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

Second consultation in relation to BT's equity beta

BT's response to the
Ofcom consultation document
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Annexes to main response

This document includes the following annexes referred to in BT's main response, written on behalf of BT by Professor Ian Cooper, London Business School:

Annex 1:
Comments on the Brattle Group document "Beta analysis of British Telecommunications: Update"

Annex 2:
Comments on the PwC document "Disaggregating BT's Beta"

This document is available electronically at http://www.btplc.com/responses

Comments on the document:

Beta analysis of British Telecommunications: Update

Brattle, June 2005

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SUMMARY

This note is a review of the evidence and arguments given in the document *Beta analysis of British Telecommunications: Update* (June 2005, Brattle), which is an update of the earlier document *Financial Analysis of British Telecommunications* (February 2004, Brattle).

In 2004 Brattle's conclusion was that the best estimate of BT's equity beta was 1.29, based on one year of daily data. Both Ofcom and BT accepted this estimate. Estimates made using the Dimson adjustment and a world index were discounted. Brattle now recommends an estimate of 1.0 based on two years of daily data, and gives some weight to estimates made using the Dimson adjustment and a world index.

Brattle's new preference for a two-year window is partly based on statistical tests that are, in my opinion, biased. Brattle itself largely discounts them. It is also based on an intuitive examination of a chart of the development of estimates of BT's beta. This shows that the two-year estimate was stable until very recently at a level of 1.2-1.3. Brattle's preference for the two-year estimate comes from this period of stability. The justification for the change in Brattle's beta estimate comes entirely from a very recent period of very high instability in this estimate. I cannot see how a change based on a period of high instability can be justified by a period of stability that implies an entirely different value.

In my opinion, the very recent very rapid change in Brattle's estimate does not reflect a change in the fundamental risk of BT. There is strong evidence that it is a statistical artefact caused by outlier observations and heteroscedasticity. These econometric problems make beta estimates unreliable. They can explain why the two-year, one-year and six month estimates have all changed rapidly recently and give conflicting signals. They also invalidate the test on which Brattle bases its justification of the Dimson adjustment.

A summary of evidence on BT's beta in a form used by Ofcom is given in the Table below, whose details are given in section 7. It shows the prior belief of 1.3, which was the beta estimate used by Brattle, Ofcom and BT as recently as last year. Unless there have been significant identifiable changes in the fundamental risk of BT in the last year, this estimate should, in my opinion, still carry significant weight. In my opinion, there have been no such changes.

The table also shows current beta estimates based on one-year, two-year and six-month windows using daily data, the estimators examined by Brattle. It shows an estimate based on five years of monthly data. It also shows a range of estimates relative to a world index that have been estimated in a way that is, in my opinion, preferable to the procedure used by Brattle.

Summary of the evidence on BT's beta

Estimated by	*Data frequency*	*Index*	*Period*	*Estimate*
Prior belief				1.3
Updating evidence				
Cooper	Daily (One year)	UK	2004-05	1.1
Cooper	Daily (Two years)	UK	2003-05	0.9
Brattle	Daily (Six months)	UK	2004-05	1.4
LBS	Monthly	UK	2000-05	1.4
Cooper	Daily	World	2004-05	0.9-1.2

In my opinion, combined with the evidence of the unreliability of the recent estimates based on daily data, Table 2 shows what closer inspection of the evidence also shows: there is no strong evidence on which to base a significant revision of the earlier beta estimate of 1.3.

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1. Introduction

This note is a review of the evidence and arguments given in the document *Beta analysis of British Telecommunications: Update* (June 2005, Brattle), which is an update of the earlier document *Financial Analysis of British Telecommunications* (February 2004, Brattle).

The discussion in this note is limited to issues raised in these Brattle documents, and their use by Ofcom. It does not examine estimates of beta produced by other services, such as London Business School, Datastream, or Bloomberg.

2. Summary of Brattle's conclusions

In Brattle (2004), the conclusions were:

1. The best estimate of BT's equity beta in February 2004 was 1.29, based on daily data from the calendar year 2003, measured against the FTSE All Share index.
2. Betas measured against a World index had statistical problems that invalidated their use.
3. No Dimson adjustment for thin trading or the bid-ask spread was necessary.

Both Ofcom and BT accepted the estimate.

In Brattle (2005), the conclusions are:

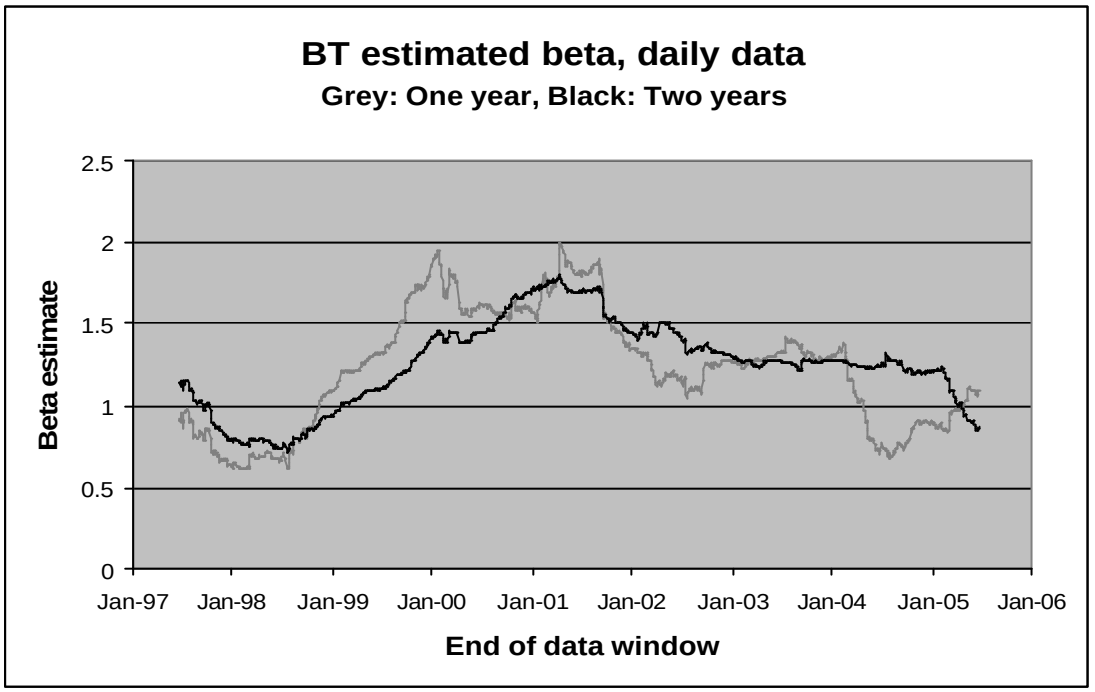
1. Betas measured against a World index have some, though limited, value.
2. The Dimson adjustment for thin trading and the bid-ask spread is significant and has some value.
3. The best data window for beta measured against the FTSE All Share Index is two years.
4. The range of possible beta estimates in June 2005 is 0.49-1.01.
5. No single estimate is given, although Brattle 'recommend(s) adopting an estimate at the top of the range'. This seems to imply a value of about 1.0.

Brattle's new conclusions are mainly based on betas measured relative to the FTSE All Share Index using daily data to 11/04/2005. First, I analyse these. Then I discuss the analysis of betas measured relative to a world index.

3. Updated estimates

Before examining Brattle's estimates, I update the evidence of how the beta estimates have evolved beyond the point where the data used by Brattle ends. Figure 1 below reproduces information in Figure 1 of Brattle (2005). It shows beta estimates for BT using one year and two-year windows of daily data. The data used by Brattle end at the point where the lines cross in April 2005.

Figure 1: BT beta estimates from 1997



In my opinion, the following features of this chart are important:

1. From 2002 until early 2004, both estimates indicated a beta of around 1.3.
2. In the recent past both estimates have behaved erratically. The one-year beta estimate has fallen and then risen rapidly while the two-year beta estimate has fallen rapidly in the very recent past.
3. The two-year beta estimate has tended to follow the one-year beta estimate with a lag.
4. Both estimates have been roughly equally volatile over the period.
5. The Brattle data ends coincidentally at the point when the two estimates are equal.

6. At the moment (using data to 4/7/2005) the one-year estimate is 1.10 and the two-year estimate is 0.88. Therefore, they are no longer equal, as at the end of the Brattle data.

Brattle also reports a beta estimate based on a six-month window, which is 1.38 at the end of its data period.

