NERA
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Update of the Equity Beta and Asset Beta for BT Group and Comparators

For the Office of Communications (Ofcom)

FINAL REPORT

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1. Introduction

Ofcom is required to undertake reviews of various communications markets every three years under the Communications Act 2003, which implements the EU regulatory framework for electronic communications. The process is designed to assess the existence of competitive pressures in the various market segments. If Ofcom finds evidence that competitive constraints are insufficient, it has the power to impose remedies such as ex ante regulation in the form of price controls. The asset beta is a measure of systematic risk and informs Ofcom's estimate of BT's weighted average cost of capital (WACC), which is a part of Ofcom's consideration of the level of any price control imposed.

In its March 2017 Wholesale Local Access (WLA) consultation[1], Ofcom proposed that BT's systematic risk can be differentiated across the following three categories: Openreach copper access, Other UK Telecoms, and Rest of BT. The Openreach copper access category covered BT's copper network business, the Other UK Telecoms category covered BT's leased lines, fixed voice, broadband and bundled services (e.g. TV), and the Rest of BT covered BT's ICT business.[2]

To support its 2018 WLA statement, Ofcom has commissioned NERA to produce updates of the equity and asset beta of BT and comparators. This report is the Third Report produced by NERA for Ofcom that estimates these betas for BT and comparators.

In our First Report for Ofcom[3], published alongside Ofcom's *Leased lines charge controls and dark fibre pricing (LLCC Consultation)*[4] in 2015, we reviewed the approach to calculating equity and asset betas for BT and comparator companies undertaken by Ofcom's previous consultants, the Brattle Group[5] and updated the equity and asset beta calculations for recent data.

In our Second Report for Ofcom ("October 2015 update")[6], we updated the equity, asset beta and gearing estimates for BT and comparators using October 2015 as the "cut-off" date, and

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1 See Annex 16, Wholesale Local Access Market Review Consultation, 31March 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0035/99638/Annexes1-19.pdf

2 In the consultation, Ofcom noted that BT completed the acquisition of EE in January 2016 and proposed to include BT's mobile activities within Other UK telecoms. This proposal was supported by a report from NERA which assessed the latest evidence on differences in systematic risk between fixed and mobile telecom operators, and specifically, assessed whether there is evidence (or otherwise) that the asset beta associated with BT's newly acquired mobile operator (EE) is similar to that of its Other UK telecoms operations, as defined above. NERA's report *Differences in the beta for fixed vs mobile telecommunications operators*, can be accessed here: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/99640/Annex-21.pdf. Ofcom has commissioned NERA to update this analysis and this has been published in a separate report *The Evidence for Differences in Risk for Fixed vs Mobile Telecoms* alongside this one.

3 NERA Economic Consulting (19 May 2015), *Estimation of BT's Equity and Asset Beta,* accessed here: http://stakeholders.ofcom.org.uk/binaries/consultations/llcc-dark-fibre/annexes/NERA_final_report.pdf

4 Documents published on Ofcom's website: http://stakeholders.ofcom.org.uk/consultations/llcc-dark-fibre/

5 The Brattle Group (3 March 2014): "Estimate of BT's Equity Beta". http://stakeholders.ofcom.org.uk/binaries/telecoms/ga/fixed-access-market-reviews-2014/draftstatement/15_annex15.pdf

6 NERA Economic Consulting (March 2016), *Update of the Equity Beta and Asset Beta for BT Group and Comparators*, accessed here: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/97039/annex_31.pdf

extended the comparator sample to include a set of (1) Information and Communications Technology (ICT) Comparators, selected as possible proxies for the beta risk of BT Global Services, and (2) pay TV Comparators, selected as possible proxies for the beta risk of BT's pay TV business.

In this Third Report for Ofcom, we assess beta evidence for BT and the comparator companies using September 2017 as the cut-off date. Ofcom also asked that in this Third Report we include recommended asset beta ranges for both the "Other UK telecoms" and "UK ICT Operators" segments of BT's business, based on the data assessed in the report.

The analysis in this report is set out as follows:

- Section 2 briefly summarizes our methodology for calculating the equity and asset beta for BT and the comparators, as set out in previous reports;
- Section 3 reports equity and asset betas for BT and the comparators discussed in previous reports (namely UK telecoms and utilities, EU telecoms, US telecoms and ICT comparators), using September 2017 as the cut-off date; and
- Sections 4 sets out our summary and conclusions on the asset beta ranges for BT and comparators, including recommended ranges for the "Other UK Telecoms" and "UK ICT Operators" segments.

The appendices to this report set out in greater detail the statistical analysis carried out to assess the robustness of the equity beta results. In addition, in Appendix B we summarise and address issues raised in the reports submitted by Oxera (on behalf of Openreach) and Frontier Economics (on behalf of TalkTalk and Sky) made in response to Ofcom's March 2017 WLA Consultation, to the extent that they are pertinent to the calculation and disaggregation of BT's beta.

2. Methodology

In this section, we briefly summarize our methodology for calculating equity and asset betas, including the required sensitivity and robustness checks (which are further detailed in statistical Appendix A). This section draws heavily on our First and Second Reports.

2.1. Comparator Selection

In this report we calculate betas for five comparator groups:

1) UK Utilities

2) UK Telecoms;

3) European Telecoms;

4) US Telecoms; and

5) ICT companies.

2.2. Data and Computation of Equity Betas

Data Sourcing and Frequency

For each of the five comparator groups listed above, we source data on stock returns, index returns and gearing from Bloomberg, using 29 September 2017 as the cut-off date.

We use daily log-returns to estimate company betas (as opposed to less granular, i.e. weekly or monthly data). The benefit of using daily data is that a greater number of data points are available for estimation, increasing the robustness of the regression results through lowering of the standard errors. However, the use of daily data is only appropriate in the case of liquid stocks which trade with similar frequency as the average market portfolio. Liquid stocks are not likely to suffer from asynchronous trading biases that arise if there is a difference between the speed with which new information is reflected in the share price of the stock in question relative to the speed of assimilation of new information in the stock market as a whole. Since both BT and the comparator sets are liquid (as set out in Appendix A.4), in this report we use beta estimates based on daily data. [7]

Relevant Index

From an investor's perspective, the cost of capital should be estimated with reference to the financial market that best represents their investment opportunity set, as the cost of capital for any single investment is defined by the entire portfolio of investment opportunities to which an investor has access. This "set" is commonly referred to as the "market portfolio".

[7] To test liquidity, we use the average bid-ask spread for each stock over a 2-year period and check whether that exceeds the threshold of 1%. All stocks considered in this sample are liquid.

Consequently, a key consideration in the estimation of betas is whether to use a local index (or regional if the same currency is used in the region in question) or worldwide index to proxy the market portfolio.

The appropriate reference market index depends on the level of integration of individual capital markets. Despite wider global integration across financial markets in recent years, the academic literature still finds a general consensus that equity markets are less integrated than bond or money markets, and that there is still a significant "equity home bias", i.e. the observation that equity investors have a preference for domestic assets, despite the wider benefits of diversification.[8] Such bias would suggest that systematic risk, as quantified by the asset beta parameter, is more appropriately captured by the stock correlations with a domestic market portfolio.

In this report, we report beta estimates against the relevant local/regional indices and also against a world index to allow for comparisons. More specifically, we use the following local/regional market indices:

- the FTSE All-Share reflecting all stocks trading on the London Stock Exchange, used to estimate betas for UK comparators;
- the FTSE Europe reflecting stocks traded in Europe, used to estimate betas for European comparators; and
- the S&P 500, a US stock index used to estimate betas for US comparators.

Due to the "equity home bias" discussed above, we consider the local/regional index to produce more relevant estimates of beta risk, while also noting that UK regulators, including Ofcom, generally use domestic indices when setting price controls.[9] However, in comparing betas for companies from different jurisdictions, Ofcom may also want to consider using a consistent index for all companies, i.e. the FTSE All World index. Using a world index reflects the systematic risk contribution of the given stock to a globally diversified portfolio, available to international investors with free access to stocks from all jurisdictions.[10]

2.3. Statistical Analysis of Equity Betas

Statistical Testing of CAPM Assumptions

The Ordinary Least Squares (OLS) method is generally the most widely used method for estimating CAPM betas, under the Classical Normal Linear Regression Model (CNLRM). However, this method is based on a set of assumptions, which when violated, results in

8 For a discussion of the literature, see Appendix B.2.2.

9 As examples: the CMA in its Final Determination for Northern Ireland Electricity used the FTSE All Share Index as a proxy for the market portfolio when estimating equity beta for GB utility comparators. See Competition Commission (March 2014), Northern Ireland Electricity Limited Price Determination – A reference under Article 15 of the Electricity (Northern Ireland) Order 1992, Final determination, Appendix 13.3.Similarly, the most recent CAA Determination of the Cost of Capital for Q6 (2014-2019) used a local market index to estimate equity betas of international comparators. See the report from its Consultants, PWC (April 2013), Estimating the cost of capital in Q6 for Heathrow, Gatwick and Stansted, A report prepared for the Civil Aviation Authority (CAA), p.67.

10 For example, a potential investor in telecoms stocks may compare BT's beta with that of Orange against a consistent world index to assess the relative riskiness of the two companies.

biased[11] and/or inefficient[12] (i.e. not minimum variance) beta estimates. We visually inspect/ formally test the following key assumptions:[13]

1) *The error terms of the regression are normally distributed around a zero mean value;*
2) *The error terms are homoscedastic*, i.e. the error terms have constant variance across the sample; and
3) *The error terms are not autocorrelated*, i.e. there is no systematic dependence across the error terms.

Failure of the normality assumption above can bias the beta estimates (e.g. if the distribution of the error term is not symmetric), and may require alternative methods of estimation which can capture non-normality (e.g. the Third-moment CAPM method). On the other hand, the presence of autocorrelation and /or heteroscedasticity does not bias the beta estimates, but affects the confidence intervals (and therefore statistical inferences) around those estimates.

We carry out standard statistical tests (see Appendix A for more detail) to assess whether the statistical assumptions above are satisfied within the respective comparator samples. In the presence of heteroscedasticity and/or autocorrelation, we report estimates based on the Generalized Least Squares (GLS) method, an alternative estimation method to the standard OLS which can address both of these issues.[14]

Outliers

We also test for "outliers", i.e. influential observations in the data, the removal of which can significantly affect the beta estimates. Excluding abnormal periods of the data is equivalent to assuming they will not occur in the future. In this instance, to assess the potential impact from outliers we: (1) conduct regressions excluding the outliers, as well as (2) robust regressions which apply alternative weighting to the observations in the sample giving less weight to observations that have strong influence on the regression output (as measured by the residual), and are therefore less sensitive to outliers.

Thin trading bias

Beta estimates based on daily data can be subject to estimation bias. A common problem cited in the academic literature is that when stocks are traded more frequently or less frequently than the market average, price signals are not assimilated simultaneously. Consequently, the firm's share price may react more slowly or quickly than the market price,

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[11] In statistics, an unbiased estimate refers to the property that the sample statistic converges to its true "population" value in repeated samples.

[12] In statistics, an efficient estimate is an estimate/sample statistic that has the minimum variance, i.e. lowest uncertainty surrounding that estimate/sample statistic.

[13] See standard textbook on Damodar N. Gujarati and Dawn C. Porter: *Basic Economics*, Chapter 3 and 4. The model also includes the following assumptions: (1) the model is linear in the parameters (2) the errors and the independent variable (in this case the market return) are independent, i.e. have zero covariance; and (3) the number of observations is greater than the number of parameters to be estimated within the model.

[14] See standard textbook on Damodar N. Gujarati and Dawn C. Porter: *Basic Economics*, Chapter 11.

and as a result a lead or a lag term of the market price can have a significant correlation with the stock price.

When markets are efficient and the stock in question is liquid, then all public information is assimilated into the stock and the market price contemporaneously. If a stock is not liquidly traded, however, formal diagnostic test for asynchronous trading are needed, e.g. as implemented by Dimson[15], to capture any non- contemporaneous correlation between the stock and the market returns.

We test the liquidity of each comparator in Appendix A.

2.4. Computation of Asset Beta

Asset beta formula

Equity betas are affected not only by the underlying structural, systematic risk of the business but also by financial risk, which depends on the level of debt obligations incurred by the business. We de-lever equity betas to control for the embedded financial risk element and arrive at asset beta estimates that are comparable across companies with different capital structures. To de-lever the equity betas we use the standard Miller formula.

$$\beta a = \frac{E}{D+E}\beta e + \frac{D}{D+E}\beta d,$$

where βa is the asset beta of the company, βe is the equity beta and βd is the debt beta of the company, and E and D are the values of equity and debt respectively. In applying this formula, our data on the gearing and debt beta values are explained below.

Gearing

We calculate gearing, defined as the total (gross) value of debt to assets, based on data provided by Bloomberg.[16] An alternative way to calculate gearing is to use the net debt, i.e. liabilities net of cash and cash equivalents, which implicitly assumes that cash can be used to cover short-term liabilities. However, the use of net debt is not justified if companies need their cash holdings to finance their ongoing activities instead of paying off debt. Since we have no evidence that short term cash held by all the different comparators would be used to cover short term liabilities, we use total value of debt (i.e. gross debt) as a gearing assumption in the asset beta calculations in this report.[17]

Debt beta

In this report, we also conduct a sensitivity check on asset beta by assuming a debt beta of both 0 and 0.1. While some other regulators have often assumed a debt beta of 0 on grounds

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[15] See NERA (May 2015), Estimation of BT's Equity and Asset beta, p.48.

[16] Bloomberg provides gearing data based on the book value of debt and the market value of equity. Debt also includes finance leases. Cash is not netted off.

[17] For a further discussion of this issue, see Appendix B.1.

that the debt of regulated utilities is relatively low-risk, Ofcom has proposed to use a debt beta of 0.1 in its March 2017 WLA consultation.[18] In this report asset beta values quoted are calculated using a debt beta of 0.1 unless stated otherwise.

[18] Ofcom March 2017 WLA Consultation, paragraphs A16.97 to A16.101.

3. September 2017 Update of the Equity and Asset Beta for BT Group and Comparators

In this section we report up-to-date beta estimates for BT and the three comparator groups set out in our First Report, i.e. (1) UK utilities and telecoms, (2) European telecoms, and (3) US telecoms. In the following sub-sections, we set out equity betas, gearing ratios and asset betas for each of these three comparator groups.

3.1. BT, UK Utilities and UK Telecoms

3.1.1. Equity beta

Table 3.1 reports equity beta estimates for BT Group, UK utilities and UK telecoms against both the FTSE All Share and FTSE All World indices using historical data over both 1-year and 2-year periods up to 30 September 2017.

Some key highlights from this table include the following:

- BT's 2-year equity beta is substantially higher than its 1 year equity beta when measured against FTSE All Share and All World respectively. We explain in Section 3.1.3 below that this appears to be due to the effects of the Brexit vote that may have placed an upward pressure on BT's beta leading up to the vote and immediately afterwards, but the effect does not appear to have been sustained for more than a few months.
- The equity betas in the UK utilities sample have almost uniformly fallen since our latest October 2015 update, across both the 1-year and 2-year estimation windows, and against both indices, although the fall in 1-year betas is more pronounced. The average 2-year equity beta for the UK utilities currently stands at 0.64 against the FTSE All Share, c.0.1 lower than our October 2015 update. Again, this result seems to be explained by the Brexit vote which appears to have depressed UK Utilities equity betas, consistent with the view that these stocks are seen as defensive in time of market volatility. By contrast, BT's equity beta has in fact increased on a 2-year basis, which suggests that unlike the traditional utilities, BT may not be perceived by investors as a "defensive" stock (we discuss this further below).
- The 2-year equity beta average of the UK telecoms sample calculated against the All Share index remains at similar levels compared to our October 2015 update (0.88 compared to 0.86 in our previous update), although individual companies show variation in trends (see Table 3.1).
- We also note that in most cases, the UK comparators' equity betas are generally higher when regressed against the home index (i.e. the FTSE All Share) relative to the world index (i.e. the FTSE All World). This tendency is more pronounced for the 1-year equity beta.

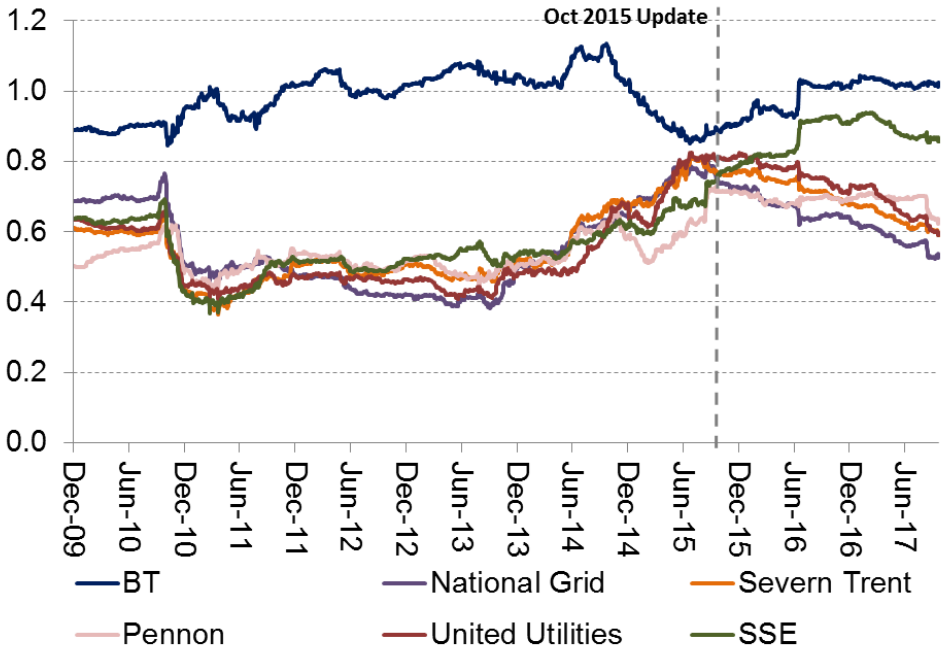
Table 3.1
BT and UK Telecoms/Utilities Equity Beta against the FTSE All Share and All World indices

		FTSE All Share				FTSE All World		
		OLS/GLS*				OLS/GLS*		
		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)
BT								
	1Y	0.61	0.22	0.93	1Y	0.44	0.30	0.88
	2Y	1.03	0.08	0.90	2Y	1.13	0.11	0.81
National Grid								
	1Y	0.59	0.10	0.78	1Y	0.27	0.14	0.67
	2Y*	0.53	0.05	0.74	2Y*	0.43	0.06	0.63
Severn Trent								
	1Y	0.44	0.12	0.77	1Y	0.30	0.16	0.69
	2Y*	0.59	0.05	0.76	2Y*	0.57	0.06	0.67
Pennon								
	1Y	0.53	0.13	0.74	1Y	0.38	0.18	0.65
	2Y	0.63	0.05	0.71	2Y	0.62	0.07	0.62
United Utilities								
	1Y	0.40	0.12	0.84	1Y	0.21	0.17	0.74
	2Y*	0.59	0.05	0.81	2Y*	0.55	0.07	0.71
SSE								
	1Y*	0.34	0.10	0.86	1Y	0.18	0.14	0.80
	2Y*	0.86	0.05	0.78	2Y*	0.96	0.06	0.70
TalkTalk								
	1Y	0.13	0.22	0.66	1Y	-0.12	0.30	0.75
	2Y*	0.79	0.12	0.70	2Y	0.82	0.16	0.73
Sky								
	1Y	0.52	0.19	0.80	1Y	0.49	0.27	0.82
	2Y	0.89	0.07	0.76	2Y	1.01	0.10	0.72
Vodafone								
	1Y*	1.04	0.09	1.07	1Y*	0.75	0.14	1.01
	2Y*	0.97	0.05	1.12	2Y*	0.82	0.07	1.06
Utilities average								
	1Y	**0.46**		**0.80**	1Y	**0.27**		**0.71**
	2Y	**0.64**		**0.76**	2Y	**0.63**		**0.67**
Telecoms average (excluding BT)								
	1Y	**0.56**		**0.84**	1Y	**0.37**		**0.86**
	2Y	**0.88**		**0.86**	2Y	**0.88**		**0.84**

Source: NERA analysis, SE=Standard Error
*Notes: *GLS reported where regression diagnostics show heteroscedasticity or autocorrelation. ** TalkTalk equity beta entered negative territory following poor results published earlier this year (Q1 2017).*

Figure 3.1 to Figure 3.3 illustrate the time series of the 2-year equity betas of BT and the UK comparator set against the FTSE All Share index, over the period December 2009 to September 2017.

