b>EMERGING</b>	<b>-0.134</b>	<b>-0.539</b>	<b>-0.017</b>	<b>-0.017</b>	<b>-0.238</b>	<b>0.008</b>	<b>-0.372</b>
s.e	-0.181	(.261)	-0.165	-0.144	-0.149	-0.145	(.136)
e(N)	53	53	53	53	53	53	53
e(r2)	0.411	0.478	0.381	0.381	0.405	0.36	0.451
e(rmse)	0.508	0.732	0.463	0.463	0.418	0.406	0.382

#### 2.3.4 “PwC does not say how the mix of activities for each company was estimated”

The revenue mixes for all the companies in our cross section sample were obtained from publicly available annual reports and other publicly available information sources. Because annual reports and company structures vary across international companies, collecting the underlying data for our sample took considerable time and effort. There is a risk that our interpretation of the revenue shares from the publicly available information may not always accurately match the real company position, but there is a benefit in having a reasonably large sample which mitigates the impact of any misinterpretation of foreign company reports. We therefore believe that our use of this data in our analysis was reasonable and appropriate.

#### 2.3.5 Results with no emerging market dummy

The results of our regressions without the emerging dummy, as requested by Professor Cooper, are provided below. This shows that without the emerging country dummy the coefficient on the fixed variable is marginally lower than the regression reported in our report. Regardless of the specification of the regression, we believe our original conclusions remain valid.

## Results of the asset beta disaggregation analysis with no emerging market dummy

Variable	Monthly Local	Monthly Global	Weekly Local	Weekly Global	Daily Local	Daily Global
<b>S<sub>mob</sub></b>	<b>0.991</b>	<b>0.943</b>	<b>0.915</b>	<b>0.685</b>	<b>1.017</b>	<b>0.759</b>
s.e	(.168)	(.254)	(.153)	(.138)	(.134)	(.133)
<b>S<sub>fix</sub></b>	<b>0.637</b>	<b>0.617</b>	<b>0.581</b>	<b>0.405</b>	<b>0.508</b>	<b>0.348</b>
s.e	(.162)	(.245)	(.147)	(.133)	(.129)	(.128)
<b>S<sub>ict</sub></b>	<b>2.360</b>	<b>3.228</b>	<b>2.072</b>	<b>1.826</b>	<b>1.809</b>	<b>1.720</b>
s.e	(.225)	(.341)	(.205)	(.186)	(.180)	(.179)
<b>S<sub>other</sub></b>	<b>1.451</b>	<b>1.950</b>	<b>0.823</b>	<b>1.026</b>	<b>0.854</b>	<b>1.012</b>
s.e	(.288)	(.436)	(.263)	(.238)	(.231)	(.229)
N	53	53	53	53	53	53
Adj. R <sup>2</sup>	0.466	0.477	0.437	0.458	0.416	0.444
RMSE	0.479	0.725	0.437	0.395	0.383	0.380

### 2.3.6 Conclusion

The conclusions of our report did not include the quantitative regression outputs precisely because of the drawbacks that we highlighted and which were reiterated by Professor Cooper. We therefore relied on the cross sectional work as providing useful directional evidence to support our qualitative findings. All of the issues raised by Professor Cooper were considered in the course of our work and we therefore consider that our conclusions remain valid.

## 2.4 Comments on historical changes to BT's beta

Our evidence on the historical changes in BT's beta is mixed and we concluded that there were too many complicating factors to enable us to draw any firm conclusions from this analysis. Professor Cooper agreed with this conclusion, but he raised a number of points of detail. Again, we take his points in turn.

### 2.4.1 "The betas for each period are measured using data from outside the period"

Because the data used in the regressions often falls into earlier time periods, Professor Cooper suggested that the higher 1.08 asset beta from the "Growing new wave and ICT" period (calculated on a monthly basis, over 5 years) actually reflected the "Back to fixed telecommunications" period, and because it was higher than the previous period of "International and product diversification", he suggested that this contradicted one potential conclusion we made that BT's beta fell during the "Back to fixed telecommunications" period.