4. Brattle's choice of estimate

4.1 Introduction

In Brattle (2005), Brattle prefers a two-year window. This is a change from its preference in Brattle (2004) for a one-year window. The choice is based on three tests:

1. Tests of statistical difference in beta estimates for different periods.
2. Chow tests of structural stability in different periods.
3. Beta development graphs.

The first two are statistical tests. The third is an informal test.

4.2 Statistical tests

The test of statistical difference in betas appears to indicate that the latest six months of data has a higher beta than the prior six months. No other tests of differences in beta show any significance. In my opinion, if this test is taken at face value, it indicates that the most recent six-month beta estimate of 1.38 should be given higher weight in any estimate, because it appears to have increased significantly over earlier periods.[1] In contrast, Brattle interprets the test as indicating that the two-year beta should be used. It is not clear to me how it draws this inference from this test. If the latest six months is statistically different from the prior six months, the two periods should not be pooled together, whether it is within a two-year window or any other.

Brattle discounts the second of the tests, the Chow test, on the grounds that it can be misleading unless there are *a priori* grounds for the choice of the break point between periods. According to the econometric

[1] Brattle discounts this change on the grounds that it simply represents 'statistical noise'. However, the point of tests of structural stability is to distinguish changes in parameters from changes caused by noise. The fact that an estimate based on a six-month window is noisier than one based on a longer window is taken into account in such a test. Although Brattle discounts the results of this test in Brattle (2005), Brattle (2004) uses the result of a similar test to justify the choice of a one-year window.

authority cited by Brattle, this also applies to the test of statistical difference in betas used by Brattle, which is a special case of the Chow test. The conclusion of this authority is stronger than that given by Brattle:

> '..in some applications the timing of the break may be unknown. The Chow and Wald tests become useless at this point.'[2]

The estimation of BT's beta is a case where the timing of the structural break is unknown.

My interpretation of both of these tests is different to Brattle's. I agree with Brattle that the lack of any *a priori* grounds for the choice of break points gives a chance of the Chow test finding spurious results. In my opinion, this also applies to the test of statistical difference in betas. There is another problem that can bias both tests. The tests assume that the regression residuals satisfy standard assumptions. In particular they require that the residuals are normally distributed. A test of the data used by Brattle indicates that they are not.[3] The problem with non-normality of daily stock returns is well known (Campbell et al (1997)). Even apart from the problem with identifying the break point, this deviation from normality invalidates the tests of stability performed by Brattle.

In conclusion, in my opinion there is no reason, based on the statistical tests performed by Brattle, to prefer a particular length of data window to any other. The lack of any *a priori* reason for the choice of periods is acknowledged by Brattle to cause a problem with the Chow test. It causes the same problem with the test of beta stability. In addition, the regression residuals are not normally distributed, which invalidates the tests performed by Brattle. I cannot see any reason, based on the statistical tests presented by Brattle, to change from a one-year window to a two-year window.

If one does take the tests at face value, they appear to indicate that the most recent six months of data should be given greater weight than previous periods, because the tests indicate a structural break six months ago. This would mean that the beta estimate of 1.38 during that period

[2] Greene (2003) page 139.

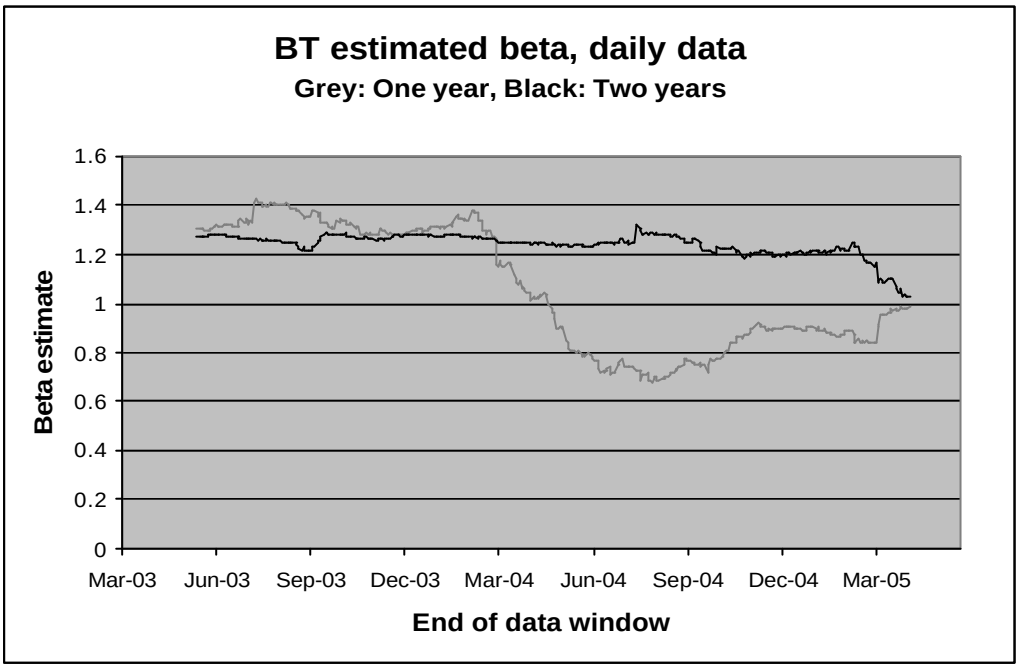
[3] In particular, the two-year regression to 11/04/2005 favoured by Brattle has three observations with standardised residuals greater than 4, and five more greater than 3. Each of these has a very small chance of being generated by a normal distribution. Collectively, there is zero chance that they come from such a distribution. More formal tests based on the kurtosis of the residuals and the Bera-Jarque statistic confirm this.

should be given higher weight. However, my own interpretation of both tests is that the deviation from normality and lack of exogenous dating of the structural break invalidates the results of the tests, so that nothing can be concluded from them regarding the best choice of the window with which to estimate the BT beta.

4.3 Beta development chart

Brattle's preference for a two-year window is also based on graphical evidence that the two-year is 'the most stable of the estimates'. The evidence given by Brattle is reproduced in Figure 2, which is a subset of Figure 1.

Figure 2: Beta development chart



According to Brattle, Figure 2 'confirms that the two-year estimate is the most stable of the estimates'[4]. In my opinion, this is not true in any sense that is relevant to the estimation of the beta of BT going forward, for the following reasons:

1. The stability does not apply in the most recent period. In particular, the estimate has fallen from 1.2 to 1.0 over the space of two months. This is a huge change in beta in such a short time that is unlikely to be related to any fundamental change in BT over that period. The most recent estimate, which Brattle advocates, comes from a period of highly unstable estimates.

[4] Brattle (2005) page 10.

2. In the very recent past, the two-year estimate has been changing faster than the one-year estimate, and so is less stable in that sense.
3. The two-year estimate is falling, whereas the one-year estimate is rising. In the past, the one-year estimate has been the better indicator of trends. The six-month estimate is also rising and, according to Brattle's analysis, is statistically significantly higher in the last six months.
4. Figure 2 starts, coincidentally, at the beginning of a period of abnormal stability of the two-year estimate. The more complete picture in Figure 1 does not indicate similar stability.
5. Points (1)-(4) above were known at the time of the Brattle analysis. In addition, changes that have occurred beyond the data period used by Brattle confirm both the instability of the two-year estimate and the continued divergence in trend from the one-year estimate.

I cannot understand the logic of the Brattle position. It seems to be that the use of a two-year estimate is justified by the fact that it was stable between April 2003 and late February 2005. In this stable period, until late February 2005, the procedure now favoured by Brattle would have given an estimate in the range 1.2-1.3.

This stability has clearly ended. The large revision that Brattle wants to make to its estimate, from 1.3 to 1.0, cannot be justified by that period of stability. If the period of stability is used, the estimate should be somewhere between 1.2 and 1.3. The lowering of the estimate can be justified only by the recent period of instability. It is difficult to see how a change in beta arising entirely from a short period of high instability is justified on the basis of a period of stability that has ended.

To put the current instability of the beta estimate in perspective, between 11 February and 11 April 2005 the two-year beta estimate has fallen by 0.2. These two estimation periods share 22 months of data. Only two months differ between them. Changing less than ten percent of the data on which the estimate is based changes the estimate by twenty percent. This level of instability indicates severe estimation problems.

In my opinion, Figure 2 indicates a conclusion that is entirely different to that reached by Brattle. It is that no judgement can be made about the relative merits of the different beta estimates until the reasons for their recent rapid change and conflicting signals are understood. Brattle does not present such an explanation. It does, however, mention issues that, for reasons given below, I believe to be central to the problem.