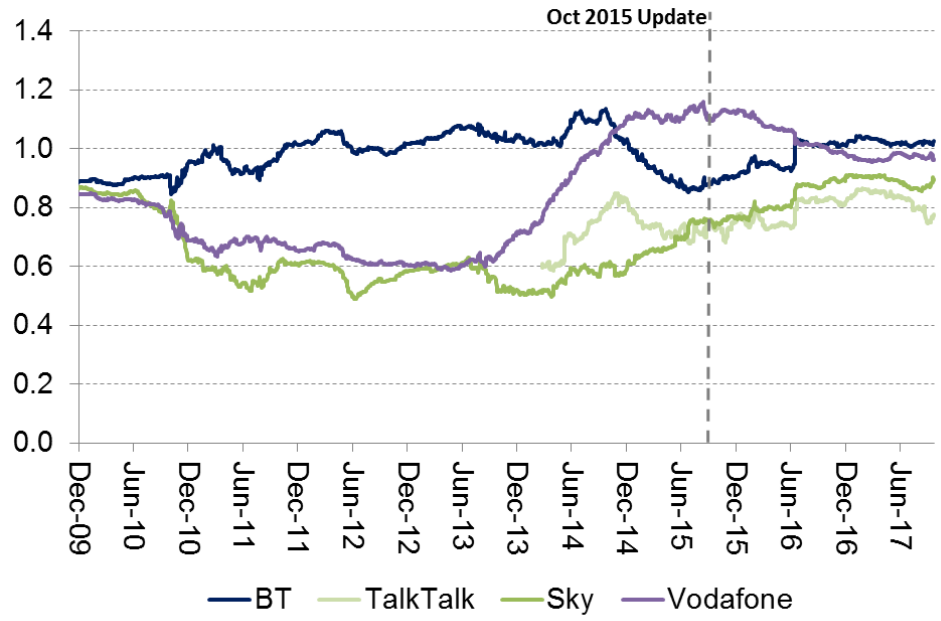
Figure 3.1
BT and UK Utilities 2Y Rolling Equity Beta against FTSE All Share



Source: NERA analysis

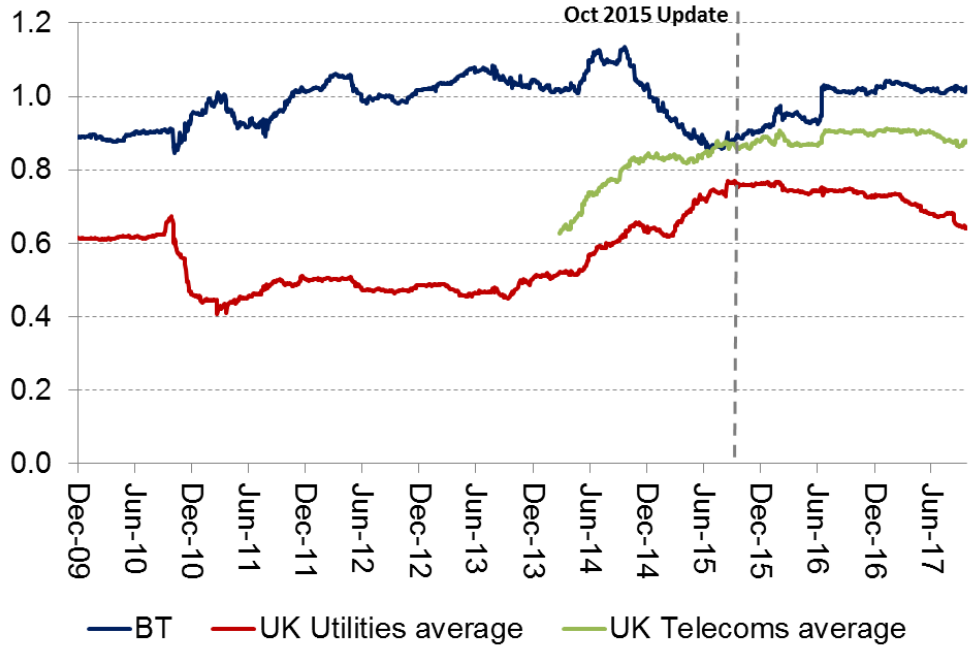
Figure 3.2

BT and UK Telecoms 2Y Rolling Equity Beta against FTSE All Share



Source: NERA analysis

Figure 3.3
BT vs. UK Telecoms / Utilities Average – 2Y Equity Beta against the FTSE All Share



Source: NERA analysis

As shown above, BT's 2-year equity beta has increased by c.0.1 since our October 2015 update (although the 1-year equity beta indicates a downward trend in the last year, see Table 3.1 above). By contrast, equity betas of UK utilities have been largely declining over the period since our October 2015 update, apart from SSE which has a substantial wholesale business and lower exposure to regulated (network) revenues compared to the rest of the sample.

UK telecoms' equity betas have also increased when measured on a 2-year basis, apart from Vodafone's equity beta, which has been on an overall declining trend since our latest update.

3.1.2. Gearing and asset beta

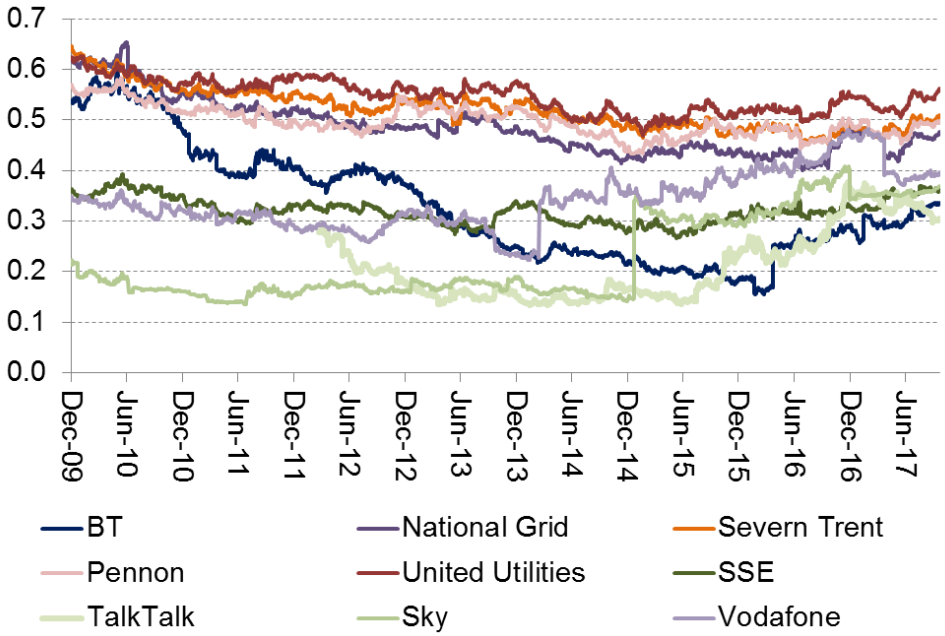
In this section, we derive asset betas for the UK comparators, which control for the financial risk element in the equity betas and are therefore comparable across companies with different capital structures. For BT and each of the comparator companies we calculate asset betas based on the Miller formula as described above in section 2.4.

We calculate gearing, defined as the total (gross) value of debt to assets, based on data provided by Bloomberg.[19] Figure 3.4 shows the evolution of gearing for the UK comparators from December 2009 to September 2017. BT's gearing was declining over much of the period since 2010, but has been on the rise since our latest update and is currently hovering at just over 30 per cent. The gearing ratios of most of the remaining UK comparators have been relatively stable or mildly increasing, with TalkTalk being a notable exception to this having seen a rise in gearing since our latest update. For BT and TalkTalk, we note that the increase in gearing is largely driven by falling equity valuations, although both have added debt on their books recently - BT via its acquisition of EE (and therefore EE's debt), and Talk Talk via a £400m bond issuance in January 2017.[20]

[19] Bloomberg provides gearing data based on the book value of debt and the market value of equity. Debt also includes finance leases. Cash is not netted off.

[20] Since our latest October 2015 update, we note a reduction in market capitalization for both BT (27%) and TalkTalk (17%) leading to higher gearing levels. BT acquisition of EE: http://www.btplc.com/News/#/pressreleases/bt-welcomes-cma-s-approval-of-ee-acquisition-1293195. Talk Talk Bond issuance: https://irpages2.equitystory.com/websites/rns_news/English/1100/news-tool---rns---eqs-group.html?article=25425501&company=talktalk

Figure 3.4
BT and UK Telecoms/Utilities Gearing Ratio



Source: NERA analysis

We have used the average gearing ratios estimated over the same estimation window as the equity betas to de-lever the equity betas.

Table 3.2 below reports asset betas for BT and the UK comparators against both the FTSE All Share and the FTSE All World indices. Our asset beta estimates, based on a debt beta of 0.1 are as follows:

- BT's 2-year asset beta stands at 0.78 against the FTSE All Share and 0.86 against the FTSE All World (with 0.1 debt beta);
- UK utilities have an average 2-year asset beta of 0.40 against both the FTSE All Share and FTSE All World indices; and
- UK telecoms have an average 2-year asset beta of 0.60 against FTSE All Share and 0.61 against FTSE All World.

As shown in Table 3.2 and Figure 3.5 to Figure 3.7, the average 2-year asset beta of both UK samples (UK utilities and UK Telecoms) have fallen by c.0.06 since our October 2015 update. The asset beta (2-year) of BT Group was increasing for the first part of the period since our last (October 2015) update, but has started declining of late.

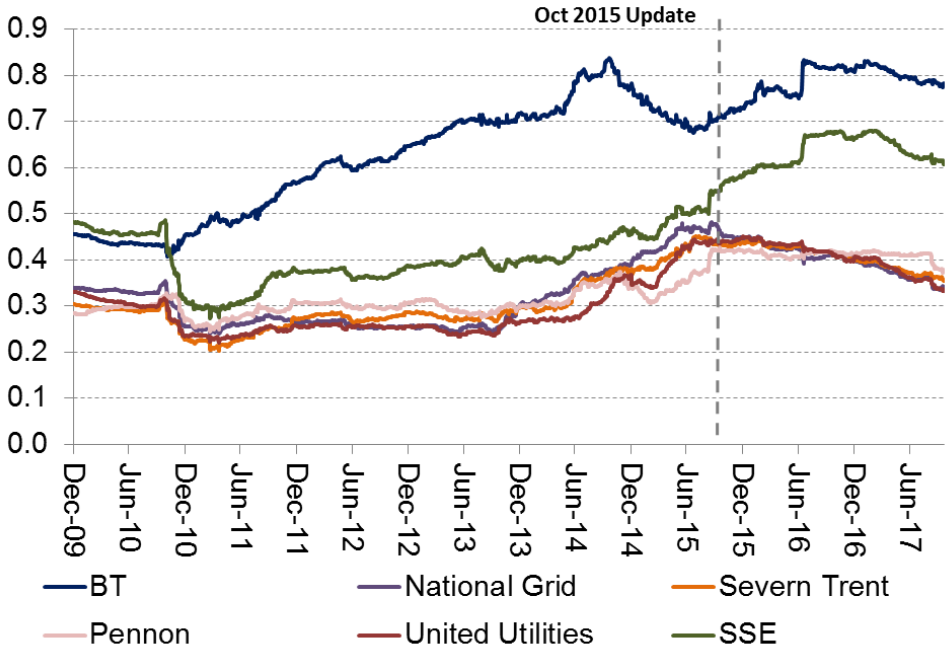
We discuss these trends further in the following section.

Table 3.2
BT and UK Telecoms/Utilities Asset Beta against the FTSE All Share and All World indices

		FTSE All Share			FTSE All World			
		Asset beta (Sep 17)		Asset beta (Oct 15)	Asset beta (Sep 17)		Asset beta (Oct 15)	Market Cap (£ billion)
	Gearing	Debt beta=0	Debt beta=0.1	Debt beta=0.1	Debt beta=0	Debt beta=0.1	Debt beta=0.1	
BT								
1Y	30%	0.43	0.46	0.76	0.31	0.34	0.72	28.2
2Y	26%	0.75	0.78	0.72	0.83	0.86	0.65	
National Grid								
1Y	46%	0.31	0.36	0.48	0.14	0.19	0.42	31.5
2Y	44%	0.30	0.34	0.45	0.24	0.28	0.39	
Severn Trent								
1Y	49%	0.23	0.27	0.44	0.15	0.20	0.40	5.1
2Y	48%	0.31	0.36	0.43	0.30	0.35	0.39	
Pennon								
1Y	48%	0.27	0.32	0.44	0.19	0.24	0.40	3.3
2Y	48%	0.33	0.38	0.42	0.33	0.37	0.37	
United Utilities								
1Y	54%	0.19	0.24	0.46	0.10	0.15	0.42	5.8
2Y	53%	0.28	0.33	0.44	0.26	0.31	0.40	
SSE								
1Y	34%	0.22	0.26	0.64	0.12	0.15	0.60	14.3
2Y	33%	0.58	0.61	0.58	0.64	0.68	0.52	
TalkTalk								
1Y	34%	0.09	0.12	0.57	-0.08	-0.05	0.64	2.0
2Y	29%	0.56	0.59	0.60	0.58	0.61	0.63	
Sky								
1Y	36%	0.33	0.37	0.60	0.31	0.35	0.61	15.7
2Y	35%	0.58	0.62	0.61	0.66	0.70	0.58	
Vodafone								
1Y	43%	0.59	0.64	0.72	0.43	0.47	0.68	56.7
2Y	42%	0.56	0.60	0.77	0.48	0.52	0.73	
Utilities average								
1Y	46%	0.24	**0.29**	**0.49**	0.14	**0.19**	**0.45**	
2Y	45%	0.36	**0.40**	**0.46**	0.35	**0.40**	**0.41**	
Telecoms average (excluding BT)								
1Y	38%	0.34	**0.37**	**0.63**	0.22	**0.26**	**0.64**	
2Y	35%	0.57	**0.60**	**0.66**	0.57	**0.61**	**0.65**	

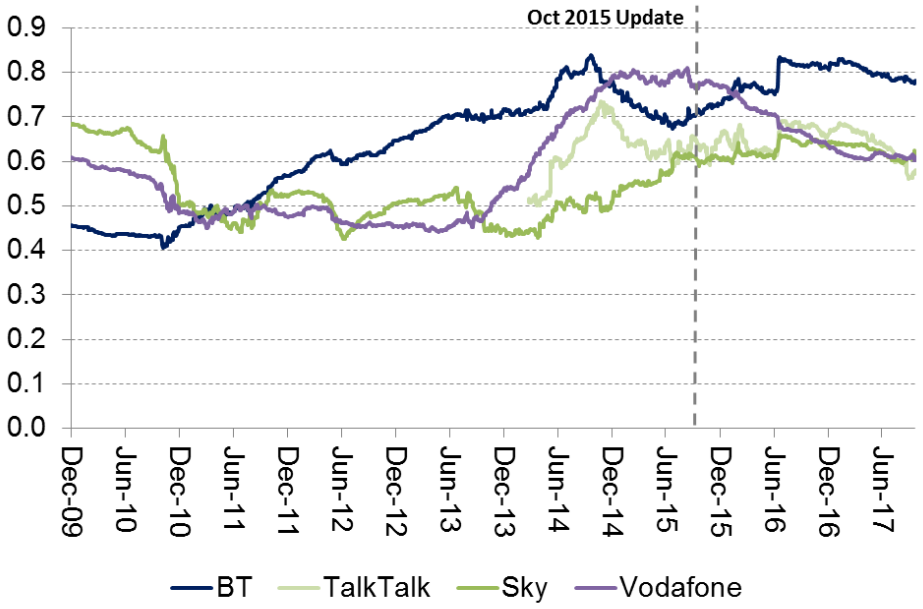
Source: NERA analysis

Figure 3.5
BT and UK Utilities 2Y Rolling Asset Beta against FTSE All Share



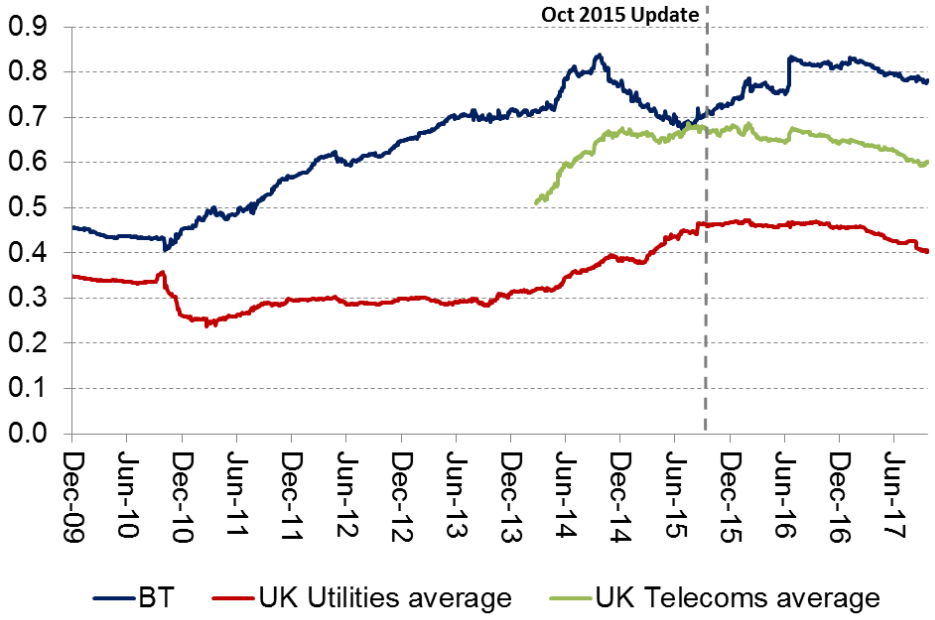
Source: NERA analysis

Figure 3.6
BT and UK Telecoms 2Y Rolling Asset Beta against FTSE All Share



Source: NERA analysis

Figure 3.7
BT vs. UK Telecoms / Utilities Average – 2Y Asset Beta against FTSE All Share



Source: NERA analysis

3.1.3. Discussion of the UK asset beta results

From the above, the following observations can be made with respect to the systematic risk for UK utilities:

1. Since our last update (October 2015), the assets betas of UK utilities **have generally fallen** against both the All Share and All World indices.
2. However, the **fall is substantially more pronounced in the more recent data i.e. in the 1-year asset betas** than in the 2-year assets betas, as the latter average over a longer period of data.

The above observations are consistent with the expected behaviour of the equity and asset betas for utilities which are perceived as "defensive" stocks. The betas for defensive stocks fall in times of heightened market uncertainty – in this case caused by the UK Brexit vote – as they are seen as offering stable returns in times of increased market volatility.

For the UK utilities sample, we show the impact from the Brexit vote by examining more closely the beta for National Grid.