This may not be correct. While the beta estimation uses historic information, the movements in shares prices, which are used to calculate betas, are dictated by investors' future expectations. This means that at any point in time the beta should be revealing something about the future known systematic risks of the business. How much forward expectation was relevant in the case of BT when looking back over historic betas is difficult to tell, given that some changes to BT's risk profile were well communicated in advance and some were sudden. This effect may mitigate Professor Cooper's point.

Our directional conclusion from this analysis was drawn from the analysis of weekly and daily betas which do show reductions over the "Back to fixed telecommunications" period and are better suited to this type of analysis because the betas are calculated over shorter time periods.

Therefore, we do agree with Professor Cooper's point, but because it is mitigated by the possible forward expectations of investors, and because our directional conclusions were drawn from betas estimated over relatively short time periods, we do not consider that it has a material impact on our conclusions.

#### **2.4.2 “The dating of the break points between periods chosen by PwC is arbitrary”**

The selection of break points requires judgement and is best if it can be related to specific exogenous events (like the end of the TMT boom in December 2000). We assessed BT's Annual Reports to select our other break points. Even when specific events can be identified, they may not be ideal. For example the sale of O<sub>2</sub> may be a good break point, but if it was anticipated by the market beforehand, then the break point could arguably be earlier. We have revisited our break points and whilst we accept that the choice is subjective, this is inevitable and we remain of the opinion that they are sensible break points, and are reasonable for our purposes.

#### **2.4.3 “Some of the beta estimates used are inherently implausible”**

Professor Cooper raised the point that the beta estimates are implausible in their erratic movements, clearly indicating an econometric problem. This is why our study went to, in Professor Cooper's words, “*heroic efforts to extract the maximum amount of information out of data*” (Cooper page 16) by stretching “*standard methods to the absolute limit*”. Because of the erratic nature of beta movements we have not sought to rely upon any one beta estimate or methodology and have looked for a broad consensus of results across all the evidence.

#### **2.4.4 Conclusion**

None of Professor Cooper's points leads us to change our conclusion of the usefulness of the historic changes to BT's beta. We are in agreement that no firm conclusions can be taken, but we still consider that the observations from the time profiles of the daily and weekly betas are useful to show that BT's beta did peak when it diversified away from UK fixed telecoms activities.

### **2.5 Comments on the time series regression**

Professor Cooper raised a number of technical econometric issues, which in his opinion meant that the time series analysis was unable to provide any robust conclusions. We were aware of the bulk of these econometric issues when we undertook our analysis, and we attempted to resolve them. Again we address Professor Cooper's points in turn.

#### **2.5.1 Selection bias**

Professor Cooper stated that the selection of our dependent variable in the time series regression conflicted with our other tests. As explained in paragraph 2.1.1 we carried out the econometric tests using a number of methods of calculating beta, and in this piece of analysis we presented the results using both weekly and daily betas. We used both pieces of evidence, which are consistent, in arriving at our conclusions, but also stated a preference for the weekly regressions. The rationale for this, as stated in our report, was that the more variable weekly estimate may pick up any changes in systematic risks better than the less variable daily estimate, and when inspecting the regression output the standard errors on the coefficients were lower for the weekly regression.

We do agree that the figure for the weekly beta is highly volatile and is more likely to be related to spurious measurement rather than large changes in fundamental systematic risk. In using a poor estimate of beta, our results are undoubtedly weakened, but we were aware of these problems and our directional conclusions took account of this issue.

An issue in relying upon the standard errors to guide us on which evidence is preferred, is that some of Professor Cooper's points below, which concern the validity of standard errors,

may invalidate the tests for the statistical quality of the coefficients. We respond to these points below.

While selection bias is a potential issue, we do not consider it to be too relevant in this case, because both beta regressions provide broadly consistent results. We were more concerned with obtaining consistent results across the different methods of estimating beta, rather than focussing on one particular regression output. We are therefore not concerned with any selection bias of the choice of one particular regression in this situation.