5. The recent change in estimates of BT's beta: Change in fundamental risk or statistical artefact?

5.1 Is it a change in fundamental risk?

Brattle has changed its estimate of BT's beta on the basis of the recent large change in the two-year estimate. This assumes that that a change of more than 0.2 has been generated by a change in the fundamental risk of BT in the last two months. In my opinion, this is highly implausible. Brattle does not present any analysis of what might have caused such a large change, and there is nothing about BT of which I am aware that could have generated such an effect. BT has not changed its business mix significantly in this period, and any change in capital structure is much too small to have generated such a large change in beta in such a short period of time.

5.2 Could it be a statistical artefact?

An alternative explanation is that the changes in the beta estimates are an artefact of the data used to estimate beta in the recent period. Possible statistical causes are non-normality of the residuals, discussed above, and heteroscedasticity (changing volatility).

Non-normality in beta residuals is usually caused by the presence of large 'outliers' in the data. Such outliers mean that standard beta estimates suffer from the following problems:[5]

1. Estimates produced using standard beta estimation techniques are unreliable, and can change rapidly over very short periods of time when there is no change in fundamental risk.
2. The accuracy of beta estimates, as measured by standard errors, is exaggerated.
3. Standard tests of statistical significance, such as the test of differences in betas, Chow test, and test of significance of the Dimson estimators, are invalid. They may find significance when none is actually present.

[5] See Judge et al (1988) section 22.1. The estimates do still have some useful properties, such as being the best linear unbiased estimators, but the accuracy of the estimates and their distribution are difficult to assess, especially some data may come from a distribution that has an infinite variance. Judge et al (1988, section 22.1.2) suggest that this is a particular problem for financial market data. In addition, when the independent variable in the regression is random, as in a beta regression, there can be other related problems.

In my opinion, the beta regressions used by Brattle suffer from these problems caused by non-normal data with outliers. As I discuss below, I believe that this problem is greatest with the recent data.

A related problem is heteroscedasticity. This was extensively analysed in Brattle (2004) as part of its selection of the estimation procedure. No such analysis is presented in Brattle (2005), although heteroscedasticity is mentioned to justify the choice of estimation procedure for the world beta, which is discussed below. Heteroscedasticity can cause similar problems to non-normality. With heteroscedasticity, the standard regression method is not the best way to estimate beta, and measures of accuracy, such as standard errors, are unreliable.[6] I show below that the period used by Brattle to draw inferences about BT's beta suffers from severe heteroscedasticity.

In my opinion, problems with outliers and heteroscedasticity fully explain the recent instability in beta estimates and the conflicting signals from the estimates based on different length windows. I now discuss the evidence for this, and the implications for the estimation of BT's true beta.

5.3 The reason for recent instability in estimates of BT's beta

It is relatively simple to understand some aspects of the recent behaviour of estimates of BT's beta. This is made easier by presenting the estimates in a different way. Figure 3 shows the same data as in Figure 1, but with the estimates dated by the date that the estimation period begins, rather than when it ends. Now there is a clear pattern that shows:

1. If the data period starts after early 2003, both estimates behave erratically.
2. Both estimates 'drop off a cliff' starting in early 2003.
3. Both estimates behave almost identically from the start of 2001 onwards, the period that Brattle says justifies using the two-year rather than the one-year estimate.

Presented in this way, there is no reason to prefer one estimate to the other. Both are highly unstable in the recent past. The only difference is that the one-year estimate appears to pick up a recent rise that reverses the fall in the estimates that occurred starting in early 2003. This is consistent with the evidence that the one-year beta appears to pick up trends in the

[6] See Judge et al (1988) Chapter 9. In addition, since the independent variable in a beta regression is stochastic, there may be other problems related to the problems with outliers and heteroscedasticity that are related to this.

estimates quicker than the two-year beta, and with the fact that the six-month beta shows a recent increase.

Figure 3: Beta estimates relative to the start of the estimation period

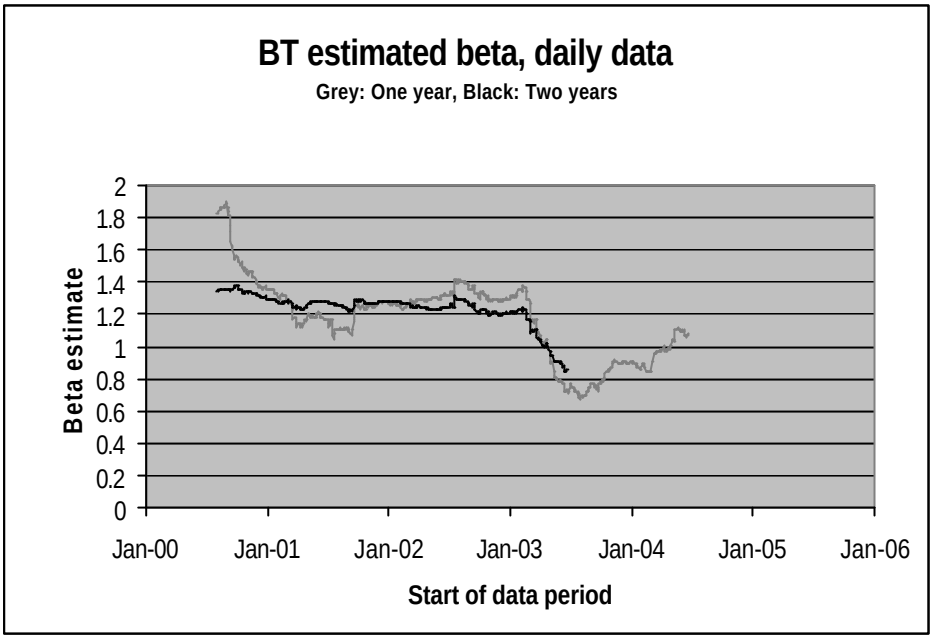


Figure 4: The volatility of the UK stock market

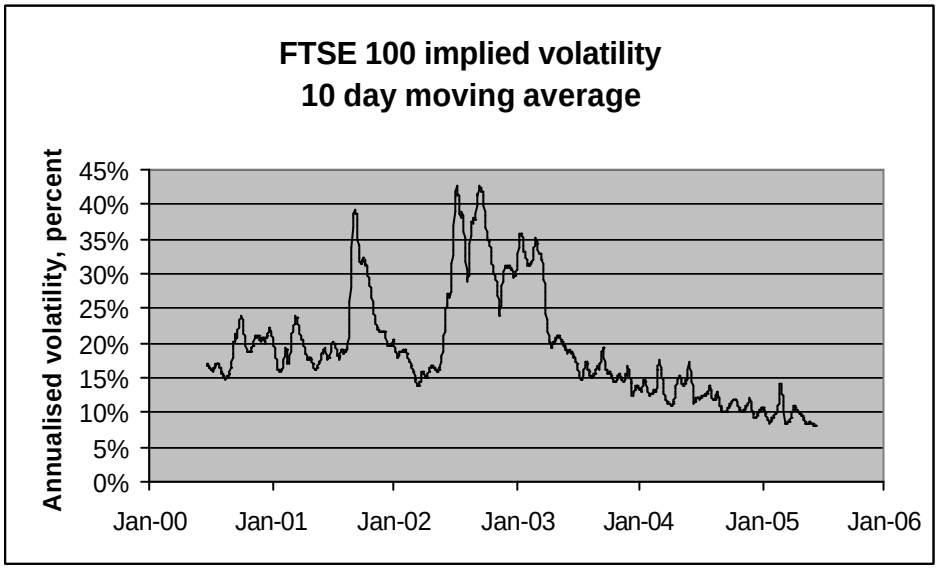


Figure 4 shows that the changes in the estimates are related to heteroscedasticity. One test for heteroscedasticity in Brattle (2004) is an examination of the volatility of the market index. Figure 4 presents a measure of this volatility. It shows the implied volatility of FTSE 100 index options. There are three periods of different volatility behaviour:

1. A period of volatility of about 20% up to mid-2001.
2. A period of high and erratic volatility up to early 2003.

3. A period of low and declining volatility after early 2003.

As a benchmark against which to judge these volatility levels, the average volatility of the UK market index over the last hundred years has been twenty percent, and this is generally considered a typical level of volatility for an equity market index.[7]

The juxtaposition of Figures 3 and 4 shows that the instability in beta estimates has occurred during the period of abnormally low market volatility after early 2003. The estimates become highly unstable if the data period used starts beyond early 2003, just as market volatility falls to levels well below its historical average. This is true for both the one-year and two-year estimates.