Figure 3.8 shows the 1-year and 2-year betas for National Grid (in green and blue) against the short-term, 3-months correlation of National Grid and the All Share index (in grey). We show

the short-term correlation as an indicator of the latest trend in the equity beta.[21] The following observations follow from Figure 3.8:

- NG's short-term (3-months) correlation with the All Share market fell markedly in the months leading up to, and after the UK Brexit vote. This is consistent with the view that NG is perceived as a "defensive" stock, whose beta falls in times of heightened market uncertainty. NG's 3-months' correlation was also falling in the months leading up to the Brexit vote, which suggests that this effect was already observed in the lead up to the referendum.
- NG's 1-year beta, which averages over 260 daily observations, fell more sharply over the period after the Brexit vote than the 2-year beta. This is because the 2-year beta averages over a long period of time (c. 520 trading day observations), and thus it falls more gradually than the 1-year beta, as it takes time for the new data to form a significant part of the 2-year sample.
- Finally, we also note that specifically for NG, the latest trends (summer 2017) show an increase in the short-term correlations and 1-year beta. This increase could be a result of the effect from the Brexit vote dissipating, though it also coincides with some announcements by UK Energy Regulator Ofgem that the next price controls will be "tougher for investors".[22] In any case, NG's 1-year beta is currently at about the same level as its 2-year beta. By contrast, for all other utilities in the UK sample, 1-year betas remain substantially depressed, and below their respective 2-year betas.

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[21] In financial theory, beta measures the riskiness of a stock relative to a market portfolio. In statistics, beta is estimated based on the following equation

$$\beta = \frac{\sigma_{im}}{\sigma^2_{market}}$$

where σ_{im} is the covariance between the stock returns and the market returns, and σ^2_{market} is the variance of the returns on the market. See any standard finance textbook, for example, *Principle of Corporate Finance* by Brealey, Myers and Allen.

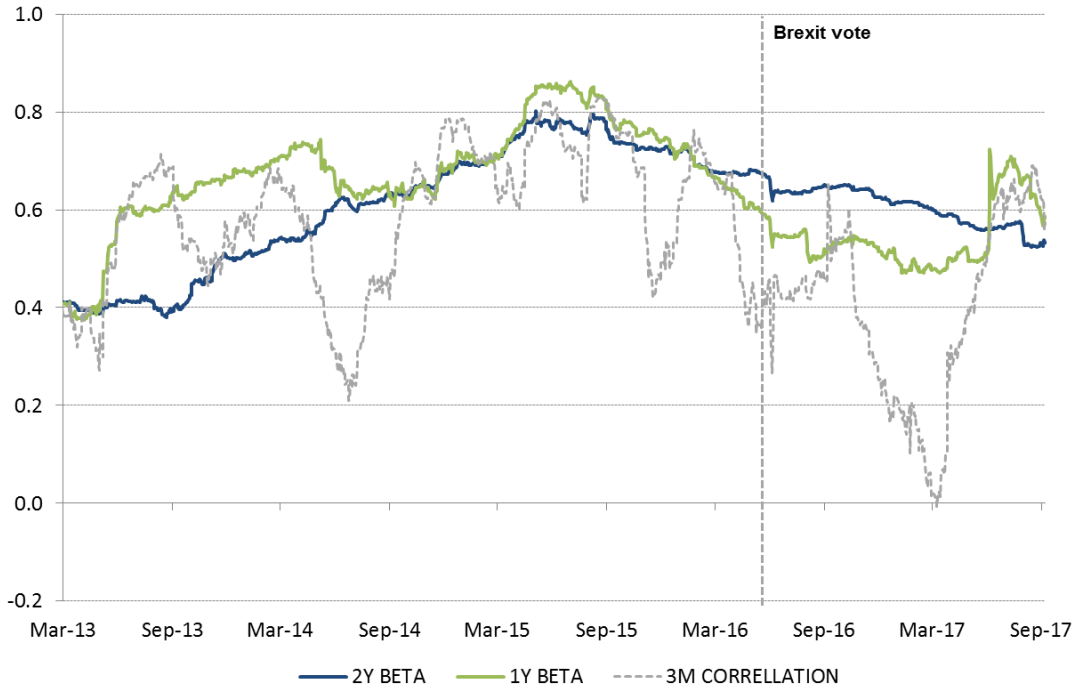
Since the covariance of the stock and the market return can be re-written as the product of $\rho_{stock,\ market}$, the correlation coefficient of the stock and the market return; σ_{stock}, the standard deviation of the stock return; and σ_{market}, the standard deviation of the market return – beta can therefore be rewritten as:

$$= \rho_{stock,\ market} \times \frac{\sigma_{stock}}{\sigma_{market}}$$

We use the short-term correlation as a key indicator of the underlying trend in the beta.

[22] Thomas Natalie (11 July 2017), "UK Electricity and gas networks making 'unjustified' profits", *The Financial Times.*

Figure 3.8
1-year, 2-year equity betas and short-term correlation for National Grid vs. All Share



Source: NERA Analysis of Bloomberg data.

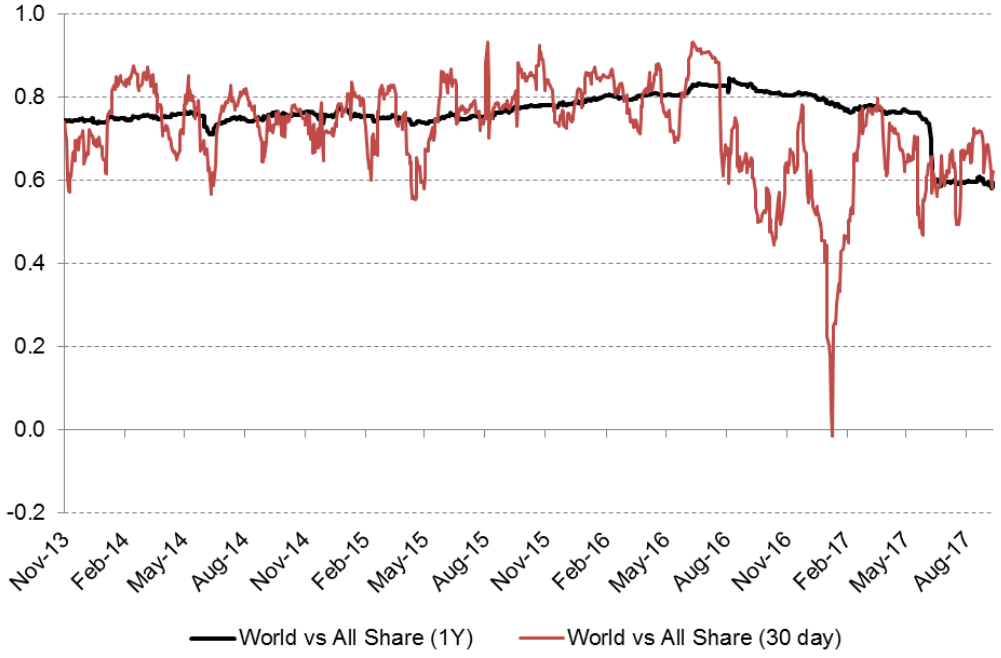
Separately, in relation to the asset betas calculated against the All World index, we notice the following:

3. The asset betas for **both UK utilities and UK telecoms continue to be generally lower when measured against the All World index** (vs the All Share);

4. For many of the UK stocks, **the 1-year asset betas against the All World index are particularly depressed, and in many cases are more than 50 per cent lower than the respective 2-year betas**. Therefore, the fall in risk (i.e. equity and asset betas) for these stocks is especially strong when calculated against the All World index.

Figure 3.9 shows that there has been a general fall in the correlation between UK (FTSE All Share Index) and the wider global portfolio (FTSE All World Index), which could explain the observation that the betas of UK Utilities against the All World index are at the moment particularly depressed, especially on a 1-year basis. As shown below, the 1-year correlation between the All Share and All World indices was hovering around 0.8 but has fallen to about 0.6 from early 2017 onwards. This means that UK stocks have on average somewhat decoupled from the global market, since they are affected by UK-related (e.g. Brexit-related) news.

Figure 3.9
Falling Correlations between the All Share and All World Indices



Source: NERA Analysis of Bloomberg data.

Finally, we note the following observation seemingly at odds with the trend of falling betas and correlations discussed above:

5. The asset betas for **BT, SSE as well as Sky have in fact *increased* since our last update (October 2015) when measured on a 2-year basis**, even though the respective 1-year asset betas of these stocks have fallen relative to the previous update (as is the case for the rest of the sample).

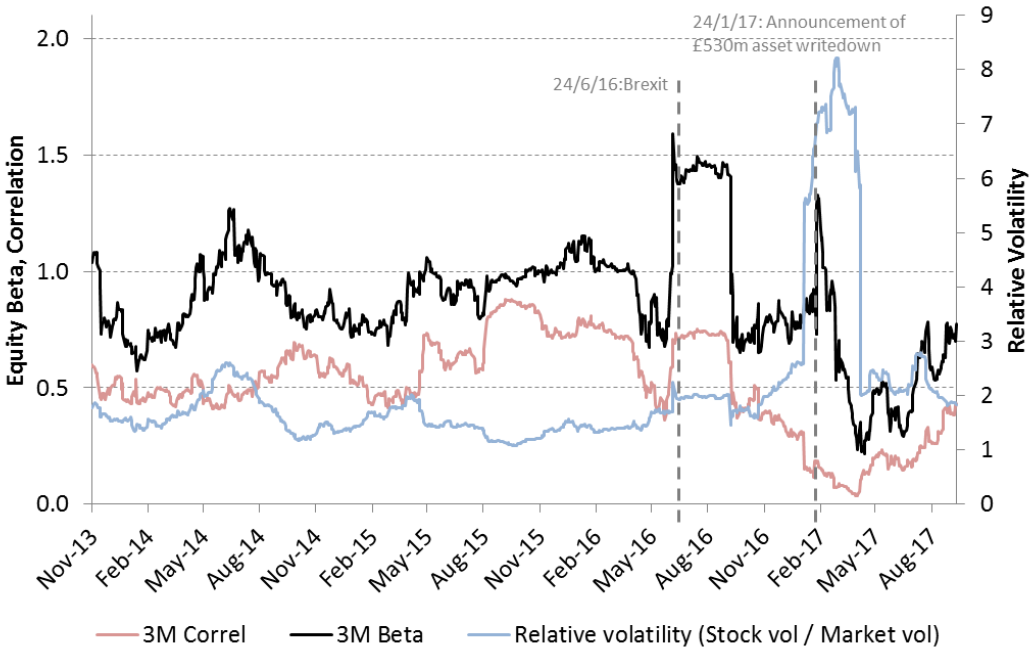
In response to this observation, we note that the common feature of these stocks is that they are currently the highest beta stocks in our UK sample, i.e. they are exposed to greater market risk compared to the other traditional (more heavily regulated) utilities. This alone could imply that the market uncertainty arising from the Brexit vote did not have the same effect on these companies as it had on the traditional utilities, which have seen a fall in their betas given the status of the latter as "defensive" stocks.

We explored the issue further for BT, by decomposing BT's short-term equity beta into short-term (3-months) market correlation, stock volatility and market volatility, shown in Figure 3.10 below.[23,24] As the figure shows, since our last update (October 2015), BT experienced a marked increase in its (short-term) equity beta on two occasions, namely as a result of:

[23] See footnote 21.

- An increase in its short-term correlation with the All Share index immediately following the Brexit vote (shown in red). However, the effect appears to have been short lived, as the short-term correlation has been substantially falling from late 2016 onwards and throughout much of 2017.
- A strong increase in the short-term relative volatility to the market in early 2017 (blue line). The increase in relative volatility followed BT's announcement in January 2017 of a £530 million asset write down, which coincided with a falling market volatility at the time, leading to a temporary increase in BT's relative market volatility and short-term equity beta. However, this announcement has also had a transitory impact on BT's short-term equity beta, as seen from the chart below.

Figure 3.10
BT Short-term Equity Beta decomposition



Source: NERA Analysis of Bloomberg data.

To place the above analysis in perspective, we show the short-term correlation against the 1-year and 2-year betas in Figure 3.11. As seen in Figure 3.11:

- The increase in correlation around the Brexit vote had an immediate impact on both the 1-year and 2-year equity betas. This reflects a likely investor perception of BT as generally a more risky asset, compared to a traditional regulated utility where we see the opposite effect (see Figure 3.8 where we show the opposite for NG).

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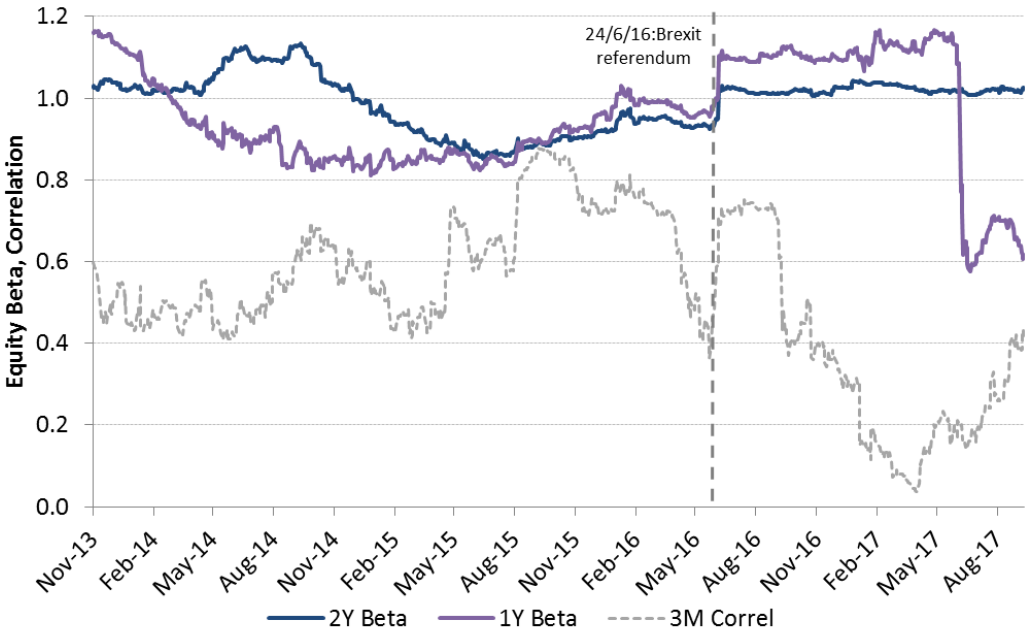
[24] We note that the short-term beta is very volatile and unstable, hence we solely rely on it to explore the short-term changes in the underlying data, in order to better understand the trends in the longer term (1-year, 2-year) betas.

- However, BT then experienced a falling correlation with the market for most of the period from late 2016 onwards. As a result, as soon as the few months surrounding the Brexit vote fall out of the 1-year sample, the 1-year beta drops substantially (i.e. around June 2017). On the other hand, we do not observe the same fall in the 2-year beta because the 2-year beta continues to be based on a sample of data that includes the period around the Brexit vote, as well as data in the year leading up to the Brexit vote, where BT's short-term correlation with the FTSE All Share was generally substantially higher than in the period following the Brexit vote.

We conclude that while the Brexit vote may have placed an upward pressure on BT's beta leading up to the vote and immediately afterward, the effect does not appear to have been sustained by more than a few months. In fact, the 1-year equity beta has already fallen substantially, but the 2-year beta remains elevated as the data around the Brexit vote continues to form part of the sample. If the current trend in the 1-year betas continues, BT's 2-year beta may reduce as soon as the data around the Brexit vote falls out of the sample.

Figure 3.11
BT 1-year, 2-year Equity Betas vs. 3M Correlation



Source: NERA Analysis of Bloomberg data.

3.2. EU Telecoms

3.2.1. Equity beta

We report equity beta estimates of the European telecoms sample, against both the FTSE All Europe and FTSE All World indices in Table 3.3 below. The average 2-year equity beta for the European comparator sample is 0.77 against the FTSE All Europe and 1.12 against the FTSE All World, where the average beta against the All Europe index has fallen relative to our October 2015 update but has increased when calculated against the All World index.

In contrast to the UK sample, we observe that the equity betas of the EU comparators are always *lower* when regressed against the home index (i.e. FTSE All Europe) relative to world index (i.e. FTSE All World). We discuss the reasons for this observation in section 3.2.3 below.

Figure 3.1 and Figure 3.13 illustrate the time series of the 2-year equity betas of BT and the EU comparator set against the FTSE All Europe index, over the period December 2009 to September 2017.

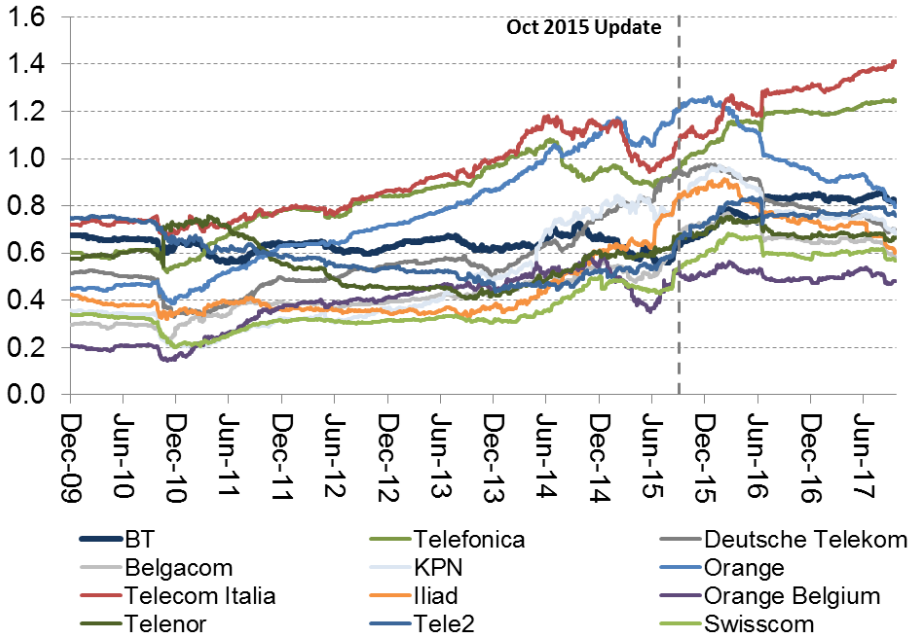
BT's 2-year equity beta has increased by c.0.2, while the average equity beta of the EU Telecoms sample has mildly decreased since our last October 2015 update. In particular, the EU Telecoms sample includes also companies which have experienced a notable increase in their equity beta (Telefonica and Telecom Italia).