## 2.5.2 Measurement error

Professor Cooper challenged our assumption of using book values to measure the value shares of the different businesses within BT. We dealt with this in our report with a full discussion of how much the market value of access is likely to vary and by performing a sensitivity that allowed the market value of the access business (i) to vary across the year by interpolation and (ii) to vary in line with BT's overall enterprise value, but constrained by the typical range for the ratio of the market value to the regulatory asset value.

The results of our sensitivities, which were not presented in our original report, are set out below. All sensitivity analysis is conducted on our preferred equation which uses the equity beta calculated on a weekly basis.

### Sensitivity test 1

We have interpolated the monthly regulatory asset values (RAV) of core and access activities, to test for the sensitivity of assuming step changes in the implied market value of the non-access business. The significance of the proportion of the non-core/access does not change and the coefficient increases only slightly (from 0.265 to 0.288).

<b>Dependent Variable: Change in Ln (Beta)</b>			
<b>Adj R-squared = 0.2820</b>	<b>F (5,111) = 10.11</b>	<b>Number of Obs = 117</b>	
<b>Independent Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>	<b>t-stat</b>
Lag 1. Ln(Equity Beta)	-0.316	0.052	-6.06
Lag 1. % of Non-A&C	0.288	0.140	2.06
Lag 1. Ln (Gearing)	0.140	0.064	2.18
Dummy – Nov 99 – Aug 01	0.163	0.066	2.45
Dummy – Sept 01 – Aug 02	-0.737	0.123	-6.01
Constant	-0.198	0.077	-2.58

### Sensitivity test 2

We have also replicated the analysis using simulated RAV figures for the access and core businesses.

We have assumed that RAV moves with perfect correlation with BT's total enterprise value, as an extreme scenario of the positive correlation between book values and market values. The simulation exercise only emphasized the importance of the proportion of non-core or access as a determinant of beta (the coefficient increases from 0.265 to 0.350).

<b>Dependent Variable: Change in Ln (Beta)</b>			
<b>Adj R-squared = 0.2878</b>	<b>F (5,113) = 10.54</b>	<b>Number of Obs = 119</b>	
<b>Independent Variable</b>	<b>Coefficient</b>	<b>Standard Error</b>	<b>t-stat</b>
Lag 1. Ln(Equity Beta)	-0.317	0.052	-6.15
Lag 1. % of Non-A&C	0.350	0.157	2.24
Lag 1. Ln (Gearing)	0.143	0.063	2.25
Dummy – Nov 99 – Aug 01	0.155	0.066	2.34

Dummy – Sept 01 – Aug 02	-0.584	0.088	-6.65
Constant	-0.216	0.078	-2.76

Both these sensitivity tests give us some confidence that whilst using book values as a proxy for market values is an approximation, it does not materially impact our results or conclusions, and if anything strengthens our original (directional) conclusions. Further sensitivities on the other specifications gave equally consistent results.

### 2.5.3 Serial correlation and heteroscedasticity

The problem of overlapping time periods and serial correlation was addressed in our initial analysis by taking the lag of the explanatory variable in our more complex functional forms (PwC p40). However, Professor Cooper considered this to be a limited correction and suggests a more complex approach:

*“In its regressions PwC uses overlapping periods as if they are non-overlapping, or with a limited correction for the serial correlation that is induced. This can result in very large biases when the data overlap as much as the data used by PwC. It can lead to apparent statistical significance where none exists. The correct adjustment for overlapping data is complex (Hansen and Hodrick (1980))”*

*“PwC estimates without making any correction a regression that includes data that, in Brattle’s opinion, exhibit heteroscedasticity (Brattle (2004) p 5).”*

Professor Cooper points out in his comment that PwC relies on beta estimates that are heteroscedastic, resulting in heteroscedasticity in our regressions. To correct for this problem we should have used for example Autoregressive Conditional Heteroscedasticity (ARCH) process to generate more efficient beta estimates. In our estimations we wanted to rely on beta measures that were calculated using standard methodology, such as the Bloomberg or LBS betas, therefore we did not correct for this (and numerous other, non-standard problems).