The relationship between the volatility of the stock market and the instability of beta estimates can be seen in Figure 5. This shows, on the right, the beta regression on which Brattle bases its estimate of 1.0 using two years of data to 11 April 2005. On the left is a beta estimate from two months earlier that includes only a little of the period of higher volatility before April 2003. Both graphs have the same scales on their axes and are presented so that a 45-degree line represents a beta of one. The data in the two graphs have considerable overlap, since they share twenty-two months of data.

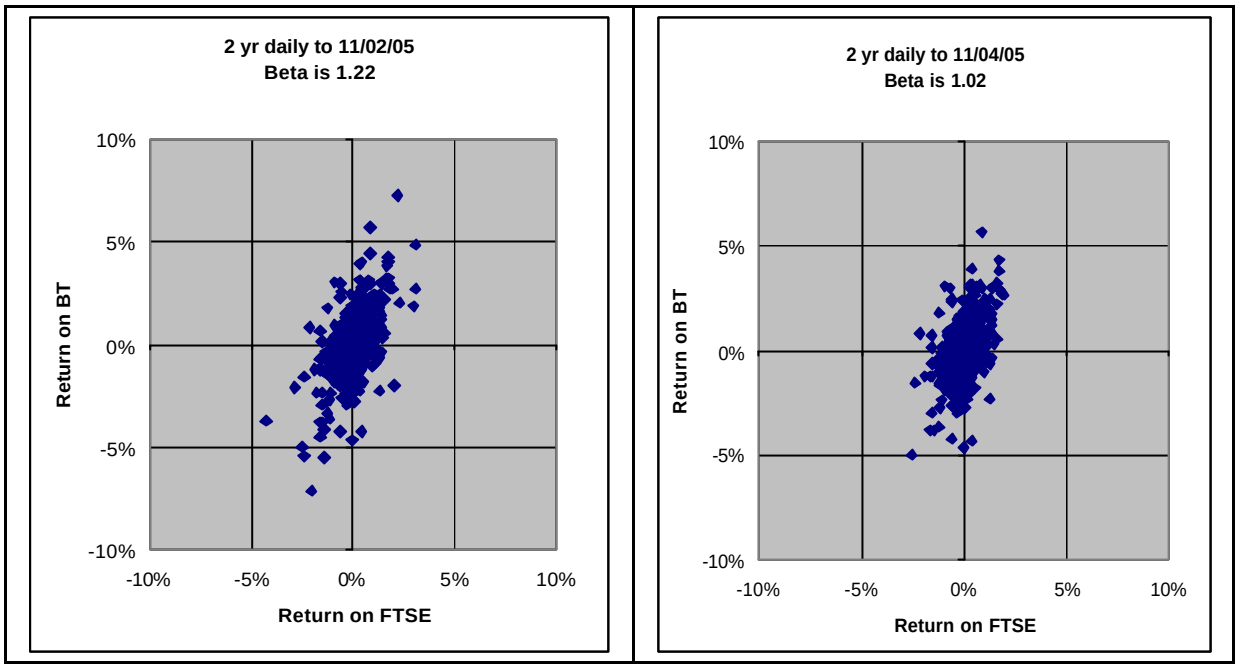
From examination of these graphs, the following points are apparent:

1. The left-hand graph has a wider range for the market return and, therefore, potentially carries more information about beta.
2. The dense clustering of the points in the right-hand side graph makes it difficult to estimate the beta. In particular, the lack of any degree of variation in the market return makes the regression uninformative about the beta.
3. Both graphs have outliers, so neither regression satisfies the standard regression assumptions.

In my opinion, both graphs look intuitively as though the beta is above one. However, the statistical estimate of beta for the period ending in April is only 1.02. The reason for this beta that is lower than the data visually suggest is the influence of the outliers. Standard regression analysis gives outliers a heavy weighting.

[7] Dimson et al (2005) Table 5.

Figure 5: Two-year beta regressions ending in January and April 2005



The influence of outliers is unpredictable. Sometimes they increase beta estimates, sometimes decrease them. The main effect they have is to make estimates volatile and unreliable. When this is combined with a period of low market volatility, which makes beta estimates relatively uninformative anyway, it can create exactly the type of behaviour seen in the recent estimates of the BT beta. This behaviour can occur even when the true beta is constant, because it is not related to changes in the actual beta. It is simply an artefact of data that is uninformative about the true beta, combined with the presence of outliers.[8]

There is no standard way around this problem.[9] One practical solution that is sometimes used is to base the estimate on monthly data, which generally suffers less from the outlier problem. Ofcom reports an estimate of 1.4 using this approach. The other way is to form a judgement about which estimates based on daily data are the most informative about the true beta of BT and weight the evidence accordingly. I now discuss this approach.[10]

[8] The uninformativeness of the beta regression is difficult to measure formally, because the presence of outliers invalidates standard estimates such as standard errors. However, the problem should be intuitively clear from Figure 5.

[9] See, for instance, Judge et al (1988) chapter 22.

[10] More sophisticated methods of dealing with heteroscedasticity and outliers are given in Schwert and Seguin (1990) Campbell et al (1997) and Berglund and Knif (1999). However, these techniques are

6. Which estimates should receive more weight?

6.1 Introduction

Until recently there seemed to be little controversy about using an equity beta of 1.3 for BT. The issue of whether this should be lowered to 1.0, as Brattle advocates, or to 1.1, as Ofcom suggests, depends on how much weight one gives evidence from the recent period of unstable and conflicting beta estimates.[11]

Brattle bases its conclusion primarily on the estimate of 1.01 for the two-year window ending in April 2005. This, effectively, gives a hundred percent weight to that estimate and a weight of zero to the previous estimate of 1.3 that was used as recently as September 2004.[12] The Brattle position essentially amounts to saying that the right-hand panel of Figure 5 represents convincing evidence that the beta has fallen by more than 0.2 from its earlier estimate of 1.29.

This fall has, apparently, happened entirely within the space of two months represented by the difference between the left-hand and right-hand panels of Figure 5. Until 11 February 2005, the two-year beta estimate, which Brattle now favours, was still above 1.2 and would not represent evidence for a reduction of the earlier estimate.

In my opinion, the reduction of the beta estimate proposed by Brattle is justified only if:

1. These recent estimates are indicative of a change in the fundamental beta of BT, rather than econometric problems.
2. It is the two-year estimate that should be given most weight, rather than the one-year or six-month estimate.
3. Beta estimates produced during a period of abnormally low market volatility that suffer from problems with heteroscedasticity and outliers are highly informative.
4. The period of low market volatility that has produced the estimates will persist.

I now give my opinion on each of these issues.

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typically aimed at dealing with the estimation for a large number of shares. For an individual share, such as BT, close examination of the data is probably as good.

[11] Adjusting beta estimates by giving lower weights to periods of abnormal behaviour is a practical solution to a complex problem. See, for instance, Franks (1995).

[12] Ofcom (2004).

6.2 Is there a change in fundamental risk?

In my opinion, these recent estimates should not be taken as indicative of a change in the fundamental beta of BT because:

1. There is no indication that they are related to fundamental factors such as changes in BT's operations or gearing.
2. They can be easily explained by econometric problems arising from outliers and heteroscedasticity.

6.3 Should the two-year estimate be given the highest weight?

In my opinion, even if they are given weight, it is not the two-year estimate that should be given the highest weight because:

1. The estimates are volatile, indicating unreliability. The period of stability of the two-year estimate is over.
2. The signals they give are conflicting. The one-year estimate is now 1.1 and increasing rapidly. The six-month estimate is, according to Brattle, 1.4 and statistically significantly higher than earlier estimates. The two-year estimate is 0.9 and falling rapidly.
3. In the past the one-year and six month estimates have been better indicators of trends than the two-year estimates.
4. The reasons given by Brattle for preferring the two-year estimate are not valid.

6.4 Are recent beta estimates highly informative?

In my opinion, the econometric problems produced by the combination of factors that affect recent beta estimates based on daily data for BT make them unreliable because:

1. The lack of market volatility reduces the informativeness of the beta estimate.
2. Heteroscedasticity raises complex problems of estimation.
3. Outliers make the estimates unreliable.

6.5 Will the period of low volatility persist?

In my opinion, even if these estimates are given weight and the two-year estimate is preferred, the weight should be low because periods of low volatility tend not to persist.