Table 3.3
EU Telecoms Equity Beta against the FTSE All Europe and FTSE All World

		FTSE All Europe				FTSE All World		
		OLS/GLS*				OLS/GLS*		
		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)
BT								
	1Y	0.43	0.19	N/A	1Y	0.44	0.30	0.88
	2Y	0.82	0.07	N/A	2Y	1.13	0.11	0.81
Telefonica								
	1Y	0.95	0.10	1.07	1Y	1.50	0.16	1.26
	2Y*	1.25	0.05	1.02	2Y*	1.85	0.08	1.27
Deutsche Telekom								
	1Y	0.66	0.08	0.96	1Y	1.18	0.12	1.39
	2Y*	0.69	0.04	0.95	2Y*	1.19	0.06	1.44
Belgacom								
	1Y	0.50	0.09	0.77	1Y	0.76	0.15	0.86
	2Y*	0.58	0.04	0.72	2Y*	0.85	0.07	0.88
KPN								
	1Y	0.72	0.12	0.89	1Y	0.80	0.20	1.03
	2Y*	0.68	0.05	0.89	2Y	0.97	0.09	1.1
Orange								
	1Y	0.81	0.08	1.27	1Y*	1.06	0.14	1.42
	2Y	0.80	0.05	1.25	2Y*	1.14	0.08	1.48
Telecom Italia								
	1Y	1.02	0.14	0.97	1Y	1.46	0.22	1.06
	2Y*	1.40	0.08	1.11	2Y*	1.96	0.13	1.25
Iliad								
	1Y*	0.61	0.10	0.98	1Y*	0.91	0.17	1.14
	2Y*	0.60	0.06	0.86	2Y*	0.84	0.09	0.95
Orange Belgium								
	1Y	0.48	0.11	0.46	1Y	0.68	0.17	0.38
	2Y*	0.49	0.05	0.48	2Y	0.65	0.08	0.48
Telenor								
	1Y*	0.53	0.11	0.63	1Y*	0.90	0.17	0.84
	2Y*	0.67	0.05	0.68	2Y*	0.96	0.08	0.88
Tele2								
	1Y*	0.76	0.10	0.76	1Y*	1.17	0.16	0.90
	2Y*	0.76	0.05	0.71	2Y*	1.04	0.08	0.85
Swisscom								
	1Y*	0.45	0.06	0.60	1Y	0.65	0.10	0.63
	2Y*	0.57	0.03	0.57	2Y*	0.84	0.05	0.64
EU Comparators Avg.								
	1Y	**0.68**		**0.85**		**1.01**		**0.99**
	2Y	**0.77**		**0.84**		**1.12**		**1.02**

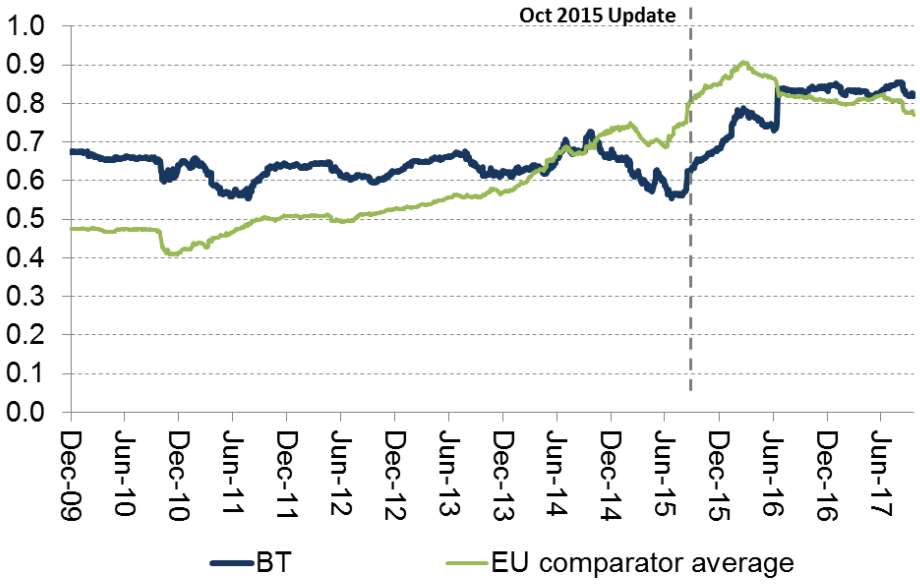
Source: NERA analysis
Note: GLS reported where regression diagnostics show heteroscedasticity or autocorrelation.*

Figure 3.12
EU Telecoms - 2Y Rolling Equity Beta



Source: NERA analysis
Note: BT's beta also estimated against the regional, FTSE All Europe index.

Figure 3.13
BT vs.EU Telecoms Average – 2Y Equity Beta

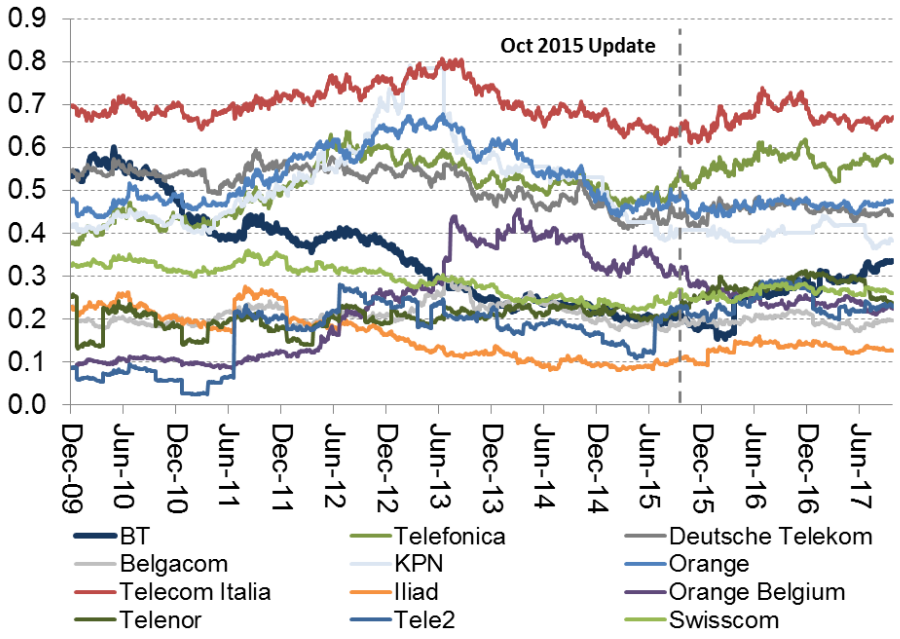


Source: NERA analysis
Note: BT's beta also estimated against the regional, FTSE All Europe index.

3.2.2. Gearing and asset beta

Figure 3.14 shows the rolling gearing ratios for the European comparators set over the period December 2009 to September 2017. As shown in Figure 3.14, the gearing levels of most European telecoms comparators have held relatively stable since our last update.

Figure 3.14
EU Telecoms Gearing Ratio



Source: NERA analysis

Table 3.4 below reports asset betas for the set of European telecoms comparators. The average 2-year asset beta for the eleven comparators has fallen to 0.49 against the FTSE All Europe, and has moderately increased to 0.70 against the FTSE All World. A comparison between BT's asset beta with that of the European telecoms shows that:

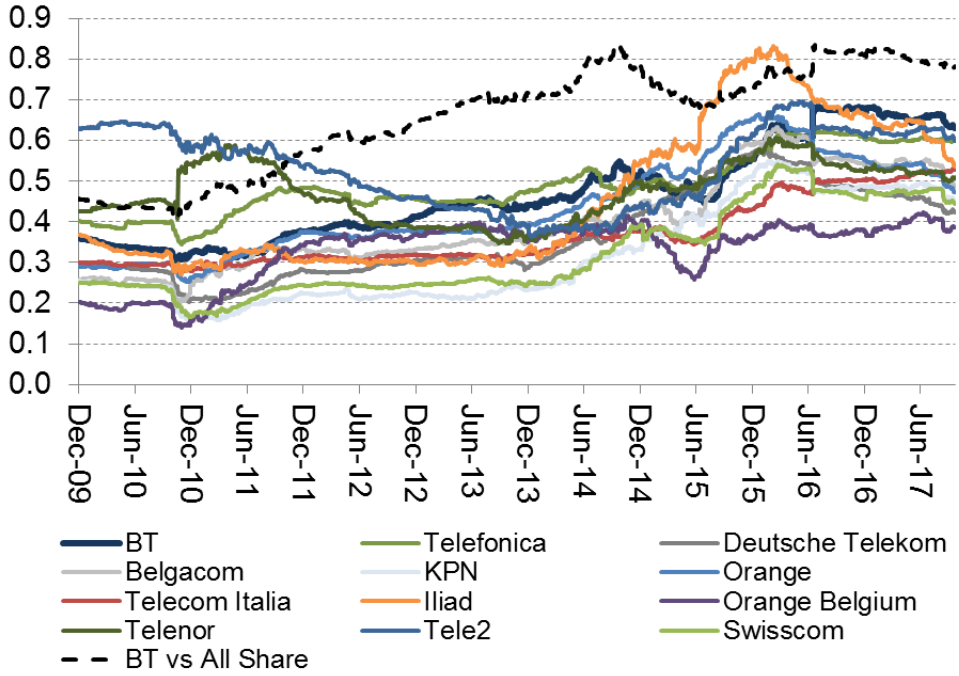
- Against the respective regional FTSE All Europe index, BT's asset beta of 0.63 is somewhat above the asset beta average of the European telecoms which currently stands at 0.49;
- Against the world index, BT's asset beta of 0.86 is also above the European telecoms average of 0.70.

Table 3.4
EU Telecoms Asset Beta against the FTSE All Europe and FTSE All World

		FTSE All Europe			FTSE All World		
		Asset beta (Sep 17)		Asset beta (Oct 15)	Asset beta (Sep 17)		Asset beta (Oct 15)
	Gearing	Debt beta=0	Debt beta=0.1	Debt beta=0.1	Debt beta=0	Debt beta=0.1	Debt beta=0.1
BT							
1Y	30%	0.30	0.33	N/A	0.31	0.34	0.72
2Y	26%	0.60	0.63	N/A	0.83	0.86	0.65
Telefonica							
1Y	57%	0.41	0.47	0.58	0.65	0.71	0.68
2Y	56%	0.54	0.60	0.55	0.81	0.86	0.67
Deutsche Telekom							
1Y	45%	0.36	0.41	0.58	0.64	0.69	0.81
2Y	46%	0.38	0.42	0.55	0.65	0.69	0.81
Belgacom							
1Y	19%	0.41	0.43	0.64	0.61	0.63	0.71
2Y	20%	0.47	0.49	0.59	0.69	0.70	0.71
KPN							
1Y	41%	0.43	0.47	0.54	0.47	0.51	0.61
2Y	40%	0.41	0.45	0.49	0.58	0.62	0.60
Orange							
1Y	47%	0.43	0.48	0.72	0.56	0.61	0.79
2Y	46%	0.43	0.47	0.64	0.61	0.66	0.75
Telecom Italia							
1Y	67%	0.33	0.40	0.39	0.48	0.54	0.42
2Y	67%	0.46	0.53	0.42	0.64	0.71	0.46
Iliad							
1Y	13%	0.53	0.54	0.89	0.79	0.80	1.04
2Y	13%	0.52	0.53	0.79	0.72	0.74	0.86
Orange Belgium							
1Y	24%	0.36	0.39	0.34	0.52	0.54	0.29
2Y	25%	0.37	0.39	0.34	0.49	0.51	0.34
Telenor							
1Y	28%	0.38	0.41	0.51	0.64	0.67	0.68
2Y	28%	0.49	0.51	0.55	0.69	0.72	0.71
Tele2							
1Y	24%	0.58	0.60	0.65	0.89	0.92	0.77
2Y	24%	0.58	0.60	0.60	0.79	0.82	0.72
Swisscom							
1Y	27%	0.33	0.35	0.48	0.48	0.50	0.51
2Y	26%	0.42	0.44	0.45	0.62	0.64	0.50
EU Comparators Avg.							
1Y	36%	0.41	**0.45**	**0.57**	0.61	**0.65**	**0.67**
2Y	36%	0.46	**0.49**	**0.54**	0.66	**0.70**	**0.65**

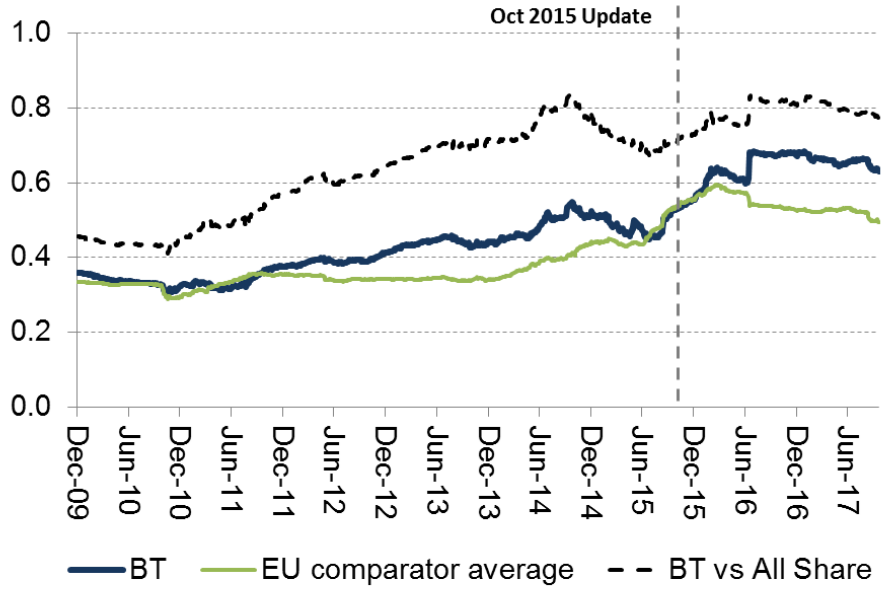
Source: NERA analysis

Figure 3.15
EU Telecoms - 2Y Rolling Asset Beta



Source: NERA analysis Note: EU and BT's beta estimated against the All Europe index, and BT's beta also shown against the FTSE All Share ("BT vs All Share).

Figure 3.16
BT vs. EU Telecoms Average – 2Y Asset Beta



Source: NERA analysis. EU and BT's beta estimated against the All Europe index, and BT's beta also shown against the FTSE All Share ("BT vs All Share).

3.2.3. Discussion of the EU telecoms results

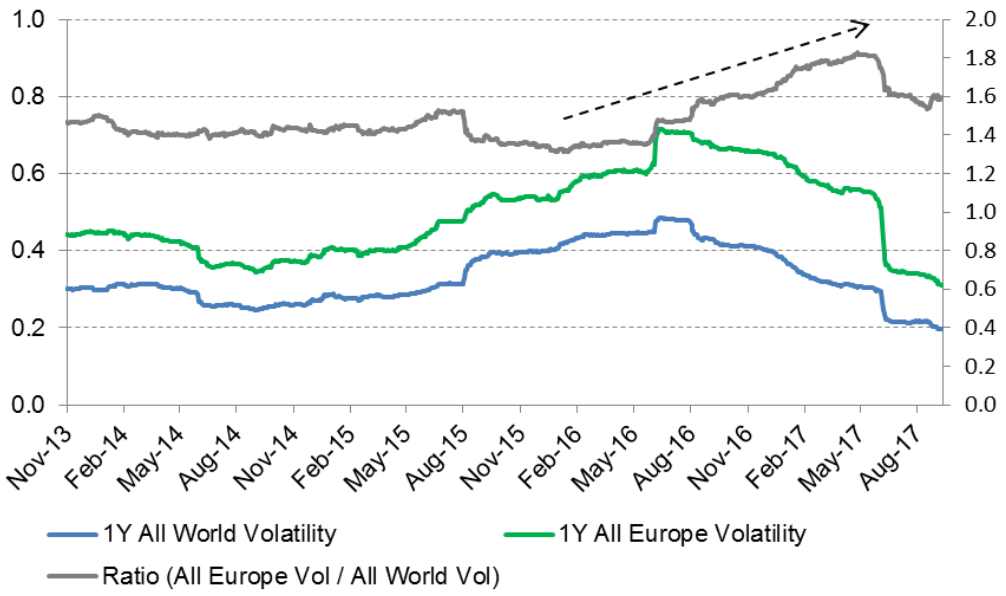
We make the following observations regarding the EU comparators sample:

1. When calculated **against the All Europe index, the majority of the EU comparators experience a fall in their asset betas** when compared to our previous update (October 2015); but
2. When calculated **against the All World index, the majority of the EU comparators experience a slight increase in their asset betas** when compared to our previous update.
3. The betas calculated against the All World therefore continue to be higher than those calculated against the regional All Europe index.

As shown in Figure 3.17, from around mid-2016 (coinciding with the Brexit vote), there has been a divergence in the volatility of the All Europe and All World indices, as evidenced by an increasing ratio of the All Europe Volatility to All World Volatility. While both experienced an increase in volatility leading up to the Brexit vote, and a fall in volatility since, the All Europe index volatility increased by more than that of the All World index in the period prior to the vote, and did not fall by as much as the All World volatility in the subsequent period. The volatility ratio of the two indices has therefore been steadily increasing for much of the period of our assessment.

Because the beta for each stock varies inversely with the market volatility, the comparatively higher volatility for the All Europe index would have placed a downward pressure on the betas against the All Europe index, leading to comparatively lower betas estimated against the All Europe vis-à-vis the All World, all else equal.

Figure 3.17
Volatility of the All Europe vs All World Index



Source: NERA Analysis of Bloomberg data.

3.3. US Telecoms

3.3.1. Equity beta

Table 3.5 reports updated equity betas for the US comparator group, based on the same sample as that in our October 2015 update[25].

Compared to our October 2015 update, the average equity beta of the US sample when calculated against the home index (S&P 500) has been relatively stable (both on a 1-year and 2-year basis), although this masks significant movements in the betas of individual companies within the sample: Century Link's equity beta has increasing substantially, while AT&T and Verizon show the opposite trend. Figure 3.18 shows these movements graphically.

When calculated against the All World index, the average 2-year equity beta of the sample has fallen substantially to 0.70 (from 0.83 in our October 2015 update), and mildly when measured on a 1-year basis to 0.81 (from 0.85 in our October 2015 update).

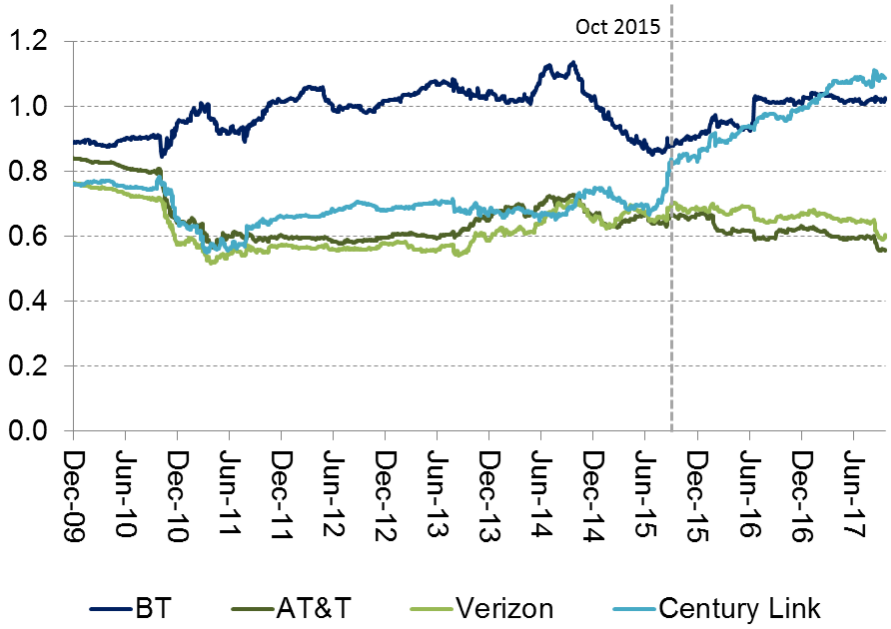
Table 3.5
US Telecoms Equity Beta

		S&P 500 OLS/GLS*				FTSE All World OLS/GLS*		
		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)		Beta (Sep 17)	SE (Sep 17)	Beta (Oct 15)
BT								
	1Y	N/A	N/A	N/A	1Y	0.44	0.30	0.88
	2Y	N/A	N/A	N/A	2Y	1.13	0.11	0.81
AT&T								
	1Y*	0.58	0.11	0.70	1Y	0.64	0.14	0.77
	2Y	0.56	0.05	0.66	2Y	0.50	0.06	0.74
Verizon								
	1Y*	0.55	0.13	0.72	1Y	0.65	0.16	0.76
	2Y	0.60	0.06	0.68	2Y	0.54	0.06	0.75
Century Link								
	1Y*	1.21	0.25	0.94	1Y	1.15	0.31	1.03
	2Y	1.09	0.11	0.85	2Y	1.06	0.12	1.01
US Comparator Avg.								
	1Y	**0.78**		**0.79**	1Y	**0.81**		**0.85**
	2Y	**0.75**		**0.73**	2Y	**0.70**		**0.83**

Source: NERA analysis
*Note: * GLS reported where regression diagnostics show heteroscedasticity or autocorrelation.*

[25] See NERA (May 2015) for the original sample, and adjustments to the sample in NERA (March 2016), in footnote 3 and footnote 6 above.