Following Professor Cooper’s suggestion, we have run a new regression, based on our preferred equation using the Hansen(1982) method<sup>11</sup>. This involves estimating a simple OLS regression correcting the variance-covariance matrix using the Newey/West method that results in standard errors that are robust to both autocorrelation and heteroscedasticity. The results are improved using the Newey/West estimator and further emphasise the significance of the effects of the proportion of non-core & access of BT on its beta. The results are presented in Section 2.5.9 below.

### 2.5.4 Omitted variables

Professor Cooper stated that the possibility of omitted variables has the potential to bias our results, but the one example he provides (market volatility) was already incorporated into our analysis, through the dummies which accounted for periods of high market volatility. With no indication of any other additional variables to include in our analysis it is unclear how he would improve the specification of the regression.

We agree that the potential for omitted variables, and the low explanatory power of our regressions, means that we should not place undue weight on the results, but this was known at the time of our analysis and was considered in drawing our conclusions.

<sup>11</sup> Bernhard & Leblang (1999) had similar problems on weekly data and 30-day forward exchange rate. They used the Newey-West estimator of the standard error “that uses a finite number of autocorrelated lags to approximate residual dynamics. As a result, it provides standard errors that are robust to autocorrelated and heteroscedastic disturbances.”

### 2.5.5 Misspecification (access)

Professor Cooper raised the misspecification point which we also raised in our report. The regressions that relied upon the change in non-access activities to determine the changes in BT's beta provided results that were more unreliable than regressions that relied upon the change in non-access and core activities. The results were inconsistent with the hypothesis that the systematic risks are lower in access than in core. This is a serious drawback of our results, but is one that we set out clearly in our report. This, together with other difficulties with the analysis, explains why we took only directional conclusions from the time series analysis.

### 2.5.6 Non-normality

Professor Cooper suggested that non-normality may restrict the use of significant tests:

*“All the significant tests assume normal distributions, but the rapid changes in beta estimates in Chart 7 suggest that this may well not be true. ... There is evidence of non-normality in the data on which these estimates are based (Cooper (2005)). This may lead to non-normality in the residuals of the regressions used by PwC.” (Cooper page 12)*

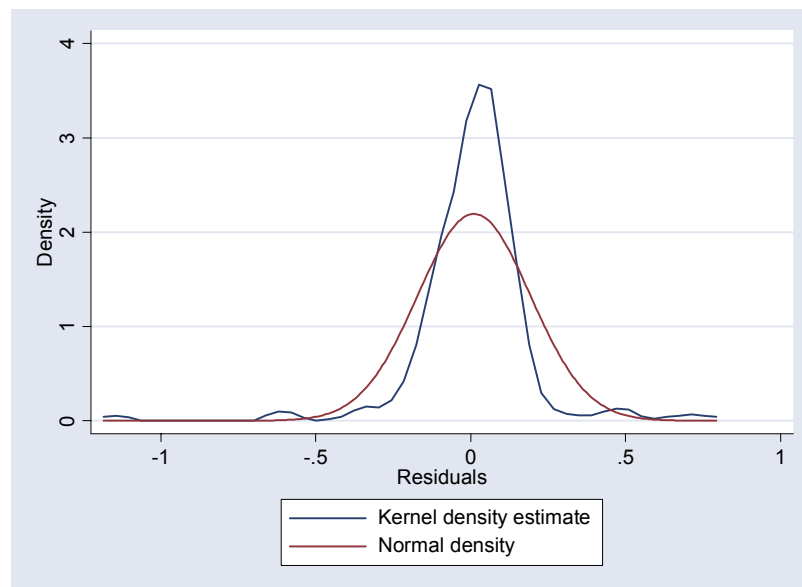
We acknowledge Professor Cooper's comments on non-normality of the residuals in some of our simpler regression analysis, but this is why we sought to improve the functional form to reduce the non-normal properties of the residuals. For the revised preferred equation (using the Newey-West method), a plot of the residuals suggested a higher concentration of residuals around the mean (lepto-kurtic) compared to a normal distribution. Such departure from normality can be attributed to the presence of a high proportion of minimal change in beta over two consecutive months and too few larger negative and positive changes. This, as Professor Cooper points out, affects the significance of the variable. Nevertheless it does not affect the estimated coefficient.