The current market volatility of below ten percent is remarkably low by historical standards. The behaviour of equity market volatility has been extensively studied. All studies of market volatility of which I am aware show that periods of abnormally low volatility do not persist very long. Volatility reverts to its long-run mean quite quickly, on average. An estimate of the speed of this mean-reversion is given in Dimson and Marsh (1990). They suggest that the best future forecast of market volatility is obtained by assuming that the current level moves back half the way to its long-run average over a quarter of a year. This would take the expected future volatility almost back to its long-run average over the space of a year. Franks and Schwartz (1991) find even faster reversion to the mean. Thus a beta estimate that is low because of low market volatility would not be a valid forecast of the future beta over any horizon longer than a year.

6.6 My weighting of the evidence

For the reasons given above, I would give the very recent estimates low weight and maintain an estimate close to its previous value of 1.3.

7. Other estimates

7.1 Introduction

Brattle also presents other estimates, based on the Dimson adjustment and a world index. Both of these are lower than its final estimate of 1.01. On this basis it says that its estimate is ‘at the top of the suggested range’. This raises the question of whether the Dimson and world betas should be taken as evidence of a lower true beta.

7.2 Dimson estimates

The Dimson method is used primarily to adjust for thin trading biases, biases induced by trading costs or, when international data are used, for differences in the opening times of markets. Brattle estimates Dimson adjustments for one day and two day leads and lags and finds that the one-day adjustment is insignificant, the two-year lead is insignificant, the two-year lag is insignificant for one year of data, but the two-year lag is significant for two years of data.

In my opinion, this is almost certainly an artefact of the data and should be ignored because:

1. There is no *a priori* reason for using the Dimson adjustment for a highly traded share such as BT.
2. If there were some thin trading or bid-ask spread problem it should show up at one-day lag rather than two days lag.
3. The problems with outliers in the data can easily cause spurious results of the type found by Brattle. Brattle says that the Dimson adjustment becomes significant only in the last two months of data, which is when these problems are greatest.
4. The problems with outliers in the data invalidate the test used by Brattle to justify the inclusion of the Dimson adjustment.
5. The Dimson adjustment estimated by Brattle is much larger than can be justified by thin trading problems for a share like BT.

Therefore, in my opinion, the analysis of the Dimson-adjusted betas should receive no weight.

7.3 World beta estimates

Brattle also presents an estimate based on one year of daily data using a world index. This is 0.49. It is based on year of daily data for the FTSE All World index denominated in dollars, converted into sterling using the dollar/sterling exchange rate. It does not include the Dimson adjustment.

In my opinion, the method used by Brattle to estimate the world beta is potentially misleading. Standard international capital asset pricing theory says that the world beta should be estimated in a way that excludes some effects of currency variation.[13] One way to do this is to include the change in currency rates in the regression. Another is to use a global index that represents the return to a portfolio hedged against currency risk, such as the MSCI index. If one does the former by including the dollar pound exchange rate return in the Brattle estimation of the BT world beta, it rises to 0.95. If one uses the MSCI global index as the world index and includes the Dimson adjustment, the estimate is 1.18.[14] In my opinion, this is the best estimate based on simple analysis.

In my opinion, the Brattle estimate of 0.49 for the world beta is based on a misspecified regression. In my opinion, the world beta, if estimated

[13] See, for instance, Adler and Dumas (1983). The intuitive reason is that the global capital asset pricing model assumes that all investors must view beta as being the same. Therefore, the measurement of beta cannot differ according to the currency perspective of the investor. Thus, although one can measure beta from any currency perspective, the inclusion of currency returns in the beta estimation means that one will get the same estimate regardless of this.

[14] Brattle (2002) advocates the use of the Dimson adjustment when dealing with international data.

correctly, is much higher. A simple estimation technique gives an estimate of 1.18. This is similar to the domestic beta before the recent period of estimate instability. If this estimate of the world beta were used in an international capital asset pricing model, the equity market risk premium would also have to be re-estimated.

7.4 Other estimates: Conclusions

Brattle also presents other estimates, based on the Dimson adjustment and a world index. Both of these are lower than its final estimate of 1.0. In my opinion, there are no theoretical or empirical grounds for including the Dimson adjustment for BT. In my opinion, the Brattle estimation of the world beta is misspecified. A more correct specification gives an estimate of 1.2.

8. The use of the estimate by Ofcom

Brattle concludes strongly that daily data should be used. In contrast, PwC (2005) uses weekly data as its preferred choice for the analysis of BT's beta. Brattle prefers a two-year window and PwC a one-year window. PwC also appears to estimate its world betas differently to Brattle. These are further illustrations that the choice of weighting to give different beta estimates is not clear. It is difficult to see how one choice can be optimal for one calculation and the other for another, when both are in the context of trying to estimate the true beta of all or part of the BT business. When the two estimates are combined, the property of the resulting estimate is unclear. In addition, the fall in the recent estimate of BT's beta is used by Brattle to adjust its own estimate downward. However, PwC attributes changes in beta estimates to changes in the business mix of BT. It estimates an adjustment to take account of this. Care must be taken that the adjustments proposed by Brattle and PwC are not, at least partially, adjustments for the same thing.

Ofcom summarises the evidence on beta in a table that is reproduced as Table 1 below. There are several noteworthy features of this table:

1. It mixes a high beta that has been adjusted downwards towards one to make it an optimal forecast (the LBS beta), with low betas that have had no similar upward adjustment.
2. It reports the Brattle estimates as though they are based on one year of data for 2004-2005 and are, therefore, simply updates of earlier estimates based on one year of data. In fact, they are based on two

years of data for 2003-2005 and represent a change in estimation method as well as updating.

3. It contains no reference to Ofcom's prior estimate of 1.3.
4. It gives equal prominence to four estimates, two of which (the Dimson adjusted beta and the world beta) Brattle itself discounts.

Table 1: Ofcom's summary of the evidence on BT's beta

Estimated by	*Data frequency*	*Index*	*Period*	*Estimate*
Brattle	Daily	UK	2004-05	1.0
Brattle	Daily (+Dimson)	UK	2004-05	0.6
LBS	Monthly	UK	2000-05	1.4
Brattle	Daily	World	2004-05	c. 0.5

Table 2 gives an alternative representation of the evidence in the form used by Ofcom. It includes the prior estimate, which apparently represented Brattle and Ofcom's view of BT's beta until quite recently. Unless there have been significant identifiable changes in the fundamental risk of BT in the last year, this estimate should, in my opinion, still carry significant weight. In my opinion, there have been no such changes.

Table 2: Alternative summary of the evidence on BT's beta

Estimated by	*Data frequency*	*Index*	*Period*	*Estimate*
Prior belief				1.3
Updating evidence				
Cooper	Daily (One year)*	UK	2004-05	1.1
Cooper	Daily (Two years)*	UK	2003-05	0.9
Brattle	Daily (Six months)	UK	2004-05	1.4
LBS**	Monthly	UK	2000-05	1.4
Cooper	Daily	World	2004-05	0.9-1.2

*Data to 4/7/2005. **After Bayesian adjustment.

Table 2 does not include the Dimson adjustment in the domestic beta because this adjustment is, in my opinion, unjustifiable. The world beta is estimated including what is, in my opinion, a more correct treatment of currency. The one-year and two-year daily estimates use the most recent data available to me, and so are slightly different from Brattle's. I have

not been able to replicate Brattle's six-month estimate, so that is included rather than a six-month estimate by me.

In my opinion, combined with the evidence of the unreliability of the recent estimates based on daily data, Table 2 shows what inspection of Figures (3)-(5) also shows, that there is no strong evidence on which to base a significant revision of the earlier beta estimate of 1.3.

References

Adler, Michael, and Bernard Dumas, 1983, International portfolio choice and corporate finance: A synthesis, *Journal of Finance* 38.3, 925-984.

Berglund, Tom, and Johan Knif, 1999, Accounting for the accuracy of beta estimates in CAPM tests on assets with time-varying risks, *European Financial Management* 5.1, 29-42.

Brattle, 2002, *Issues in beta estimation for UK mobile operators*, July 2002.

Brattle, 2004, *Financial Analysis of British Telecommunications.*

Brattle (Lapuerta and Stallibrass), 2005, *Beta analysis of British Telecommunications: Update.*

Campbell, John Y, Andrew W Lo, and A Craig MacKinlay, 1997, *The econometrics of financial markets*, Princeton.

Dimson, Elroy, and Paul Marsh, 1990, Volatility forecasting without data-snooping, *Journal of Banking and Finance 14*, 399-421.