Figure 3.18
US Telecoms 2Y Rolling Equity Beta



Source: NERA analysis
Note: BT's beta is estimated against BT's home index, i.e. FTSE All Share

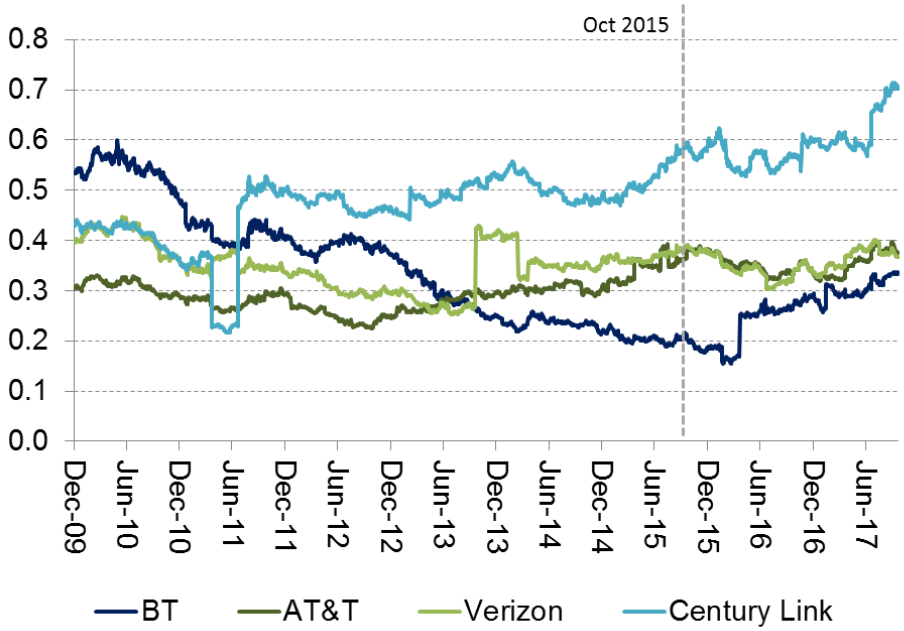
3.3.2. Gearing and asset beta

In this section we report the gearing ratios and asset betas for the US comparator sample.

As shown in Figure 3.19, the gearing ratio of Century Link has been notably rising since our last update, consistent with the rise in its equity beta which reflects financial leverage. By contrast, the gearing ratios of AT&T and Verizon have been relatively stable.

As shown in Table 3.6, the 2-year asset beta average of the US telecoms sample against the home index is slightly lower at 0.44 (compared to 0.47 in our October 2015 update) and is notably lower when calculated against the world index, at 0.41compared to 0.53 in our previous update.

Figure 3.19
US Telecoms Gearing Ratios



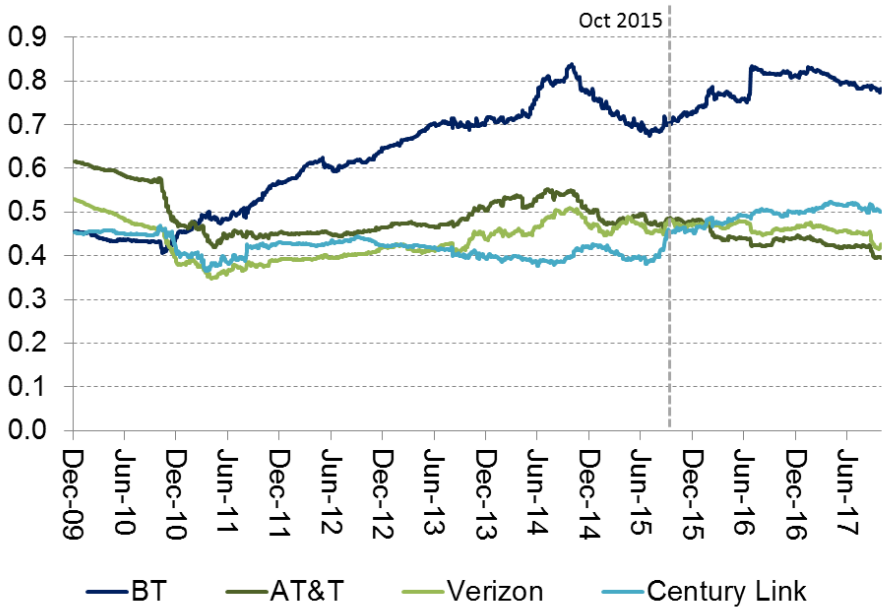
Source: NERA analysis

Table 3.6
US Telecoms Asset Beta

		S&P 500			FTSE All World		
		Asset beta (Sep 17)		Asset beta (Oct 15)	Asset beta (Sep 17)		Asset beta (Oct 15)
	Gearing	Debt beta=0	Debt beta=0.1	Debt beta=0.1	Debt beta=0	Debt beta=0.1	Debt beta=0.1
BT							
1Y	30%	N/A	N/A	N/A	0.31	0.34	0.72
2Y	26%	N/A	N/A	N/A	0.84	0.86	0.65
AT&T							
1Y	35%	0.38	0.41	0.49	0.42	0.45	0.54
2Y	35%	0.36	0.40	0.48	0.32	0.36	0.53
Verizon							
1Y	36%	0.35	0.39	0.49	0.41	0.45	0.52
2Y	36%	0.39	0.43	0.47	0.35	0.38	0.51
Century Link							
1Y	62%	0.46	0.52	0.50	0.44	0.50	0.54
2Y	59%	0.44	0.50	0.46	0.43	0.49	0.54
US Comparator Avg.							
1Y	45%	0.39	**0.44**	**0.49**	0.42	**0.47**	**0.53**
2Y	43%	0.40	**0.44**	**0.47**	0.37	**0.41**	**0.53**

Source: NERA analysis

Figure 3.20
US Telecoms 2Y Rolling Asset Beta



Source: NERA analysis
Note: BT's beta is estimated against BT's home index, i.e. FTSE All Share

3.4. ICT Comparators

BT provides ICT services via its Global Services (GS) and Business and Public Sector divisions. [26] BT's ICT operations involve combining its connectivity, network, and IT capabilities to deliver global information and communications technology (ICT) services to around 5,500 corporate and public clients in 180 countries.[27]

For our last beta update, Ofcom asked that we include an assessment of the betas of comparators for BT's ICT operations. In this section, we update the beta estimates for the ICT comparators identified in our October 2015 update.[28]

For ease of reference, we summarize the portfolio of ICT products and services offered by BT below. In the following sections, we update the beta estimates for the ICT comparators that cover one or more of these products or services.

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[26] Prior to 1 April 2016 most of BT's ICT services were provided out of GS. Since then, GS has focused on multinational and international clients while Business and Public Sector deals with UK-focused clients. See press release dated 1 February 2016: http://www.btplc.com/news/#/pressreleases/bt-announces-new-structure-1304769.

[27] BT 2017 Annual Report, p. 9.

[28] We use the same sample of companies as that used in October 2015, with one exception where we exclude the Italian company "Engineering Spa" which was delisted in July 2015 after it was acquired by MIC Bidco S.p.A.

3.4.1. BT's ICT Service and Product Offering

BT offers a diversified portfolio of ICT products and services, which we group as follows:

1) **Managed Networked IT Services and Security** is the largest segment under the GS umbrella, and covers:

   - Managed networked services, offered under the *BT Connect* brand; BT Connect comprises the largest source of revenue within GS[29], and offers a range of network and connectivity solutions to large corporate clients, including set-up and management of secure IP, Ethernet and internet virtual private network services; and
   - The cyber security services, offered under the *BT Security* brand; BT Security covers a range of products and services to protect clients from cyber threats, including firewalls, web security, intrusion prevention etc.

2) **Unified Communications and IT Infrastructure** covers**:**

   - Collaborative communications, offered under the *BT One* brand; BT One offers integrated connectivity solutions for corporate clients, including integrated conferencing and collaboration services, Cisco off-the-shelf solutions, managed IP telephony etc.; and
   - IT infrastructure services, offered under the BT *Compute* brand; BT Compute offers a range of services from traditional tele-housing and colocation to public, private and hybrid cloud solutions.

3) **Professional Services and IT Consulting** covers**:**

   - Professional advisory services, offered under the *BT Advise* brand; BT Advise includes IT Consulting and integration services; and
   - Outsourced client relationship management services, offered under the *BT Contact* brand.

We provide more detail of the type of activity within each segment in Table 3.7 below.

[29] BT's segmental accounts for 2011 report that 66% of GS revenues came from managed solutions. BT has since discontinued the segmental revenue reporting, but BT's Annual Reports continue to discuss the managed network services as the dominant line of business within GS.

Table 3.7
BT's ICT Product and Service Offering

(1) Managed Networked IT Services	(2) Unified Comms / IT Infrastructure		(3) Professional Services/ IT Consulting (CRM / BPM)	
BT Connect (& Security)	**BT One**	**BT Compute**	**BT Contact**	**BT Advise**
A range of managed network solutions – including secure IP, Ethernet, and internet VPNs – provided through different access technologies: - Access choices (e.g. Ethernet via fiber or copper) - Application performance management - Dedicated Services - Internet services - IP address management - Managed network services - Virtual Private Network services A range of **security solutions,** including firewalls, web security, intrusion prevention and threat monitoring.	**Unified Connectivity,** provides integrated communication channels: - Conferencing and Collaboration services (e.g. cloud unified communications) - Hosted Unified Communications Services (e.g. Cisco Unified Communications) - Managed IP Telephony - Voice VPN (own corporate telephone networks) **Calls and lines,** provides: - Business exchange lines - Call & lines packages - Analytics	Provides **reliable and flexible IT platforms and services** for business apps, data storage and security: - Traditional telehousing and colocation centres; - Latest public, private and hybrid cloud solutions; - Professional Services for IT (infrastructure assessment and optimization)	**Outsourced Client Relationship management,** including: - Cloud contact centres - Contact recording and analytics - Inbound services - Onsite contact centres - Self-service and queue management platforms	**Professional advisory**, including: - CRM Professional services (e.g. BT Contact Centre Efficiency Quick Start assess contact center operations) - IT professional services (infrastructure assessment, optimization, storage design and data management) - Mobility professional services

Source: NERA Analysis of BT Annual Reports

3.4.2. Asset beta Estimates

Table 3.8 reports the asset betas of our sample of ICT comparators, indicating whether each comparator is active in each of BT's ICT product and service lines discussed in the section above.[30]

Based on the product and service lines coverage in Table 3.8, we categorize the sample of comparators into two tiers, namely:

1) *Tier 1* – includes companies that are active across all three main ICT product and service lines offered by BT. The average 2-year asset beta of this group of comparators has fallen to 0.72 against the local/regional index (from 0.84 in our previous update) and 0.80 against the world index (vs 0.96 in our previous update); and
2) *Tier 2* – includes companies that are active across two of the three main ICT product and service lines offered by BT. The average 2-year asset beta of this wider group of companies now stands at 0.76 against the local/regional index (vs 0.81 in our latest update) and 0.88 against the world index (vs 0.90 in our previous update).

[30] The sample of companies does not report segmental accounts on a consistent basis – hence a consistent breakdown of revenues into GS equivalent business areas is not readily available.

We note that the variability of the asset betas for ICT comparators is greater than the variability of the telecoms sample. The asset beta range for the Tier 1 comparators is 0.45 - 1.06 against the local/regional index and 0.65-1.07 against the world index.

Table 3.8
Betas of ICT Companies

Company	Country of listing	(1) Managed networked IT services	(2) Unified Comms/ IT Infrastructure	(3) Professional Services/ IT consulting	Local/Regional index	Average 2y gearing	2Y Equity beta (Local index)	SE	2Y Equity beta (World index)	SE	2Y Asset beta (Local index)		2Y Asset beta (World index)		Tier 1?
IBM	US	Y	Y	Y	S&P 500	23%	0.90	0.06	0.92	0.06	0.72		0.73		✓
Unisys Corp	US	Y	Y	Y	S&P 500	44%	1.81	0.20	1.83	0.22	1.06	*	1.07		✓
Amdocs Ltd	US	Y	Y	Y	S&P 500	1%	0.74	0.05	0.70	0.06	0.73		0.69		✓
Computer Science	US	Y	Y	Y	S&P 500	29%	1.15	0.12	1.17	0.13	0.84		0.85	*	✓
Teletech Hldgs	US	Y	Y	Y	S&P 500	10%	0.96	0.08	0.88	0.09	0.88		0.80		✓
Cdw Corp	US	N	Y	Y	S&P 500	29%	1.05	0.07	1.01	0.08	0.77		0.74		
Cognizant Tech	US	N	Y	Y	S&P 500	3%	1.27	0.08	1.24	0.09	1.24		1.21		
Xerox Corp	US	N	Y	Y	S&P 500	42%	1.30	0.10	1.34	0.11	0.79		0.82		
Indra Sistemas	SP	Y	Y	Y	FTSE All Europe	33%	0.85	0.07	1.32	0.12	0.60		0.92	*	✓
Cancom	GE	Y	Y	Y	FTSE All Europe	39%	0.68	0.07	1.12	0.11	0.45	*	0.72	*	✓
Atos SE	FR	Y	Y	Y	FTSE All Europe	47%	0.79	0.05	1.12	0.08	0.47		0.65	*	✓
Sopra Steria Group	FR	N	Y	Y	FTSE All Europe	8%	0.86	0.07	1.26	0.11	0.80		1.17	*	
Cap Gemini	FR	N	Y	Y	FTSE All Europe	0%	0.93	0.05	1.30	0.09	0.93		1.30	*	
Tieto	FI	N	Y	Y	FTSE All Europe	7%	0.56	0.05	0.81	0.08	0.52	*	0.76	*	
Cgi Group Inc	CA	N	Y	Y	S&P/TSX Composite	1%	0.61	0.07	0.75	0.07	0.61		0.74		
Average Asset Beta (Sept 2017)															
Tier 1						**28%**	**0.98**		**1.13**		**0.72**		**0.80**		
Tier 2 (all comparators)						**21%**	**0.96**		**1.12**		**0.76**		**0.88**		
Average Asset Beta (Oct 2015)															
Tier 1							**1.02**		**1.17**		**0.84**		**0.96**		
Tier 2 (all comparators)							**0.96**		**1.07**		**0.81**		**0.90**		

Source: NERA Analysis
*Note: * GLS reported where regression diagnostics show heteroscedasticity or autocorrelation.*

4. Summary and Conclusions on Asset Beta Risk for BT and Comparators

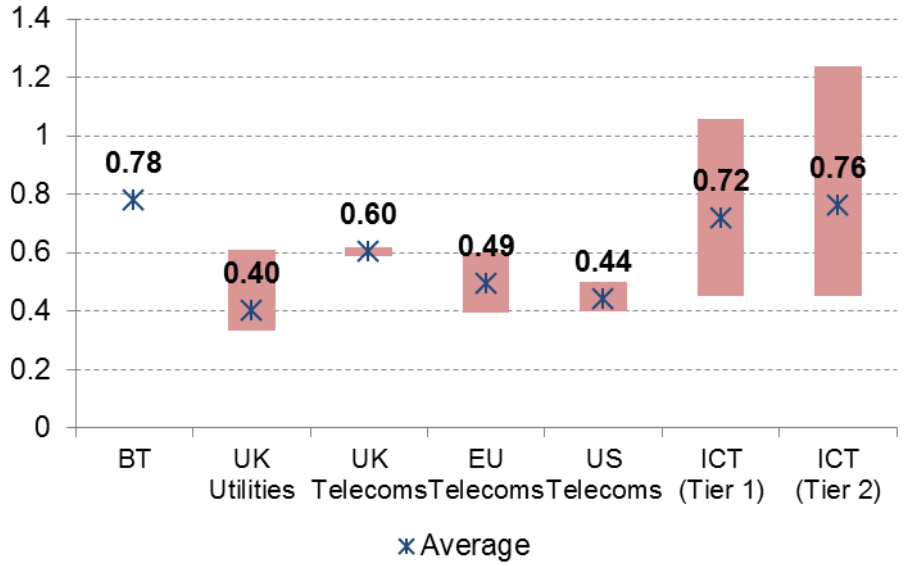
4.1. Summary of trends in the asset betas of BT and Comparators

We summarize the trends in the betas of BT and comparators below.

Figure 4.1 and Figure 4.2 compare our current estimates of the 2-year asset betas of BT and comparators against the local/regional indices with our previous (October 2015) update. In summary, we find that:

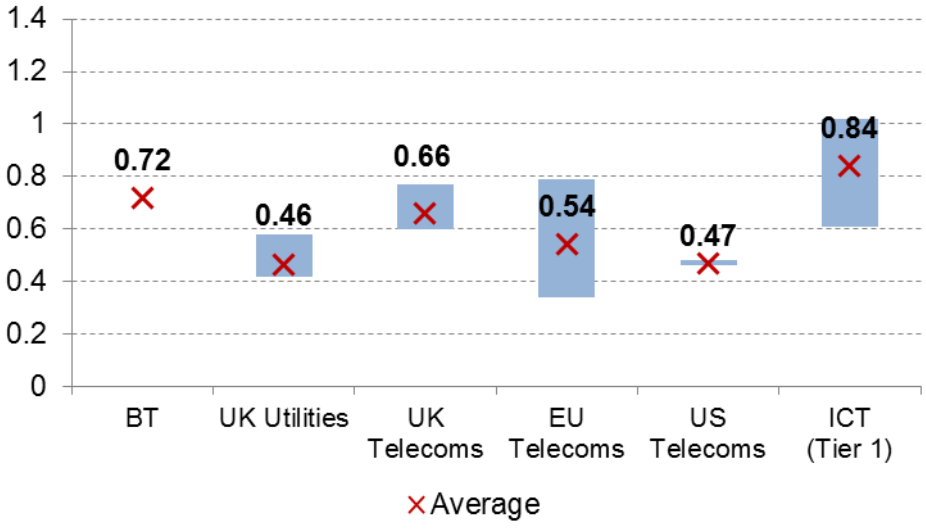
- Since our latest update, **BT's** 2-year asset beta has increased against both the FTSE All Share and FTSE All World indices. As we discussed above, this is a result of heightened perceived risk around the Brexit vote, leading to increased correlations with the market around and immediately following the vote, which continues to form part of the 2-year data sample (but have fallen out of the 1-year data sample). However, much like the rest of the UK Utilities sample, BT's 1-year asset beta has been decreasing in the period following the UK Brexit vote, and is now lower relative to our previous update;
- The **UK utilities** sample has seen a fall in asset betas since the Brexit vote, consistent with the view of utilities as "defensive" stocks, which provide stable returns in times of heightened uncertainty. Since BT's 2-year beta increased since our last update, this has led to a larger gap between BT and the UK utilities on a 2-year basis.
- The **UK Telecoms** sample has also seen a fall in asset betas, both on a 1-year and 2-year basis. However, while the 2-year asset betas of the UK telecoms sample (excluding BT) have slightly decreased since our October 2015 update, the 1-year asset betas have fallen more notably.
- The **EU telecoms** sector has also seen falling asset betas against the All Europe index, although the opposite is true when 2-year asset betas are calculated against the All World index (1-year asset betas are broadly stable). We discussed that one reason for this is the increased volatility of the All Europe index relative to the All World, which all else equal, leads to lower betas against the regional index given the inverse relationship between beta and market volatility;
- The **US telecoms** asset betas have uniformly decreased against both the local index (S&P) and the All World index, seeing the strongest fall in the 2-year asset beta against the All World index; and
- The **ICT companies (Tier 1)** have also seen falling asset betas, although the ICT companies continue to have the highest average asset betas of the comparator groups considered. The range of asset beta estimates for the ICT comparators is also much wider than for the other groups. As a result of this variability, there is a degree of overlap in the asset betas between ICT companies and the other comparator groups.

Figure 4.1
Summary of 2-year Asset Beta against the Local/ Regional Index – Current (September 2017)



Source: NERA analysis.