In the case of lepto-kurtic residuals, the “correct” standard error would be lower than if normality is assumed, and would only amplify the significance of the independent variables. A particular correction might be re-estimation using the GARCH model as it allows the series to have excess kurtosis without violating the normality assumptions. We experimented with a simplistic GARCH (1,1)<sup>12</sup>, presented in Section 2.5.9, from which we do not draw inferences, but merely to indicate that correction for normality would not change the estimated coefficients, and would only stress their significance.

---

<sup>12</sup> Implementing GARCH procedures would involve extensive tests and further analysis. We have therefore presented a simple specification for the purpose of illustration. Choice of p and q in the GARCH (p, q) are arbitrary in this case, in the interest of having a 'good starting point'. PwC has not conducted further analysis of BT's beta in GARCH and will not accept responsibility of any conclusions or inferences from this particular set of results.

### K-density plot of residuals



The non-normality of residuals does not impact the estimated coefficients, and therefore does not impact our directional findings from this evidence. Having investigated the residuals in greater depth, we could probably strengthen the significance of the conclusions compared to our original analysis.

#### **2.5.7 Ex-post selection of dummy variable**

Professor Cooper challenged our inclusion of the dummy variable for the period of high market volatility around the time of the TMT boom. We note that this challenge appears somewhat inconsistent with his point on omitted variables, where he suggested some variable for market volatility should be included.

We think that the inclusion of a dummy variable per se was not the primary concern of Professor Cooper<sup>13</sup>, but instead the selection of the time period for the dummy variable. The time period was selected by reference to the movement in overall market volatility<sup>14</sup>, and we conducted sensitivities around the dates used for the dummy period in our report which showed that the overall results were not sensitive to the precise choice of date.

Professor Cooper also questioned why the break points were not the same for the time series analysis and the analysis of BT's beta over time. This is because they are different pieces of analysis. The analysis of beta over time uses break points based upon changes in BT's activities, whereas the break points for the dummies in the time series analysis are based upon periods of market volatility, with BT's changing activity mix being picked up by the explanatory variables.

#### **2.5.8 Misspecification (beta)**

Professor Cooper questioned our practice of using period end activity mix figures with our beta estimates, which in his view may have caused an error.

As mentioned in Section 2.4.1, because betas are somewhat forward looking this may mitigate the timing mismatch between the beta estimates and the date of the activity mixes. Furthermore we use one year betas in this analysis over a long time period, so we would expect any error cause by this misspecification to be small and to have no impact on the conclusions that we draw from this analysis.

---

<sup>13</sup> As referred to in our report, a number of economists have investigated the impact of market volatility on beta.

## 2.5.9 Revised regression

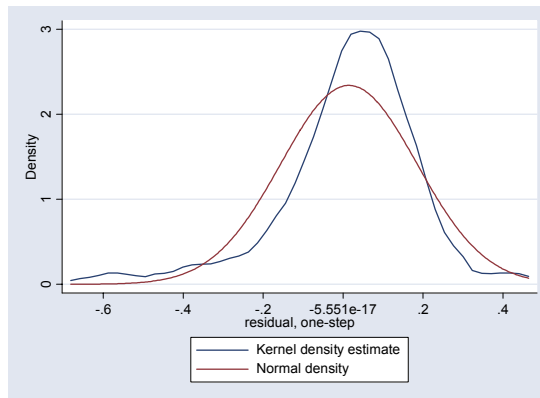
Following a number of suggestions from Professor Cooper, as mentioned above, we have run a revised regression to improve the treatment of serial correlation, heteroscedasticity and non-normality. This results in a limited change to the coefficient on the proportion of non access and core and improves the t-statistics.<sup>15</sup>