Dimson, Elroy, Paul Marsh and Mike Staunton, 2005, *Global investment returns yearbook 2005*, ABN Amro.

Franks, Julian R and Eduardo Schwartz, 1991, The stochastic behaviour of market variance implied in the price of index options, *Economic Journal* 101, 1460-1475

Franks, Julian R, 1995, US/UK Arbitration concerning Heathrow Airport User Charges, *International Law Reports* vol. 101, 216-583.

Greene, William H, 2003, *Econometric analysis* (Fifth edition), Prentice Hall

Judge, George G, R Carter Hill, William E Griffiths, Helmut Lutkepöhl, and Tsoung-Chao Lee, 1988, *Introduction to the theory and practice of econometrics* (second edition), Wiley.

PwC, 2005, *Disaggregating BT's beta*.

Ofcom, 2004, *Partial private circuits charge control: Final statement,* 30 September 2004.

Ofcom, 2005, *Ofcom's approach to risk in the assessment of the cost of capital*, 26 January 2005.

Ofcom, 2005, *Ofcom's approach to risk in the assessment of the cost of capital: second consultation in relation to BT's equity beta*, 23 June 2005.

Schwert, G William, and Paul J Seguin, 1990, Heteroskedasticity in stock returns, *Journal of Finance* 45.4, 1129-1155.

Comments on the document:

Disaggregating BT's beta by PwC (June 2005)

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July 18 2005

SUMMARY

This is a review of the econometric evidence in the document *Disaggregating BT's beta* by PwC. The evidence is in four parts:

1. Analysis of the betas of a selection of ICT companies.
2. Analysis of the evidence from historical changes in BT's beta.
3. Cross-sectional regression.
4. Time-series analysis.

The evidence is hard to interpret, for the following reasons:

1. The measure of beta used as the principle evidence for each test differs between the tests.
2. The measures of beta are inconsistent with those used in the analysis performed by Brattle for a closely related purpose.
3. The tests used by PwC are inconsistent with those used by Brattle.
4. PwC appears to weight evidence on *a priori* grounds.
5. It is not clear how the samples used for analysis have been chosen.
6. Different measures of the same thing are used in different parts of the analysis.

In addition to these problems, there are considerable econometric problems with all the tests except the first.

In my opinion, there is only one robust piece of evidence in the econometric analysis provided by PwC. It is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group. Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. The quantitative interpretation placed on this by PwC is heavily affected by the fact that it uses betas that have not been adjusted to be optimal forecasts. This would significantly reduce the size of the adjustment to the access beta. In addition, uncertainty about whether these are the right comparators for the BT ICT business and whether the revenue weights are the right proxy for value adds to the uncertainty about the adjustment.

The only robust result found by the cross-sectional analysis essentially repeats the result from the ICT analysis.

PwC itself concludes that it is not possible to draw any firm conclusions from the historical changes analysis.

The time-series analysis is subject to so many problems that the results of it should, in my opinion, be ignored. It is not a standard procedure for beta disaggregation.

In my opinion, the econometric analysis of PwC stretches standard methods to the absolute limit. Even so, it still does not result in a beta estimate for the local access business alone. In the one case where PwC does estimate this beta, it discounts it.

Overall, my interpretation of the evidence is that PwC has made heroic efforts to extract the maximum amount of information out of data that are, essentially, uninformative about the problem to be addressed. I believe that this creates econometric and other problems that are so great that the conclusions must be extremely limited.

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1. Introduction

This is a review of the document *Disaggregating BT's beta* by PwC (June 2005). The pages and paragraphs are referred to as follows:

PwC 1 means paragraph 1, PwC p6 means page 6.

The structure of the note is:

Section 2 discusses the general structure of the evidence given by PwC. Section 3 discusses the econometric evidence. Section 4 discusses the use of the evidence and section 5 gives my conclusions.

2. The general structure of the evidence

2.1 Introduction

The PwC document includes discussions of fundamental factors and regulatory practice, which I do not discuss in this note. The note concentrates on the econometric evidence in the PwC document. This is in four parts:

1. Analysis of the betas of a selection of 'ICT' companies (PwC 3.1.6).
2. Analysis of the evidence from historical changes in BT's beta (PwC 3.3).
3. Cross-sectional regression (PwC 5.2).
4. Time-series analysis (PwC 6).

2.2 Difficulties in interpreting the evidence

The evidence is hard to interpret, for the following reasons:

1. The measure of beta used as the principle evidence for each test differs between the tests. In the ICT test an average of weekly, daily, and monthly betas is used for 'illustrative purposes' (PwC p15). In the cross-sectional test, the daily beta is used 'as an example of our output' (PwC p33). In the time-series test the 'preferred equation' uses weekly betas (PwC p43). It is not clear to me what criteria have been applied to make these selections. They may introduce biases into the conclusions drawn.

2. The measures of beta are inconsistent with those used in the analysis performed by Brattle (2005) for a closely related purpose. Brattle concludes that a two-year beta using daily data is best for the estimation of BT's beta. PwC does not mention this measure. Brattle's criterion for its best estimate is stability, whereas the estimate chosen for PwC for its time-series analysis appears to be the least stable. Ofcom proposes to combine the conclusions of these two studies that are, in a large part, based on conflicting analysis of the same problem.
3. The tests used by PwC are inconsistent with those used by Brattle. For instance, Brattle also conducts tests similar to the 'historical changes' test of PwC. Brattle conducts the test in an entirely different way, discussed below. Brattle uses entirely different break points in the data.
4. PwC appears to weight evidence on *a priori* grounds. For instance, the result for the time-series analysis of the BT beta using access alone is given lower weight than the results based on access and core, even though it is the former that PwC is trying to estimate (PwC p45). It is not clear what criterion PwC is using to make this kind of choice. Similarly, the time-series analysis using daily data, which Brattle prefers, is given lower weight than that using weekly data because the results of the former are 'implausible' (PwC p45).
5. It is not clear how the samples used for analysis have been chosen. For instance, the sample of ICT companies chosen does not appear to be a sample that satisfies any simple criteria.
6. Different measures of the same thing are used in different parts of the analysis. For instance, the cross-sectional analysis uses revenue weights for different parts of the business, whereas the time-series analysis uses a mixture of book values and market values. It is hard to see how different measures of the same thing can both be the best measure. In general, the choice of the best measure of an economic entity does not depend on its use.

All the above make it difficult to determine how much weight to give different pieces of evidence.

3. PwC's econometric analysis

3.1 Introduction

PwC presents two pieces of econometric evidence. The first is cross-sectional, based on the betas of ICT companies (PwC 3.1.6) and cross-

sectional regressions (PwC 5). The second is time-series analysis, based on betas in sub-periods (PwC 3.3) and time-series regressions (PwC 6).

3.2 Cross-sectional analysis

3.2.1 Test of the difference between ICT companies and BT

In my opinion, the only robust piece of evidence in the econometric analysis provided by PwC is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group (PwC 3.1.6). Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. These are:

1. In its test of differences between a sample of ICT companies and BT, PwC (3.1.6) uses beta estimates that have not been adjusted to be optimal forecasts. Betas as high as the monthly betas in PwC Table 1 are known to be overestimates of future betas. This is why all widely used commercial beta services such as Bloomberg, Datastream and LBS that use monthly or weekly betas adjust such high estimates downwards. For instance, the asset beta based on the LBS estimate of Logica's beta is 1.29[1], rather than the 2.14 reported by PwC as its estimate in Table 1. PwC includes the monthly estimates in its calculation of the adjustment to the BT beta. The use of unadjusted betas will overestimate the size of the adjustment that should be made to get the access beta.
2. Another indication that the PwC estimate may be implausible is that there is not a single industrial or commercial company in the UK market with an *equity* beta estimated by LBS based on monthly data higher than 1.82[2], whereas PwC estimates the average *asset* beta based on monthly data for ICT businesses as 2.32 (PwC Table 1).
3. As discussed above, it is not clear how the comparison companies have been chosen. I do not know whether these are the most appropriate comparators. It is important, however, to ensure that the mix of activities in the firms used by PwC as ICT comparators is the same as that in the part of BT's business that it defines as ICT.
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. The use of revenue weights without any

[1] London Business School Risk Measurement Service, April-June 2005 gives an equity beta of 1.45. I have combined this with leverage data from Datastream.
[2] London Business School Risk Measurement Service, April-June 2005.

validation of whether they are a good proxy for value weights is not appropriate and can lead to large biases. According to PwC, the ICT business has a higher risk and required return that the other BT businesses. Therefore, all else being equal, the same amount of revenue will have less value in the ICT business than in the other businesses. This implies that, all else equal, the value weight of the ICT business should be lower than the revenue weight, and the adjustment to BT's beta smaller than the adjustment made by PwC.