Figure 4.2
Summary of 2-year Asset Beta against the Local/ Regional Index –October 2015

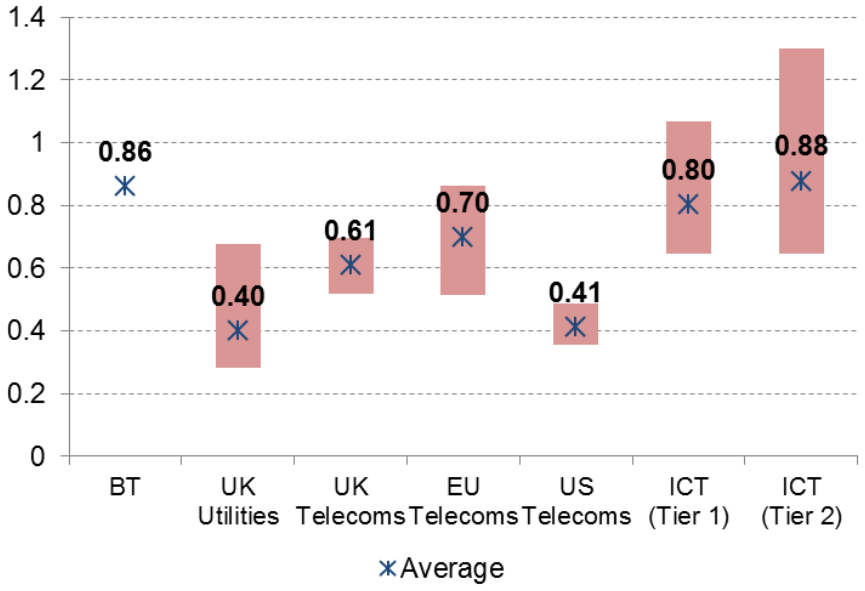


Source: NERA analysis
Note: We show beta averages and ranges for the ICT sample based on Tier 1 comparators.

Figure 4.3 and Figure 4.4 compare our current estimates of the 2-year asset betas of BT and comparators, estimated against the world index, with our October 2015 update. For all

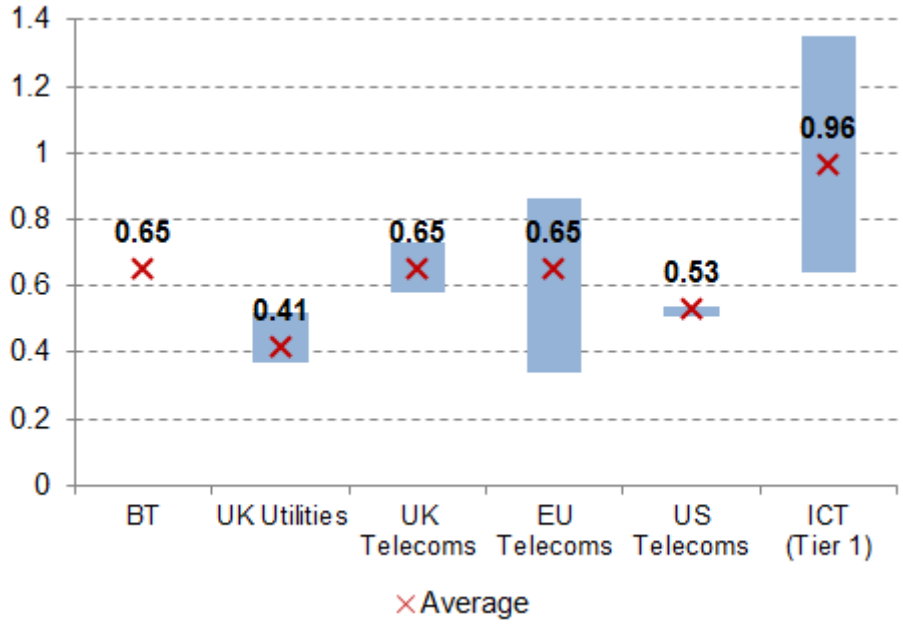
European and some US comparators, asset betas are higher against the world index relative to the local / regional index, whilst for the UK comparators sample the 2-year averages are generally similar at present.

Figure 4.3
Summary of 2-year Asset Beta against World Index – Current (September 2017)



Source: NERA analysis

Figure 4.4
Summary of 2-year Asset Beta against World Index –October 2015



Source: NERA analysis
Note: We show beta averages and ranges for the ICT sample based on Tier 1 comparators.

4.2. Asset beta ranges for the "Other UK Telecoms and "ICT" Segments of BT's business

For this report, Ofcom asked NERA to comment on the plausible asset beta ranges for BT's "Other UK Telecoms" and "Rest of BT" segments.

As a reminder, the "Other UK Telecoms" segment covers BT's telecoms services outside of the Openreach copper access business and includes: mobile, leased lines, wholesale and retail telephony, broadband and bundled services (e.g. TV). On the other hand, BT's "Rest of BT" segment covers BT's ICT product and service offering.

Drawing on the comparator data above, we present our recommended ranges below.

Asset beta range for the "Other UK Telecoms" segment

In its March 2017 WLA Consultation, Ofcom considered evidence on the asset beta from UK telecoms and EU telecoms to assess whether the range for BT's Other UK Telecoms segment that had been used in the 2016 Business Connectivity Market Review Statement was still appropriate. Based on this evidence, Ofcom proposed that the same range of 0.55 – 0.75 for the Other UK Telecoms segment asset beta should be used.[31]

With respect to the UK telecoms sample, we continue to recognize that none of the companies in the UK telecoms sample are perfect comparators for BT's Other UK Telecoms segment. Specifically:

- TalkTalk, despite being a fixed telecoms operator, is much smaller in size compared to BT. It also has fewer infrastructure assets and focuses on retail customers;
- Sky predominantly sources revenues from its pay TV operations; and
- Vodafone is different from BT given that 1) it is globally diversified (only c. 15% revenue generated from the UK); [32] and 2) its biggest business area is mobile (accounting for c. 64% revenue).[33]

Be that as it may, their current 2-year asset betas against the local (FTSE All Share) index lie within the range of 0.59 – 0.62. Given that the Telecoms sample consists of only 3 companies, we find it appropriate to use a 90% confidence interval in our estimates[34].

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31 Ofcom (March 2017), WLA Consultation, Annex 16, pp. 296-297. See here: https://www.ofcom.org.uk/__data/assets/pdf_file/0035/99638/Annexes1-19.pdf

32 Vodafone 2017 Annual Report, p. 8

33 Source: Bloomberg.

34 To calculate the confidence interval for the Asset Betas, we first calculated the confidence interval of the Equity Betas for the Sky and TalkTalk companies, and then we de-levered the values obtained using the standard Miller formula (as explained in Section 2.4)

By considering the companies with the highest and the lowest Asset Beta (Sky and TalkTalk respectively), the Asset Beta derived is in the range of 0.45 to 0.70, and therefore overlaps closely with Ofcom's proposed range for BT's Other UK telecoms segment, of 0.55 – 0.75. Therefore, the updated data from this sample does not suggest increasing the proposed range for BT's Other UK Telecoms segment.

With respect to the EU telecoms sample, we note that the sample is diverse, and results in a wide asset beta range; calculated against the FTSE All Europe index, the asset beta range lies within 0.39 – 0.60, and is notably higher at 0.51 – 0.86 when betas are calculated against the FTSE All World index.

In principle, we consider that the regional index would better represent the investment opportunity set of the marginal investors in the EU telecoms assets (see Appendix B.2.2 for details) and therefore the former range (0.39 – 0.60) is more relevant for our recommendations. However, given the market conditions prevailing at the time of this update, we consider that the upper end of the range calculated against the All Europe index provides a more appropriate benchmark than the lower end of the range. This is because we observe that the fall in EU telecoms asset betas against the All Europe index has at least partly been driven by increased volatility of the All Europe index, as discussed above (see discussion around Figure 3.17). However, since we also observe that the volatility of the All Europe index is currently on a downward trend (also see Figure 3.17), we consider that going forward, the upper bound of the historically observed asset beta range is likely to better reflect forward-looking conditions of systematic risk in the European telecoms sector. For these reasons, we consider that the latest data on asset betas on EU telecoms does not support a change in the "Other UK Telecoms" range of 0.55 – 0.75 previously used by Ofcom in the context of Business Connectivity Market Review (BCMR), consistent with the evidence based on the UK telecoms sample.

This recommendation is consistent with the observation that the asset betas of EU telecoms have been increasing when regressed against the All World index, which is also considered by Ofcom.

Finally, note that in our separate report for Ofcom[35] we considered whether there is evidence that there is a difference in the betas of fixed vs. mobile telecoms operators. We find that the latest data continues to support the conclusions from earlier analysis by NERA, where we find no evidence of statistically significant difference in the betas of fixed vs. mobile telecoms operators.[36] Therefore, we consider that the acquisition of EE will not have materially affected the systematic risk and asset beta of BT's Other UK Telecoms segment, all else equal.

Asset beta range for the "Rest of BT" segment

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35 NERA (2018), *The Evidence for Differences in Risk for Fixed vs Mobile Telecoms* . The report has been commissioned by Ofcom and has been published alongside this one.

36 Ibid.

Since the introduction of a three-part disaggregation of BT's asset beta, Ofcom has generally relied on the ICT comparators as cross-checks on the implied asset beta for the Rest of BT segment, given Ofcom's view on the asset betas for the remaining two segments, their weights, and the observed asset beta for BT Group.[37] We favour this approach, given that the ICT beta is the most uncertain parameter in the three-part disaggregation for BT (e.g. it has the highest beta range, as shown in the section above).

We continue to find that the ICT comparators display a wide asset beta range, at 0.45 to 1.06 for the Tier 1 comparators, and even wider at 0.45 – 1.24 for the Tier 2 comparators (all comparators), when calculated against the home index. The range is somewhat higher when calculated against the All World index, at 0.65 – 1.30 for the Tier 2 comparators (all comparators).

Since there is substantial uncertainty around the central estimates for the ICT Comparators, we recommend that Ofcom continues to derive a value for the Rest of BT segment backed out by taking a view on the beta values of the other two segments (Openreach and Other UK Telecoms), and cross-checking it against the range provided by the ICT comparators above.[38]

As we would expect the ICT business of BT to be the segment with the highest systematic risk, given the nature of these products and services which we would expect to have greater income elasticity than the more traditional telecommunications services, we would expect Ofcom to set an asset beta for the Rest of BT higher than for the other two segments (and specifically higher than for Other UK Telecoms, being the segment with greater systematic risk compared to Openreach copper access, where the latter is most akin to a traditional regulated utility). Given our recommendation that the range for Other UK Telecoms of 0.55 – 0.75 proposed by Ofcom in the March 2017 WLA consultation remains appropriate and because the top of the telecoms asset beta range overlaps with the lower end of the ICT comparator range (calculated against both the local and the global indices), we would expect the Rest of BT segment to have an asset beta range with a lower bound of around 0.7. This would be below the average for ICT comparators against the local/regional index and close to the bottom of the range for ICT comparators on the global index. The latest data from the ICT comparators above suggests that the plausible upper bound based on the observed ICT comparator data is around 1.25, which lies between the maximum two-year asset betas of 1.24 – 1.30 calculated against the local and global indices, respectively.

Therefore, in our view, a plausible range for the Rest of BT asset beta would be around 0.7 to 1.25..

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[37] Ofcom (March 2017), WLA Consultation, Annex 16. See here: https://www.ofcom.org.uk/__data/assets/pdf_file/0035/99638/Annexes1-19.pdf

[38] For example, in the WLA Consultation, Ofcom proposed a three-part disaggregation of BT's asset beta, where BT Group's asset beta was set to be equal to the weighted average of the three segments, Openreach, Other UK Telecoms and Rest of BT. In the WLA consultation, Ofcom proposed that the weights for the three segments were 20%, 65% and 15% respectively, and proposed that the asset betas of the first two segments were 0.55 (Openreach) and 0.75 (Other UK Telecoms). Given BT Group's asset beta then estimated at 0.76, this implied an ICT asset beta of 1.08 (by reference to the FTSE All Share Index). See Appendix 16, para A16.137 for details, accessed here: https://www.ofcom.org.uk/__data/assets/pdf_file/0035/99638/Annexes1-19.pdf

Appendix A. Statistical Tests

In this appendix we set out statistical tests carried out to test the assumptions underpinning our beta estimation (see section 2). Based on visual inspection of the data, and the set of formal statistical diagnostic tests carried out for this assignment, we conclude that:

- Visual inspection of the data does not indicate structural problems with the data; some evidence of autocorrelation and heteroscedasticity exists, but is likely to be caused by outliers;
- The GLS estimates, used to correct for autocorrelation and heteroskedasticity are generally similar to the OLS estimates across the samples;
- While there is evidence of outliers, the beta estimates corrected for outliers are almost always within one standard deviation of OLS estimates.
- All comparator stocks and market indices are liquid, indicating that there is no ex ante need to apply Dimson adjustments for asynchronous trading bias.

We structure the remainder of this appendix as follows:

- A.1 reports our visual inspection of the data and results for the UK comparators set;
- A.2 reports test results on heteroscedasticity and autocorrelation;
- A.3 reports test results on outliers as well as beta estimates accounting for outliers;
- A.4 reports our liquidity checks for each comparator.

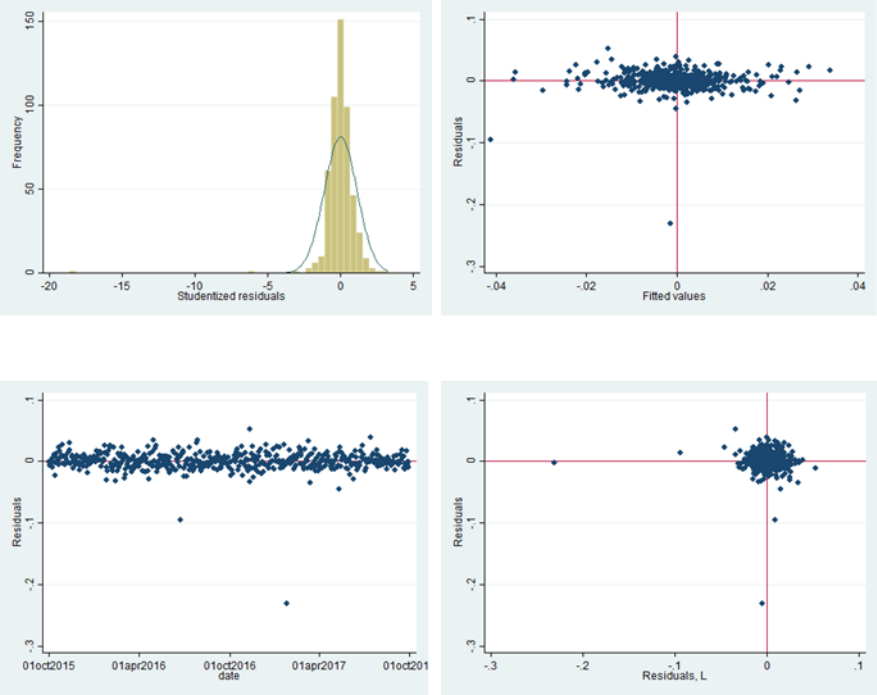
A.1. Visual Inspection of the Data

In this section we show for each UK comparator, the following results associated with the 2-year beta regression against the FTSE All Share:

1) a histogram of residuals, to assess evidence on the normality of the error terms;
2) a scatter plot with fitted value on the X-axis and residual on the Y-axis, to assess whether the variation of the error term is systematically different when the independent variable changes value;
3) a scatter plot of the residuals through time, to assess whether the variance of the error term appears constant through time; and
4) a scatter plot of residuals and their lagged values to assess any positive/negative dependence which would be indicative of autocorrelation of the error terms.

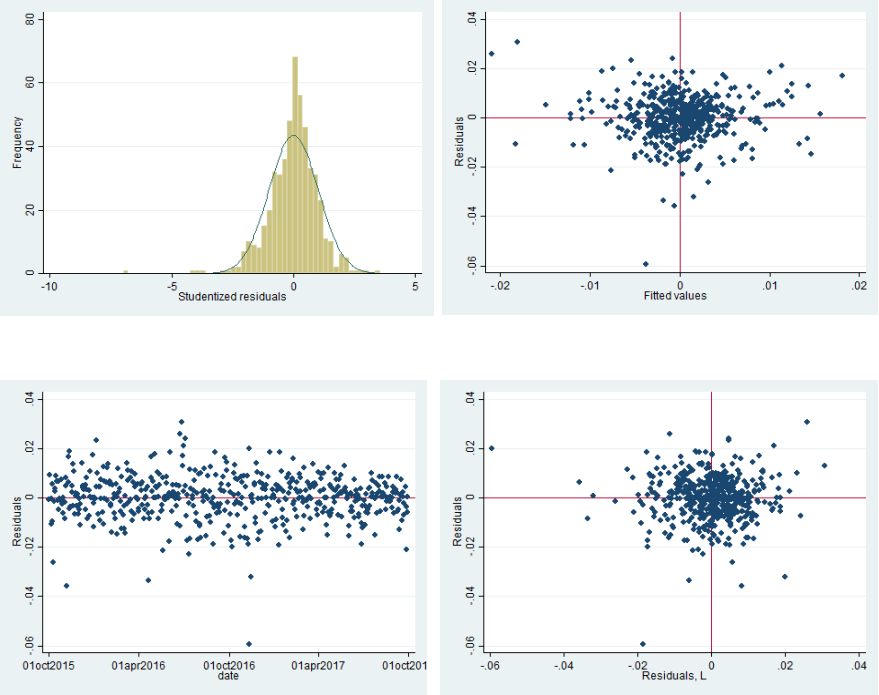
The charts below do not exhibit systematic relationships which would indicate a violation of the OLS assumptions. We carry out further statistical tests in the following sections to assess these findings more formally.