Dependent Variable: Change in Ln (Weekly Beta) Access & Core with Dummies & Lags						
	OLS Regression		Newey-West Regression Lag(12)		GARCH (1,1) (Indicative only)	
Independent Variable	Coeff	t-stat	Coeff	t-stat	Coeff	z-stat
Lag 1. Ln(Equity Beta)	-0.315	-6.11	<i>(see note i)</i>		-0.367	-9.75
Lag 1. % of Non-A&C	0.265	1.96	0.250	2.33	0.300	3.13
Lag 1. Ln (Gearing)	0.137	2.17	0.152	1.69	0.181	4.10
Dummy – Nov 99 – Aug 01	0.163	2.48	-0.062	-2.10	0.276	5.71
Dummy – Sept 01 – Aug 02	-0.571	-6.55	-0.211	-2.43	-0.623	-8.95
Constant	-0.183	-2.51	-0.145	-2.15	-0.220	-4.50
Adjusted R-squared	0.28		<i>(see note ii)</i>		<i>(see note iv)</i>	
RMSE	0.186		<i>(see note ii)</i>		<i>(see note iv)</i>	
Effect of Non-core/Access	Positive Significant		Positive Significant		Positive Significant	

### Notes:

- i. Lag beta is no longer required under the Newey-West approach, as serial correlation is corrected in the approach.
- ii. R-squared and RMSE not reported in Stata under Newey-West. F-statistic is  $F(4, 115) = 4.02$  and significant at the 1% level.
- iii. The choice of lags to be included is 12 (number of overlaps), given that our dependent variable is monthly 1-year beta.
- iv. R-squared and RMSE not reported in Stata under Newey-West. Log-likelihood is  $LL = 46.62$  and Wald  $\chi^2$  is 123.78, both significant at the 1% level.
- v. The k-density graph for the residuals under GARCH procedures is presented below.

<sup>15</sup> The one change of note is the sign on the first dummy variable, which switches to a negative sign in the Newey-West approach. This may be caused by the interaction of the Newey-West technique for serial correlation and the dummy variable timings and means that interpretation is difficult.



### 2.5.10 Conclusions

There are typically many econometric problems inherent with this type of time series analysis, and Professor Cooper’s list of issues shows the complexity and difficulty in achieving a truly robust regression result. We accept that in a number of instances we can improve on our original regressions, and the results from our improved regression specification in Section 2.5.9 provide coefficients which are consistent with our earlier work but with lower standard errors, suggesting an improved reliability.

However, the improvement of this revised regression is not sufficient to warrant a significant re-rating of the strength of the evidence provided by the time series regression. Econometric issues still remain. Some we consider are not of sufficient importance to restrict our conclusions, but some issues, particularly concerning the variability of the results and the potential misspecification discussed in Section 2.5.5, mean that we remain of the opinion that whilst the time series analysis provides useful directional evidence in support of our other evidence, it is unable to provide robust quantitative disaggregated beta figures.

## 2.6 The use of the evidence

Professor Cooper questioned how we were using our evidence, and in particular focussed on our analogy to standard beta estimation.

In our report we drew an analogy between the difficulty in disaggregating beta and the estimation of beta in the first place – both are subject to considerable error, and ultimately require judgement. For example, Ofcom needs to use its judgement to decide on what group beta to choose. Any use of the capital asset pricing model inevitably requires a regulator to exercise judgement, on issues such as the beta measure to use, the period of estimation to consider, which comparators to include, and what equity risk premium to apply etc. We simply stated in our report that this inevitable need for judgement in choosing the group beta established a precedent for the possible exercise of judgement in choosing whether, and if so by how much, to disaggregate the group beta.

Professor Cooper disputed this analogy because the evidence of BT’s beta comes from a more direct source (share prices) than our more indirect work (which in addition, relies on revenue share information and asset share information). While we agree that our approach is more indirect, our analogy was focused on the range of *outputs* rather than inputs that can be observed for both types of analysis, beta and disaggregation.