3.2.2 Cross-sectional regression

The cross-sectional regression (PwC 5) does not provide much more evidence for disaggregation than the examination of ICT betas discussed above. The only robust result it finds is that the ICT beta is significantly higher than the other parts of the business.

Therefore, it does not seem to merit lengthy discussion. However, there are some important issues that affect the interpretation of the results:

1. The disaggregation performed by PwC estimates a beta for the total fixed line business, rather than the local access business. According to PwC the fixed line business constitutes 75% of BT (PwC p34). Therefore, the cross-sectional analysis of PwC is a quite complicated way of adjusting the BT group beta for 25% of its business. However, it appears that some estimates give an aggregate beta for the BT group that is different from the actual beta (PwC p33). Since the fixed line business is such a large part of the total business, the BT group beta is fairly direct evidence about the beta of the fixed line business. In my opinion, a method that gives a beta that conflicts with the BT group beta has serious problems.
2. PwC says it tested a number of variables to control for other things that affect betas (PwC p31). However, it does not include a very important variable that Alexander et al (1996) find to be a primary variable explaining the cross-sectional difference in telco betas. This is the nature of regulation. It is likely that the proportion of fixed line assets is correlated with a variable measuring the presence of low-powered regulation. This will bias downwards the estimate of the beta for BT's fixed line business, which is subject to high-powered regulation.
3. PwC regresses the beta on the revenue mix of the companies rather than the proportions of value (PwC p 31). If the different parts of the business have different ratios of value to revenue (which they

should if they have different risks) the results will be biased. PwC (footnote 58) says that it tested for this, but it is not clear how this was done.

4. PwC does not say how the mix of activities for each company was estimated, and does not report these data. The results will be sensitive to these estimates, but it is not possible to comment further without the details of how the mix was estimated.
5. PwC includes a variable for emerging markets, which it finds generally to be insignificant. It says that the inclusion of this does not affect the results, but it does not report the results without it.

In my opinion, these issues, in addition to the concerns raised by PwC itself, make the estimates of the divisional beta of the fixed line business resulting from the cross-sectional analysis highly uncertain. In my opinion, the one robust result that the cross-sectional analysis finds is a repeat of the result of the ICT analysis. This is the principle conclusion reached by PwC (PwC p 35). In my opinion, the additional conclusion of PwC that '…the actual equations may give some indication of the magnitude of differences of divisional betas [of BT]…' is not valid.

3.3 Time-series analysis

3.3.1 Evidence from historical changes

PwC analyses the levels of BT beta estimates in different periods (PwC 3.3). Its conclusion is that 'there are too many complicating factors to enable us to draw any firm conclusions from this analysis' (PwC p22). I agree with this conclusion. However, in addition to the problems that PwC mentions, I believe there are others, including:

1. The betas for each period are measured using data from outside the period. For instance, the monthly beta for the period from Oct 2003 to April 2004 uses data that are, on average, from about June 2002.[3] This date falls in the earlier sub-period. In my opinion, therefore, it would be legitimate to conclude that the high asset beta, of 1.08, applies mainly to the earlier 'Back to UK fixed telecommunications' period, rather than the 'Growing new wave and ICT period' to which PwC attributes it. This would contradict one of PwC's conclusions, that the BT beta fell during the 'Back to UK fixed telecommunications' period. PwC notes this problem (PwC page 22) but does not use the standard procedure to deal with

[3] The middle of the period is about November 2004, and data are, on average, 2.5 years before this.

it. Brattle conducts similar tests, but estimates betas using data only from within the period, which is standard. In my opinion, the Brattle procedure is correct and the PwC procedure is non-standard and may introduce significant biases.

2. The dating of the break points between periods chosen by PwC is arbitrary. For instance, they might have chosen to date a break point at the sale of O_2. This would satisfy standard econometric criteria for the dating of a break point. When break points cannot be dated precisely, it introduces severe problems in this type of analysis (see Brattle (2005)).
3. Some of the beta estimates used are inherently implausible. For instance, the weekly asset beta looks like it changes from about 2.3 to about 0.1 between late 2000 and late 2001 (PwC Chart 4). This clearly indicates an econometric problem, yet PwC's analysis treats it as though it measures a change in the fundamental risk of BT.

PwC itself concludes that it is not possible 'to draw any firm conclusions from [the historical changes] analysis' (PwC p22). In my opinion, when the above problems are included, this conclusion is even truer.[4]

3.3.2 Time-series regression

Because it does not reach any firm conclusions from its historical changes analysis, PwC concludes that it needs 'to investigate time-series movements in a more robust manner' (PwC p22). To do this, it conducts a series of time-series regressions (PwC 6). This raises the issue of whether this time-series analysis is the robust evidence that PwC is seeking. In my opinion, it is not.

The time-series analysis of BT's beta suffers from a large number of well-known econometric problems, including the following:[5]

1. The time-series result that PwC uses is based on weekly betas. The use of weekly betas conflicts with the use of daily betas advocated by Brattle and the use of daily betas by PwC as its main evidence elsewhere. PwC acknowledges that daily betas do not give plausible disaggregated beta estimates (PwC p45). This is taken by PwC as a reason to give more weight to results based on weekly

[4] There is a version of this type of analysis that is sometimes used when companies merge. It involves observing the beta of the acquired company and adjusting the merged company for it. In this case, however, the date of the change is known, and the beta of the separate target company can be observed before the merger, so the problem is entirely different.

[5] Discussion of most of these can be found in any standard econometrics textbook, such as Judge et al (1988).

betas. An alternative interpretation is that the whole procedure is unreliable. Apart from the fact that daily betas give implausible results, PwC does not explain why it prefers weekly betas. It does not say how it dealt with the well-known problem of the dependence of the estimates on the day of the week, which it acknowledges as a problem elsewhere (PwC p33). As discussed in the previous section, the weekly betas look the most implausible. As is acknowledged by PwC, they are highly erratic (PwC p33).

2. (Measurement error) PwC attributes almost all variation in the market value of BT to the non-access business by using book values for the access business. If, as is likely, the true market value of the access business has varied over the period in a way that is correlated with the level of the stock market, this may bias down the estimate of the access beta. It will attribute all the increase in beta estimates when the stock market was high to the non-access business. This is a potentially large bias. PwC says that it tested for this (PwC p45) and that it does not make a difference, but it is not clear that its test is the right one, and it does not report the results.
3. (Serial correlation, overlapping data) 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 appears to accept that one statistically correct approach would make it difficult to reach conclusions (PwC p40 fn 67).
4. (Omitted variables) PwC does not include some other variables that might explain the changes in beta over the period. For instance, the *estimates* of BT's beta over this period are related to changes in the volatility of the stock market (Cooper (2005)). PwC does not include this variable, except indirectly through dummies. Omitting this and any other variables that are related to the change in beta estimates may bias down the estimate of the access beta. The analysis performed by PwC may attribute changes in beta estimates to changes in the mix of operations when they are actually caused by other factors.
5. (Heteroscedasticity) PwC estimates without making any correction a regression that includes data that, in Brattle's opinion, exhibit heteroscedasticity (Brattle (2004) p 5). PwC Chart 8 also appears to indicate heteroscedasticity, in that the spread of the points is clearly related to the proportion of non-core activities. Omission of any

adjustment for heteroscedasticity will tend to bias estimates and exaggerate the significance of any results.

6. (Misspecification) PwC uses the combined proportion of access and core, whereas it is trying to estimate the beta of access alone. It reports that there is a result using access alone, which it does not use (PwC p45). Therefore, the results it reports are from a regression that is misspecified.
7. (Non-normality) 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. PwC does not test for non-normality, which will lead to spurious significance tests. 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. Inspection of PwC Chart 8 suggests that it does.
8. (Ex-post selection of dummy variable) PwC chooses its TMT boom dummy variable by looking at the *ex post* behaviour of beta (PwC p39 fn 65). This can induce significant biases. The dummy periods chosen differ from the periods in the historical change analysis discussed in the previous section. It is not clear why they are different, since they are attempting to measure the same thing, structural changes in BT's beta. Their difference illustrates the potentially arbitrary nature of such analysis.
9. (Misspecification) The level of beta in a period is generated by the average mix of operations during that period. PwC appears to assume that the level of beta during a period is related to the mix of operations at the end of the period. This will bias the estimates.