Figure A.1
BT



Source: NERA analysis

Figure A.2
National Grid

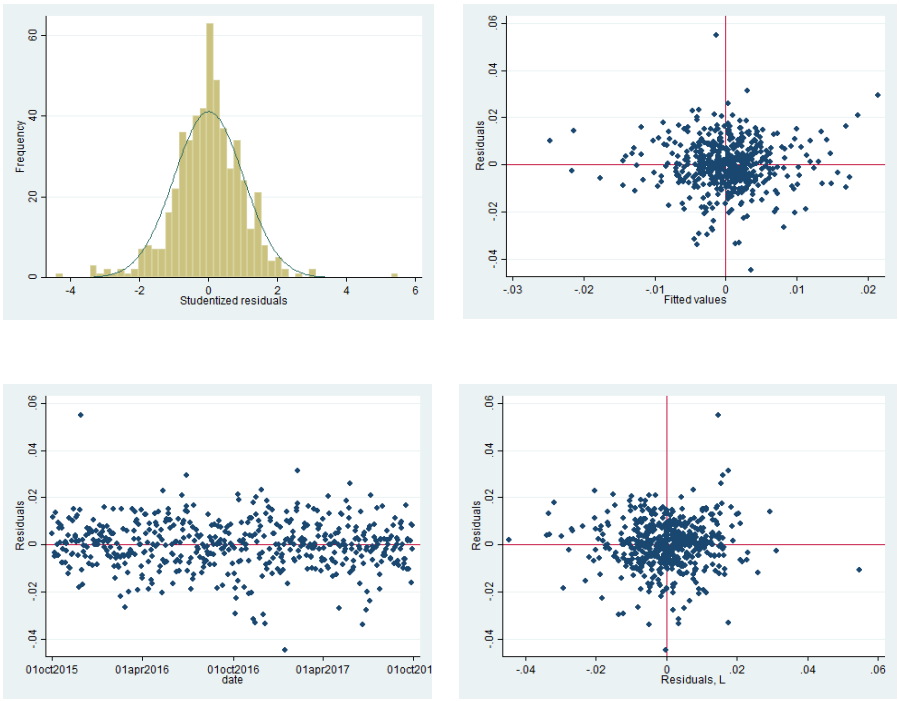


Source: NERA analysis

Figure A.3
Severn Trent

Source: NERA analysis

Figure A.4
Pennon

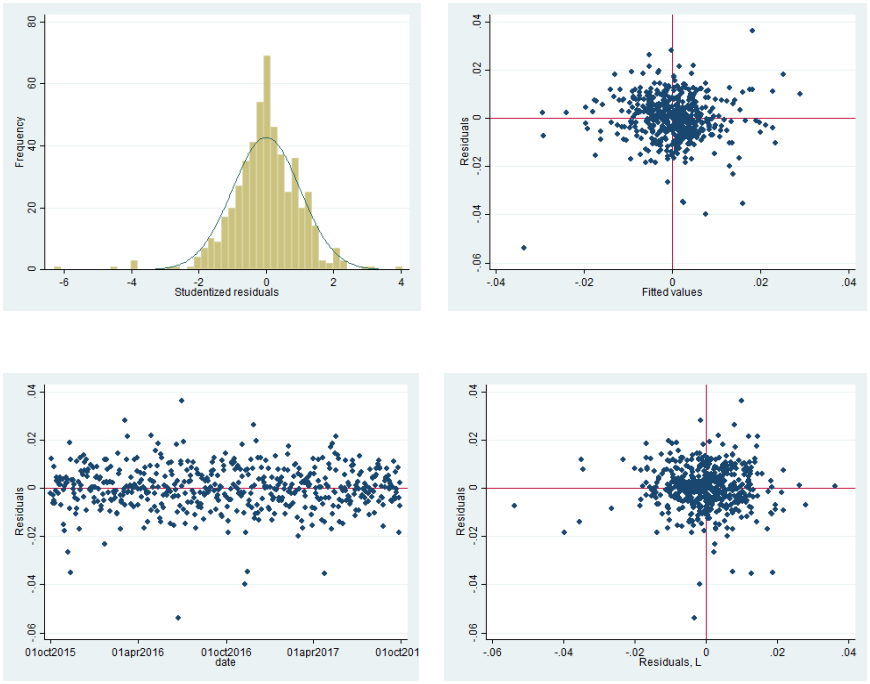


Source: NERA analysis

Figure A.5
United Utilities

Source: NERA analysis

Figure A.6
SSE

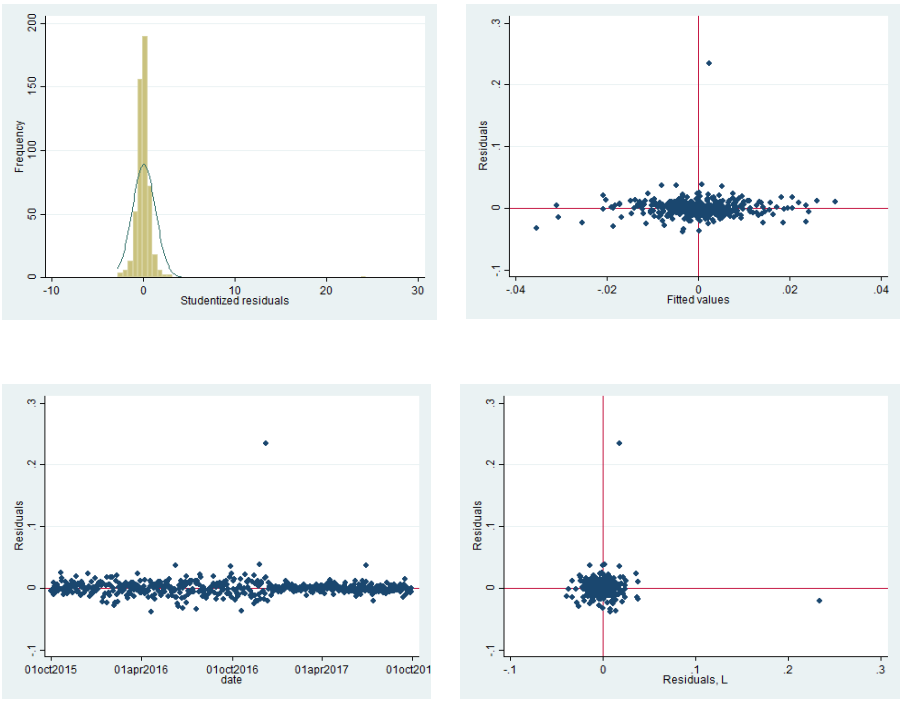


Source: NERA analysis

Figure A.7
Talk Talk

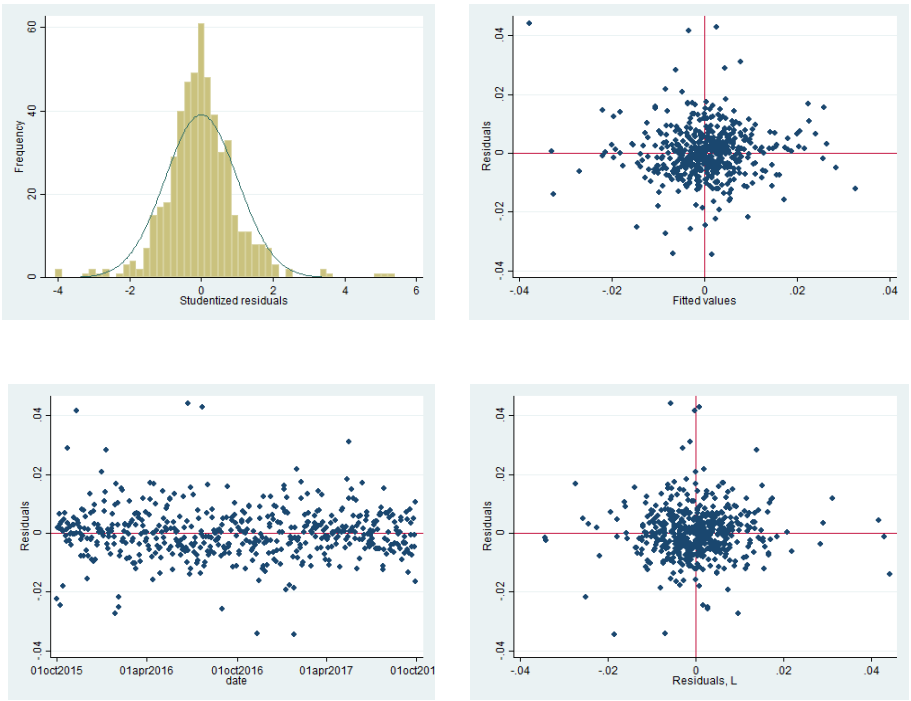
Source: NERA analysis

Figure A.8
Sky



Source: NERA analysis

Figure A.9
Vodafone



Source: NERA analysis

A.2. Heteroscedasticity and Auto-correlation Tests

We carry out a series of diagnostic tests on the error terms of the regressions to assess whether there is evidence of autocorrelation and/or heteroscedasticity in the error terms.

We have run White and Durbin Watson tests in STATA to detect heteroscedasticity and autocorrelation respectively. We define significance at 95% confidence level for both tests (as reported below). When either heteroscedasticity or autocorrelation is detected, we report GLS (Generalized Least Squares) estimates instead of OLS estimates. However as shown in Table A.1 for the UK comparators, the GLS estimates are generally very similar to the OLS estimates across the comparators – an observation that also holds for all other comparator sets.

Table A.1
UK Comparator Heteroscedasticity/Autocorrelation Tests

	FTSE All Share						FTSE All World					
	White Stat	P-val	Durbin Watson	Hetero-skedas ticity	Serial Correla tion	GLS?	White Stat	P-val	Durbin Watson	Hetero-skedas ticity	Serial Correla tion	GLS?
BT												
1Y	0.23	0.89	2.11	NO	NO	NO	1.43	0.49	2.09	NO	NO	NO
2Y	2.48	0.29	2.09	NO	NO	NO	4.13	0.13	2.06	NO	NO	NO
National Grid												
1Y	3.14	0.21	2.00	NO	NO	NO	0.07	0.96	1.90	NO	NO	NO
2Y*	14.00	0.00	2.01	YES	NO	YES	10.84	0.00	1.98	YES	NO	YES
Severn Trent												
1Y	1.96	0.38	2.11	NO	NO	NO	0.51	0.77	2.09	NO	NO	NO
2Y*	6.24	0.04	2.01	YES	NO	YES	6.44	0.04	2.00	YES	NO	YES
Pennon												
1Y	1.38	0.50	2.04	NO	NO	NO	1.75	0.42	2.03	NO	NO	NO
2Y	1.18	0.56	1.95	NO	NO	NO	3.98	0.14	1.93	NO	NO	NO
United Utilities												
1Y	3.49	0.17	2.11	NO	NO	NO	0.00	1.00	2.09	NO	NO	NO
2Y*	12.08	0.00	2.03	YES	NO	YES	11.82	0.00	2.03	YES	NO	YES
SSE												
1Y	11.34	0.00	1.84	YES	NO	YES	2.36	0.31	1.81	NO	NO	NO
2Y*	50.34	0.00	2.04	YES	NO	YES	65.80	0.00	1.96	YES	NO	YES
TalkTalk												
1Y	2.34	0.31	2.07	NO	NO	NO	4.58	0.10	2.07	NO	NO	NO
2Y	0.31	0.85	2.14	NO	Inconc	YES	1.84	0.40	2.14	NO	NO	NO
Sky												
1Y	0.41	0.81	2.09	NO	NO	NO	0.65	0.72	2.11	NO	NO	NO
2Y	0.03	0.98	2.03	NO	NO	NO	0.10	0.95	2.05	NO	NO	NO
Vodafone												
1Y*	0.21	0.90	1.76	NO	YES	YES	2.80	0.25	1.75	NO	YES	YES
2Y*	23.55	0.00	1.93	YES	NO	YES	63.22	0.00	2.07	YES	NO	YES

Source: NERA analysis
*Note: * GLS reported where regression diagnostics show heteroscedasticity or autocorrelation.*

Table A.2
OLS vs. GLS estimates for UK Comparators

		FTSE All Share					FTSE All World			
		OLS		GLS			OLS		GLS	
BT		Beta	SE	Beta	SE		Beta	SE	Beta	SE
	1Y	0.61	0.22	0.61	0.22	1Y	0.44	0.30	0.42	0.30
	2Y	1.03	0.08	1.02	0.08	2Y	1.13	0.11	1.12	0.11
National Grid										
	1Y	0.59	0.10	0.59	0.10	1Y	0.27	0.14	0.26	0.14
	2Y*	0.53	0.05	0.53	0.05	2Y*	0.43	0.06	0.43	0.06
Severn Trent										
	1Y	0.44	0.12	0.44	0.12	1Y	0.30	0.16	0.31	0.16
	2Y*	0.59	0.05	0.59	0.05	2Y*	0.57	0.06	0.57	0.06
Pennon										
	1Y	0.53	0.13	0.53	0.13	1Y	0.38	0.18	0.38	0.18
	2Y	0.63	0.05	0.63	0.05	2Y	0.62	0.07	0.62	0.07
United Utilities										
	1Y	0.40	0.12	0.41	0.12	1Y	0.21	0.17	0.23	0.17
	2Y*	0.59	0.05	0.59	0.05	2Y*	0.55	0.07	0.55	0.07
SSE										
	1Y*	0.35	0.10	0.34	0.10	1Y	0.18	0.14	0.18	0.14
	2Y*	0.86	0.05	0.86	0.05	2Y*	0.96	0.06	0.96	0.06
TalkTalk										
	1Y	0.13	0.22	0.13	0.22	1Y	-0.12	0.30	-0.12	0.30
	2Y*	0.78	0.12	0.79	0.12	2Y	0.82	0.16	0.84	0.15
Sky										
	1Y	0.52	0.19	0.51	0.19	1Y	0.49	0.27	0.50	0.26
	2Y	0.89	0.07	0.89	0.07	2Y	1.01	0.10	1.01	0.10
Vodafone										
	1Y*	1.05	0.09	1.04	0.09	1Y*	0.77	0.15	0.75	0.14
	2Y*	0.96	0.05	0.97	0.05	2Y*	0.82	0.07	0.82	0.07

Source: NERA analysis
*Note: * GLS reported where regression diagnostics show heteroscedasticity or autocorrelation.*

A.3. Outliers & Robust Regressions

In this section we consider two approaches to assessing the impact of outliers on beta estimates for the UK comparators.

One approach is to re-run the OLS regression after excluding the outliers. We detect outliers in our dataset using Cook's Distance test – if Cook's D measure exceeds four divided by the number of observations in the regression, we consider this data point as an outlier.

The alternative is to run robust regressions in STATA, which effectively assign lower weights to data points that have a strong influence on the regression line (i.e. outliers).

The table below reports different beta estimates under OLS, OLS with excluded outliers, and robust regressions, for the UK comparators. The beta estimates accounting for outliers are mostly within one standard deviation of the OLS estimates, although we do notice a greater variation in this iteration relative to previous updates. Nevertheless, we do not consider there to be a strong, a priori reason to exclude observations from the data sample, because 1) these may be features of the data that could be repeated over the next regulatory period and 2) there is no systematic pattern in how outliers affect the beta estimates, even for individual stocks (e.g. where for some companies we observe the 1-year betas increasing, and the 2-year betas decreasing).

Table A.3
Outliers Tests & Robust Regressions for UK Comparators

	FTSE All Share				FTSE All World			
	OLS	Robust	Excl. Outliers	No of Outliers	OLS	Robust	Excl. Outliers	No of Outliers
BT								
1Y	0.61	0.62	0.60	3	0.44	0.67	0.67	3
2Y	1.03	0.94	0.92	17	1.13	0.93	0.92	16
National Grid								
1Y	0.59	0.59	0.61	11	0.27	0.26	0.34	11
2Y	0.53	0.58	0.57	27	0.43	0.46	0.43	33
Severn Trent								
1Y	0.44	0.41	0.51	11	0.30	0.26	0.39	11
2Y	0.59	0.62	0.60	31	0.57	0.53	0.53	26
Pennon								
1Y	0.53	0.44	0.55	18	0.38	0.29	0.26	17
2Y	0.63	0.61	0.61	29	0.62	0.58	0.60	31
United Utilities								
1Y	0.40	0.31	0.40	13	0.21	0.21	0.27	17
2Y	0.59	0.58	0.58	25	0.55	0.52	0.55	29
SSE								
1Y	0.35	0.42	0.39	14	0.18	0.17	0.21	16
2Y	0.86	0.80	0.76	27	0.96	0.81	0.81	30
TalkTalk								
1Y	0.13	0.29	0.22	11	-0.12	-0.06	-0.14	11
2Y	0.78	0.74	0.65	28	0.82	0.77	0.75	27
Sky								
1Y	0.52	0.24	0.43	2	0.49	0.25	0.38	3
2Y	0.89	0.74	0.77	19	1.01	0.81	0.80	16
Vodafone								
1Y	1.05	1.02	1.04	10	0.77	0.89	0.94	11
2Y	0.96	1.02	1.01	26	0.82	0.97	0.91	29

Source: NERA analysis

A.4. Liquidity test

In this section we test the liquidity of each comparator stock, by using the bid-ask spread measure. We define a stock as illiquid if its 2-year average daily bid-ask spread is larger than 1%.[39] The liquidity threshold of 1% bid-ask spread has been used by other regulators, e.g. the German Energy and Telecommunications Regulator (BNetzA) for setting WACC allowance for gas/electricity transmission and distribution.[40]

As shown in Table A.4 all comparators across the four sample groups pass the liquidity test, which indicates that these stocks are unlikely to be subject an asynchronous trading bias.[41]

[39] Daily bid-ask spread is calculated as ask price minus bid price, divided by the average of bid and ask price. Bid and ask prices are downloaded from Bloomberg.

[40] See Bundesnetzagentur (2008), Beschluss hinsichtlich der Festlegung von Eigenkapitalzinssaetzen fuer Alt- und Neuanlagen fuer Betreiber von Elektrizitaetsversorungsnetzen und Betreiber Von Gasversorgungsnetzen fuer die erste Regulierungsperiode in der Anreizregulierung (Decision), BK4-08-068, p.18

[41] Also see Ian Cooper (June 2005), Comments on the document: Beta analysis of British Telecommunications: Update which advised that there is no need to include / apply E.g. Dimson adjustments for asynchronious trading to liquid stocks (in his case BT). Accessed at: http://faculty.london.edu/icooper/assets/documents/commentsonBRATTLE2forpdf(3).pdf

Table A.4
Comparator Liquidity Test

	Bid - Ask Spread		
	1Y Average	2Y Average	Liquidity
UK Utilities/Telecoms			
BT	0.03%	0.03%	YES
National Grid	0.04%	0.04%	YES
Severn Trent	0.06%	0.06%	YES
Pennon	0.08%	0.08%	YES
United Utilities	0.08%	0.07%	YES
SSE	0.08%	0.08%	YES
TalkTalk	0.11%	0.11%	YES
Sky	0.07%	0.08%	YES
Vodafone	0.03%	0.03%	YES
EU Telecoms			
Telefonica	0.03%	0.03%	YES
Deutsche Telekom	0.18%	0.19%	YES
Belgacom	0.15%	0.14%	YES
KPN	0.11%	0.10%	YES
Orange	0.06%	0.06%	YES
Telecom Italia	0.09%	0.09%	YES
Iliad	0.14%	0.13%	YES
Orange Belgium	0.21%	0.21%	YES
Telenor	0.11%	0.12%	YES
Tele2	0.08%	0.09%	YES
Swisscom	0.04%	0.05%	YES
US Telecoms			
AT&T	0.03%	0.03%	YES
Verizon	0.02%	0.02%	YES
Century Link	0.04%	0.04%	YES

	Bid - Ask Spread		
	1Y Average	2Y Average	Liquidity
ICT comparators			
IBM	0.01%	0.01%	YES
Unisys Corp	0.41%	0.26%	YES
Amdocs Ltd	0.02%	0.03%	YES
Computer Science	0.02%	0.03%	YES
Teletech Hldgs	0.17%	0.12%	YES
Cdw Corp/De	0.03%	0.03%	YES
Cognizant Tech-A	0.02%	0.02%	YES
Xerox Corp	0.10%	0.10%	YES
Indra Sistemas	0.07%	0.07%	YES
Cancom Ag	0.36%	0.41%	YES
Atos Se	0.12%	0.11%	YES
Sopra Steria Gro	0.16%	0.19%	YES
Cap Gemini	0.07%	0.07%	YES
Tieto Oyj	0.09%	0.10%	YES
Cgi Group Inc-A	0.13%	0.14%	YES

Source: NERA analysis

Appendix B. Responses to issues raised by stakeholders on Ofcom's March 2017 WLA Consultation

This appendix sets out NERA's response to the issues raised in the Oxera report, submitted on behalf of Openreach, and the Frontier report submitted on behalf of TalkTalk and Sky, made in response to Ofcom's March 2017 WLA Consultation.

B.1. The use of net debt in calculating gearing when setting a company's Cost of Capital (Oxera, section 3.2)

B.1.1. Oxera's position on the use of net vs gross debt

In their report "Response to Ofcom's WACC proposals for the WLA charge controls"[42] Oxera references other regulatory determinations where other UK regulators have used the stock of debt net of cash, rather than the gross stock of debt, when calculating gearing.

Moreover, Oxera argues that by using the gross value of BT's short term and long term debt obligations, Ofcom are substantially overestimating BT's gearing (section 3.2). Oxera state that BT's average cash balances over the last two years have been around c.£2.5bn, and that netting off this position from the gross stock of debt, would result in a substantially lower gearing assumption of c.17%.