Professor Cooper seemed to suggest that our indirect work on beta disaggregation should not be relied upon in favour of more direct evidence on BT’s group beta. Our response is that the group beta contains estimation error and the disaggregation analysis also contains estimation error (which may be potentially larger because of the additional layers of complexity). Ofcom should therefore consider both pieces of evidence in arriving at its best judgement of what BT’s access beta should be.

## 2.7 Overall Conclusions from Professor Cooper's response

It is important to consider what aspects of Professor Cooper's response we had not fully considered in our original report and therefore whether we should *change* our original conclusions.

Professor Cooper's comments about the ICT comparators, cross section evidence and historical changes to BT's beta over time were considered during the course of our work and therefore do not cause us to change our opinions about those pieces of evidence. Where Professor Cooper's comments did cause us to revisit our analysis was in the time series section, but this did not have a material impact on the regression results. We therefore stand by the conclusions in our report.

## 3 Response to comments by BT

### 3.1 Main points relevant to our report

The BT submission drew heavily upon the Annex provided by Professor Cooper to which we have responded in section 2 above.

The additional points made by BT<sup>16</sup> were:

- “BT accepts that there are some *a priori* grounds for suggesting that copper access may have lower risk than the riskiest parts of BT. However, the direct evidence for this, and the evidence on which to base a numerical estimate, is not convincing.” (BT page 4)
- “BT’s equity beta for copper access activities could be 0.15 below the group equity beta.” (BT page 2)
- On the ICT comparators: “we remain doubtful that the range of possible betas is relevant. The sample chosen was small (only five comparators as per Table 1 on page 15 of the PwC paper), and although these companies operate in what is broadly described as ICT, it is by no means clear that they are comparable either with each other or with BT’s ICT activities.” (BT page 10)

### 3.2 Our response

We welcome BT’s acceptance that there are some *a priori* grounds for suggesting that copper access may have a lower risk than the riskiest parts of BT, as we found from looking at our first principles assessment of BT’s systematic risks.

While there are only 5 comparators for BT’s ICT activities in our sample, their equity betas were consistently above BT group’s equity beta. We still conclude that this evidence, taken with an understanding of the risk characteristics of the ICT business and the directional results of our cross section regression analysis, is sufficiently robust to show that ICT risks are higher than the Group, and therefore disaggregation to at least this level is justified.

BT does not provide any additional comparators for its ICT business, but Telewest provides an analysis of equity betas in the UK computer services sector, which supports our directional conclusion. Telewest also suggest that the evidence is sufficiently robust to disaggregate BT’s group beta.

---

<sup>16</sup> BT’s response to the consultation document, 22<sup>nd</sup> July 2005

## 4 Response to comments by Telewest

### 4.1 Main points relevant to our report

Telewest agreed that while our evidence does support some directional difference in the systematic risk of BT's differing activities, little of this evidence is able to quantify these differences in a robust manner.

Telewest suggested disaggregating BT's ICT activities, but making no further disaggregation, and they provided an alternative table of a number of different comparators, drawn from the UK computer services market. Telewest concluded that the overall equity betas from their sample was around 1.8, which supported their conclusion that BT's ICT activities are of higher risk than the remainder of BT.

### 4.2 Our response

The Telewest sample provides additional evidence in support of one of our principal conclusions – that BT's ICT activities are of higher risk than the remainder of BT.

In taking a wider group of computer services companies, the Telewest sample does risk including companies with activities that are significantly different to BT's ICT activities, and companies that are significantly smaller, which may produce different betas<sup>17</sup>. For example, World Television Group is a company with 43 employees and describes itself as an international corporate communications, news production, webcasting and event management company<sup>18</sup>. However, we do think that the Telewest analysis of computer services betas is a useful addition to our analysis of ICT betas and could be considered by Ofcom, if it were to choose to disaggregate BT's beta by stripping out BT's ICT activities.

---

<sup>17</sup> Fama and French produced some of the early work to show that size, in addition to beta, could explain required returns. See Eugene F. Fama and Kenneth R. French, "Multifactor Explanations of Asset Pricing Anomalies," *The Journal of Finance* (1996).

<sup>18</sup> [www.world-television.com](http://www.world-television.com)