These problems are not merely of academic interest. Any one **alone** can generate spurious results and introduce large biases in a time-series regression of the type estimated by PwC. PwC itself acknowledges many of them. In my opinion, taken together they mean that the time-series analysis conducted by PwC does not give any quantitative or directional evidence about the relative beta of the access business of BT. In my opinion, it is not the 'robust' analysis that PwC is looking for.

This conclusion is reinforced if one looks more closely at the variation in beta estimates from which PwC derives its conclusions. PwC does not attempt to explain the precipitous changes in beta shown in Chart 7 (PwC p38). It is completely implausible that these are caused by changes in the mix of BT's operations, yet the subsequent analysis treats them as such. They are almost certainly statistical artefacts, but no attempt is made to investigate them.

Furthermore, time-series analysis of the type proposed by PwC is not mentioned by any standard authority on divisional cost of capital estimation. For instance, the approach is not mentioned in the book on estimation of the cost of capital written by three senior PwC practitioners in the area (Ogier et al (2004)). It is not mentioned in any standard corporate finance textbook of which I am aware. All these books discuss the estimation of divisional cost of capital, of which the estimation of the beta of BT's local access business is an example. The standard methods are the ones that have survived tests of their reliability. It is, in my opinion, dangerous to use non-standard methods whose properties are not known.

3.4 PwC's econometric analysis: Conclusion

In my opinion, there is only one robust piece of evidence in the econometric analysis provided by PwC. It is that the sample of ICT businesses chosen by PwC has a higher average asset beta than the BT group. Even that analysis is subject to several significant weaknesses that reduce the robustness of the conclusions drawn. The quantitative interpretation placed on this by PwC is heavily affected by the fact that it uses betas that have not been adjusted to be optimal forecasts. This would significantly reduce the size of the adjustment to the access beta. In addition, uncertainty about whether these are the right comparators for the BT ICT business and whether the revenue weights are the right proxy for value adds to the uncertainty about the adjustment.

The only robust result found by the cross-sectional analysis essentially repeats the result from the ICT analysis.

PwC itself concludes that it is not possible 'to draw any firm conclusions from [the historical changes] analysis' (PwC p22).

The time-series analysis is subject to so many problems that the results of it should, in my opinion, be ignored. It is not a standard procedure for beta disaggregation.

4. The use of the evidence

Apart from the detailed evaluation of the econometric evidence, I disagree with PwC on two fundamental points regarding the interpretation of this evidence. These are the analogy it makes with

standard beta estimation and the weight it gives to different parts of the evidence.

4.1 Analogy with standard beta estimation

PwC several times says that the difficulty of estimating betas in general justifies the use of its disaggregation techniques. For instance, in justifying its general approach:

> 'We note that in many business applications it is difficult to find a significant number of good comparators for beta estimation, but conducting such analysis on less than perfect comparators is generally preferred to not conducting the analysis at all. We also note that any calculation of beta involves a degree of judgement.' (PwC p28)

As a justification for giving little weight to the fact that time-series analysis using daily data gives 'implausible results':

> '..uncertainty surrounding how to calculate beta is an inherent issue in financial economics, and such analysis can still be of value.' (PwC p45)

As a justification for its conclusions:

> 'There is, for example, no precise, accepted estimate of BT's group beta available to Ofcom, but nevertheless Ofcom needs to adopt a figure….' (PwC p48)

In my opinion, the analogy between PwC's evidence on the disaggregation of BT's beta and normal beta estimation is invalid. For instance, when the BT group beta is being estimated, the evidence is direct. It involves only share prices, which can be measured accurately. The historical level the beta of BT's share price relative to a market index can be measured directly. What is at issue is how to convert this to an optimal forecast. In the evidence for disaggregation produced by PwC the evidence is extremely indirect. It involves a mixture of share price data and other information, such as revenue shares, which are imperfect proxies for the variables of interest. The share price data is for variables (such as ICT companies) that are only extremely indirectly related to the variable of interest, the beta of the local access business of BT. It also involves complex problems of statistical inference. The idea that these two problems, estimating the group beta of BT and estimating the beta of

the local access business, are in any sense equivalent is, in my opinion, wrong.

Even when PwC's methods are compared with normal divisional cost of capital analysis, this conclusion is still true. In normal divisional cost of capital estimation, the companies used may be imperfect proxies, but they are imperfect proxies for the division whose cost of capital is being estimated. This introduces one extra layer of difficulty over estimating a cost of capital for a company directly. In the procedures applied by PwC, there is not just the problem of choosing proxies and estimating their betas, but these proxy betas do not estimate the beta for the local access business. So complex issues of statistical inference arise, over and above any normal problems with beta estimation and proxy choice. As I have discussed above, my opinion is that these make the quality of information so poor as to be unreliable.

In my opinion, the issue is one of the quality of the evidence. Normal beta estimation carries some uncertainty, but the evidence is quite direct. The type of disaggregation analysis performed by PwC carries an entirely different order of uncertainty and the evidence is entirely indirect.

4.2 The weight given to the evidence

At several important points in the analysis, there is a choice between different interpretations of the evidence. Examples are:

> The result for the time-series analysis using access alone implies that 'the beta for core is less than the beta for access' and 'access & core gives a markedly higher beta for the rest of the business than is the case if access only is applied' (PwC p46). This seems to imply that the estimate for access alone is markedly higher than the beta for access & core combined. PwC appears to draw the implication from this that the results using access alone are unreliable. In my opinion, there are no clear grounds for this interpretation. In my opinion, equally valid interpretations are that the whole procedure is unreliable, or that the result for access & core combined is unreliable.
>
> PwC calculates the implied group beta for its disaggregated betas based on its cross-sectional analysis. It finds, for the daily local market betas, that this is similar to the actual beta of BT. It reports this result as supportive of its analysis, whereas it also reports that 'for some of the other regressions there is difference between BT's

predicted and actual beta.' (PwC p33) An alternative interpretation is that the procedure is unreliable because it generally appears to lead to divisional beta estimates that are inconsistent with the BT group beta.

The time-series analysis using daily data, which Brattle prefers, generates results that are 'implausible' (PwC p45). As a result, PwC bases its time-series results on weekly data. In my opinion, an equally valid interpretation is that the procedure is unreliable.

PwC says that 'not too much reliance can be placed on the absolute numbers emerging from our time series analysis'. Yet it interprets the evidence as though it suggests that 'deviations from the group beta could be relatively large' (PwC p47). In my opinion, an equally valid interpretation would be that these deviations could be relatively small.

In my opinion, the correct interpretation in all these cases is that almost all of the econometric evidence tells one little about the beta of the BT local access business. It is extremely indirect. It is ambiguous. In my opinion, it is fraught with the econometric difficulties discussed above.

5. Conclusions

In my opinion, the econometric analysis of PwC stretches standard methods to the absolute limit, because of the problems given above. Even so, it still does not result in a beta estimate for the local access business alone. In the one case where PwC does estimate this beta, it discounts it.

Therefore, my interpretation of the evidence is that PwC has made heroic efforts to extract the maximum amount of information out of data that are, essentially, uninformative about the problem to be addressed. I believe that this creates econometric and other problems that are so great that the conclusions must be extremely limited.

References

Alexander, Ian, Colin Mayer, and Helen Weeds, 1996, *Regulatory structure and risk and infrastructure firms*, The World Bank.

Brattle, 2004, *Financial Analysis of British Telecommunications.*

Brattle (Lapuerta and Stallibrass), 2005, *Beta analysis of British Telecommunications: Update*.

Cooper, Ian, 2005, *Comments on the document: Beta analysis of British Telecommunications: Update, Brattle, June 2005*.

Hansen, Lars Peter, and Hodrick, Robert J, Forward exchange rates as optimal predictors of future spot rates: an econometric analysis, *Journal of Political Economy* 88.5, 829-849.

Judge, George G, R Carter Hill, William E Griffiths, Helmut Lutkepöhl, and Tsoung-Chao Lee, 1988, *Introduction to the theory and practice of econometrics* (second edition), Wiley.

London Business School Risk Measurement Service, April-June 2005.

Ofcom, 2005, *Ofcom's approach to risk in the assessment of the cost of capital: second consultation in relation to BT's equity beta*, 23 June 2005.

Ogier, Tim, John Rugman, and Lucinda Spicer, 2004, *The real cost of capital*, Prentice Hall.

PwC, 2005, *Disaggregating BT's beta*.