B.1.2. NERA Response

The financial literature stipulates that in principle, the correct approach to calculate gearing is to include the full value of the long-term as well as short-term financial obligations of the firm, despite many practitioners including long-term obligations only. For example, standard Corporate Finance textbook by Brealey and Myers states the following:

> *"Many companies consider only long-term financing when calculating WACC. They leave out the cost of short-term debt. In principle this is incorrect. A company that ignores this claim will misstate the required return on capital investments."*[43]

Netting off cash from the total stock of debt, or in other words, using a "net of cash" as opposed to "gross of cash" measure of debt in calculating the WACC, may be warranted in certain instances, namely when the cash is not used to finance ongoing operations, and when it can be freed up to cover the short term liabilities. Brealey and Myers give the following example of when "zeroing out" short term debt may be appropriate:

> *But "zeroing out" short-term debt is not a serious error if the debt is only temporary, seasonal, or incidental financing or if it is offset by holdings of cash and marketable securities. Suppose, for example, that one of your foreign subsidiaries takes out a six-month loan to finance its inventory and accounts receivable. The dollar equivalent of this loan will show up as a short-term debt. At the same time headquarters may be lending*

[42] Oxera (June 2017), Response to Ofcom's WACC proposals for the WLA charge controls.

[43] Brealey R. A, Myers S. C and F. Allen (2011), Principles of Corporate Finance 10th ed, p 480.

> *money by investing surplus dollars in short-term securities. If this lending and borrowing is offset, there is no point in including the cost of short-term debt in the weighted-average cost of capital, because the company is not a net short-term borrower. [emphasis added]* [44]

However, Brealey and Myers then caution that there are instances when it would not be appropriate to net off the cash or other liquid short-term assets from the short-term liabilities, namely, in instances when the short-term debt is an "important" and "permanent" source of financing for a company. This would be the case when the company cannot easily use the cash (or other short-term assets) to cover its short-term liabilities, because e.g. the cash is required to manage the ongoing operations of the company:

> *Since current liabilities include short-term debt, netting them out against current assets excludes the cost of short-term debt from the weighted-average cost of capital. We have just explained why this can be an acceptable approximation.[see above] But when short-term debt is an important, permanent source of financing—as is common for small firms and firms outside the United States—it should be shown explicitly on the right-hand side of the balance sheet, not netted out against current assets. The interest cost of short-term debt is then one element of the weighted-average cost of capital.* [45]

Brealey and Myers suggest that a practitioner's way of deciding whether to include short-term debt in the debt calculation (and use "gross debt" as gearing), or net off the cash position against short term debt (and use "net gearing" instead), is to use a rule of thumb of checking whether the short-term debt is at least 10% of total liabilities and whether net working capital is negative. If these hold, Brealey and Myers argue it would mean that short term debt is "almost surely" used to finance long-term assets and should be included in the WACC.

In our 2015 report[46], we argued that we prefer to use the gross debt position consistently when calculating gearing for all comparators, as the baseline correct approach in corporate finance textbooks is to include the value of both short term and long term debt in the gearing calculations (as per first paragraph above), and because we do not have evidence that the cash held by each company is not required for financing ongoing operations, which would mean it can be used to cover the short-term liabilities. We also noted that applying the working capital screen (as suggested by Brealey and Myers, and as previously applied by Brattle in its reports for Ofcom) did not make a difference in the case of BT, as its net working capital had been negative over an extended period of time. As we show in Table B.1, BT's current liabilities consistently exceed its current assets including cash (i.e. it continues to have a negative working capital). Therefore, it continues to be true that BT appears to need the cash in its ongoing activities, given the negative working capital position, and therefore both the short-term and long-term liabilities (i.e. the gross value of debt) should be included in the WACC calculation for BT, as discussed above.

[44] Brealey and Myers, p480 - 481.

[45] Brealey and Myers, p480 - 481.

[46] NERA (2015), published here: https://www.ofcom.org.uk/__data/assets/pdf_file/0033/57768/nera_final_report.pdf

Table B.1
BT's net working capital position continues to be negative

	Notes	2017 £m	2016 Revised[a] £m	2015 Revised[a] £m
Non-current assets				
Intangible assets	12	15,029	15,450	3,170
Property, plant and equipment	13	16,498	15,971	13,498
Derivative financial instruments	27	1,818	1,462	1,232
Investments	23	44	46	44
Associates and joint ventures		31	24	26
Trade and other receivables	17	360	218	179
Deferred tax assets	9	1,717	1,247	1,559
		35,497	**34,418**	**19,708**
Current assets				
Programme rights	15	264	225	118
Inventories	16	227	189	94
Trade and other receivables	17	3,835	3,978	3,093
Current tax receivable		73	65	65
Derivative financial instruments	27	428	177	97
Investments	23	1,520	2,918	3,523
Cash and cash equivalents	24	528	996	848
		6,875	**8,548**	**7,838**
Current liabilities				
Loans and other borrowings	25	2,632	3,736	2,314
Derivative financial instruments	27	34	48	168
Trade and other payables	18	7,437	7,418	5,348
Current tax liabilities		197	271	222
Provisions	19	625	178	142
		10,925	**11,651**	**8,194**

Source: BT Annual Report 2017, Group Balance Sheet.

B.2. The appropriate market index for European telecoms (Frontier, section 2.3.2)

B.2.1. Frontier's position on the appropriate market index

Frontier's report[47] discusses the issue of the appropriate reference market by discussing what it sees as inconsistencies in what Ofcom does for the different comparator sets, rather than from a theoretical perspective of what is the appropriate reference market for each sample. Specifically, Frontier points out that in setting the *level of asset betas*, e.g. for BT Group or UK based comparators, Ofcom has preferred to use home indices, but when assessing *relative betas*, e.g. when assessing evidence from European comparators and comparators outside of Europe, Ofcom has used betas against the FTSE All World. Frontier then suggest that when calculated against the FTSE All Europe index, the European sample of comparators does not support an asset beta range for Other UK telecoms as high as 0.75, as proposed by Ofcom in the March 2017 WLA consultation. Frontier, therefore, appears to suggest that the home index is the appropriate index for calculating betas across the board (Frontier consider the FTSE All Europe index to be the "home index" for European comparators, although in fact this is a regional index).

[47] Frontier (June 2017), WLA Market Review – Cost of capital for regulated services

B.2.2. NERA Response

B.2.2.1. The theory

The CAPM model defines the required equity return from the perspective of a marginal investor (i.e. the investor who sets the price of the asset) and assumes that this marginal investor is well diversified. The asset's return is then defined in relation to the *relative risk* it contributes to the well diversified investment portfolio of the marginal investor.[48] It follows that the appropriate reference market for estimating the beta is the market that best represents the investment opportunity set of this marginal investor.

A key consideration in the estimation of betas is therefore how to define the "investment opportunity set", and specifically, whether to use a local, regional (e.g. if same currency is used in the region in question) or worldwide index as a proxy for the market portfolio available to the investors holding the asset. As Damodaran points out, in practice the choice depends on the extent to which the marginal investor in the stock is locally or globally diversified, which in turn depends on the level of integration in global capital markets, and the existence of transaction costs to international diversification:[49]

> *In the CAPM, for instance, with no transactions costs, the diversified portfolio includes all asset classes and is globally diversified. If there are transactions costs and barriers to global investment, the market portfolio may not include all asset classes or be as globally diversified. ..In coming up with a diversified portfolio, we should take the perspective of the marginal investor in the market. The extent to which that marginal investor is diversified should determine the composition of our diversified portfolio.*

In practice, therefore, to determine the relevant market portfolio, the theoretically correct approach would be to assess the extent to which the marginal investor is able to diversify (locally or internationally). Greater market integration implies that investors face low transaction costs and barriers to international trade, allowing them to tap foreign capital markets. In this case, the relevant investment opportunity set is wider than the home market, and the equity and asset beta estimates should be based on a broad market index that captures the potential for diversification. The reverse holds for markets with high transaction costs and barriers to trade.

In terms of current trends, despite wider global integration, the academic literature has generally found that equity markets are less integrated than bond or money markets[50], and that there is a significant "equity home bias"[51], i.e. the observation that equity investors have a preference for domestic assets, despite the wider benefits of diversification.

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[48] For accessible explanation, see e.g. Prof. Damodaran, Aswath, "Estimating Risk Parameters", Stern School of Business. Accessed here: http://people.stern.nyu.edu/adamodar/pdfiles/papers/beta.pdf

[49] Ibid.

[50] See for e.g. Ogier, Tim et al (2004), The real cost of capital : a business field guide to better financial decisions.

[51] See the seminal work of French, Kenneth; Poterba, James (1991). "Investor Diversification and International Equity Markets". American Economic Review 81 (2): 222–226 and Tesar, Linda; Werner, Ingrid (1995). "Home Bias and High Turnover". Journal of International Money and Finance 14 (4): 467–492.

Below we review the recent academic and empirical evidence on 1) the degree of market integration, and especially the extent of integration of the UK market on a regional / global level, and 2) the extent to which the evidence continues to suggest a "home bias" in developed markets, and especially in UK equities.

B.2.2.2. Review of recent empirical evidence on global market integration and the "home bias" phenomenon

The recent literature finds strong evidence that financial markets in the developed world are becoming increasingly correlated, which implies increasing levels of market interdependence

Recent academic evidence suggests that the equity markets of developed countries have become increasingly integrated over time, and their current level of integration is very high.[52] However, implicit barriers to trade still prevent emerging markets from reaching full and effective integration with developed markets.[53]

One way of gauging the extent of integration between markets is through assessment of the degree of correlation between the relevant markets. Recent evidence using this measure (Meric et al, 2015) suggests that the European and American stock markets are highly correlated, and have been even more so since the stock market crash of 2008.[54] Specifically, the authors show that the average correlation between the US market and a set of twenty European stock markets increased from 0.522 before 2008 to 0.737 in the 5-year period after the financial market crash of 2008 (2009 – 2013), which represents a 41% increase.

As regards the UK equity market, Meric et al (2015) show that it is most highly correlated with other European markets, including e.g. the French and the Dutch markets, where correlations exceed 0.90. In fact, given the extent of European integration via the single market which institutionalizes the freedom of movement of goods, services, people and capital in the EU, the European economies exhibit the highest degree of correlation with one another, typically in excess of 0.9.[55] Meric et al (2015) show that these markets, with the exception of Italy, also exhibit a very high degree of correlation vis-à-vis the US stock market.[56]

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52 Carrieri, Francesca, Ines Chaieb and Vihang Errunza, (2013), "*Do Implicit Barriers Matter for Globalization?",* Review of Financial Studies, vol 26, no 7, p1694 – 1793. Also supporting the view that the European and US markets are highly related is the evidence found by Schmidt et al (2011). See Peter S. Schmidt, Urs von Arx, Andreas Schrimpf, Alexander F. Wagner, Andreas Ziegler (2011), *"On the Construction of Common Size, Value and Momentum Factors in International Stock Markets: A Guide with Applications",* Working Paper No. 670, National Centre of Competence in Research Financial Valuation and Risk Management.

53 Ibid.

54 Meric, Ilhan, Lan Ma Nygren, Jerome T. Bentley, Charles W. McCall (2015), *"Co-movements of US and European stock markets before and after the 2008 global stock market crash",* Studies in Business and Economics, vol. 10, issue 2, p 83-98.

55 Meric et al, 2015 list the following as the most correlated markets in the developed world, assessed in the post-crash period (2009 – 2013): France – Germany (0.960); France – Netherlands (0.955); France – Italy (0.940); Germany – Netherlands (0.936); Italy – Spain (0.917); Italy – Netherlands (0.913); France – UK (0.910); Netherlands – UK (0.902); France – Spain (0.900); Belgium – Netherlands (0.900).

56 Meric et al, 2015.

Furthermore, Dorodnykh (2012) finds that a set of 24 developed markets are highly correlated with a measure of the global equity market (MSCI World Index), suggesting high global financial integration.[57] Markets like the USA, the UK, Germany, France, the Netherlands and Canada demonstrate a particularly high degree of correlation with the global market, and the strength of the relationship has been increasing through time.

In summary, the evidence above shows that there is strong co-movement between the national stock-markets in the developed world, which indicates high level of interdependence across these markets (due to e.g. strong trade relationships) leading to similar sensitivity to global macroeconomic factors (e.g. an interest rate change in the US would have impact on demand in the UK if the US is a significant export market for the UK etc). However, strong equity market correlations need not imply full capital mobility, since equity correlations do not have a direct implication on asset ownership. For example, an open economy which trades significantly with the rest of the world is likely to experience stronger equity market correlations with its trading partners, but it could nevertheless face implicit or explicit capital mobility restrictions (e.g. regulatory restrictions, informational asymmetry etc.) which could limit the share of international ownership on its equity market. We explore the issue further below.

Despite stronger equity market correlations, there is continued evidence of "home bias" in equity markets

Despite increased equity market integration, however, the recent academic literature continues to find persistent evidence of "home bias", i.e. the tendency for investors to hold a disproportionately high exposure to domestic equities, despite the purported benefits of diversifying into foreign equities. Researchers use the EHB*i* measure of Equity Home Bias, which is calculated as[58]:

$$EHB_i = 1 - (Foreign\ Equity_i / Foreign\ Equity\ to\ Total\ Market_i)$$

Where

Foreign Equity$_i$ is the share of country *i'*s holding of foreign equity in country *i*'s total equity portfolio (also equal to 1-share of domestic equity)

Foreign Equity to Total Market$_i$ = the share of foreign equity in the world portfolio available to country *i* (also equal to 1- share of country *i* in the total market capitalization).

The EHB_i, therefore, takes values of between 0, if a country's equity portfolio has the same share of foreign equity as the share of foreign equity in the world portfolio; and 100% if a country's share of foreign equity is 0, or in other words if it only invests in domestic assets.

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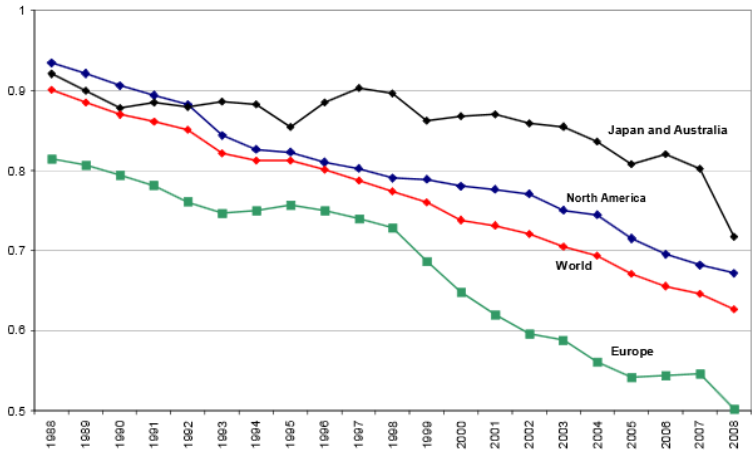
[57] Dorodnykh, Ekaterina (2012), *"What is the Degree of Convergence among Developed Equity Markets?"*, International Journal of Financial Research, Vol. 3, No. 2; April 2012.

[58] For details see, Schoenmaker Dirk, and Chiel Soeter, (September 2014), "New evidence on the home Bias in European Investment". DSF Policy Briefs, No 34.

According to this measure, research shows that the extent of home bias has been decreasing for developed markets, and especially across the European markets, where on aggregate it stood at 50% measured under the EHB*i* measure, as shown in Figure B.1.[59]

Figure B.1
Home bias in equities measured across the developed world



Source: Reprinted from Coeurdacier & Rey (2011).

More recent evidence, however, suggests that the equity home bias in the EU-14 zone is actually higher than that shown in Figure B.1 above, which uses a slightly more restricted sample.[60] In 2012, the EU-14 average EHB stood at c.75%.[61] Specifically, in the UK, the EHB*i* measure indicated a home bias of 76% in 2012.[62]

The academic literature and investment professionals suggest that the following factors contribute to the continued existence of equity home bias puzzle, including:

- The existence of barriers to the mobility of goods and services, which according to Ford and Horioka (2016) are necessary in order to achieve international capital mobility; [63]

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59 See Coeurdacier, Nicolas and Hélène Rey, (2011), *"Home bias in open economy financial macroeconomics",* Working Paper 17691, National Bureau of Economic Research Working Paper Series. Also see Balta and Delgado, (2008), "Home Bias and Market Integration in the EU", CESifo Economic Studies, Vol. 55, 1/2009, p110–144.

60 Schoenmaker Dirk, and Chiel Soeter, (September 2014), "New evidence on the home Bias in European Investment". DSF Policy Briefs, No 34. The EU-14 region in this paper includes Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Poland, Portugal, Spain, Sweden and the UK. For comparison, the "Europe" index represented in Figure B.1 includes the EU-14 above, less Greece , Portugal and Poland. We note that these three markets have significantly higher EHB compared to the average. Therefore the "Europe" average in Figure 1.1 and the EU -14 average are not directly comparable.

61 Schoenmaker Dirk, and Chiel Soeter, (September 2014), "New evidence on the home Bias in European Investment". DSF Policy Briefs, No 34.

62 Ibid.

63 Ford, Nicholas and Charles Yuji Horioka (2016), "The 'real' explanation of the Feldstein-Horioka puzzle",Working Paper 22081, National Bureau of Economic Research Working Paper Series.

- The existence of other explicit and implicit restrictions, such as costs and barriers to investment (e.g. commissions, opportunity costs, market-impact costs and repatriation of investment income), a preference for the familiar, inadequate corporate governance standards, or the need to hedge domestic liabilities, as argued by Westaway et al (2014).[64] The authors argue that these real-world considerations may support a different allocation to UK equities than that recommended by market proportions, simply based on investor preferences.
- The existence of (i) real exchange rate and non-tradable income risk, (ii) asset trade costs in international financial markets (such as transaction costs or differences in tax treatments between national and foreign assets), and (iii) informational frictions and behavioural biases, according to Coeurdacier and Rey (2011).[65]

In sum, the above suggests that despite the move towards ever closer integration, a degree of equity home bias continues to drive asset allocations, suggesting that a globally diversified market portfolio may be overstating the extent of portfolio diversification generally seen in western markets, including in the UK.

B.2.2.3. Review of latest regulatory precedent

In this section, we investigate the market portfolio choices in recent international regulatory decisions in the telecoms industry. As shown in Table B.2, European regulators within the Eurozone have used regional, Europe-wide indices (i.e. Euro Stoxx index), but regulators outside the Eurozone have opted for more diversified, global indices (i.e. the MSCI World Index).

[64] See Westaway et al, (2014), Considerations for global equities: A UK investor's perspective, Vaguard Research.

[65] See ibid.

Table B.2
Regulatory Precedent in the Telecoms Industry on the use of Local vs Global Market Indices

Country	Regulator	Year	Beta Reference Index	Rationale
Netherlands	ACM	2015	Euro Stoxx index*	Investor diversifies portfolio within single currency zone.
Sweden	PTS	2014	MSCI World Index	PTS deems it reasonable to base the analysis on the MSCI World Index since it is established on the stock market, used by other regulatory authorities, shows the evolution on the international stock market and PTS has used it in previous return rate calculations.
Italy	Agcom	2013	Dow Jones Euro Stoxx 600 index	Argues that it is representative of the average price of a large number of listed companies belonging to the telecoms sector in 18 Eurozone countries.
Norway	NKom	2013/14	MSCI World Index	Use of international beta estimates are in accordance with (i) the principle that the hurdle rate should compensate the cost of capital for professionally (internationally diversified) ownership, (ii) the choice to use an international market premium, and (iii) the requirement to have a meaningful comparison of business risk between telecom companies listed in different countries.
Ireland	Comreg	2014	MSCI Europe Index	Argues that the Eurozone is a unified capital market.
New Zealand	Commerce Commission	2014	Local Index	E.g. NZX 50 for Chorus

Source: NERA Analysis of regulatory decisions

*The authors state that they use a "broad Euro Stoxx index" although it is not clear whether this is the Euro Stoxx 50 or 600.

We also note that UK regulators, including Ofcom in the past, generally use domestic indices when setting price controls.[66]

B.2.2.4. Conclusions

The academic literature review above showed that there are increasing correlations between developed equity markets, which indicates a high degree of interdependence across these markets. Specifically, the UK equity market has exhibited strong correlations with the European markets (with coefficients exceeding 0.9) and the US market (a coefficient of >0.8), following the financial market crash of 2008.

However, the review above also showed that a high degree of correlation does not imply full capital mobility and that a significant "equity home bias", i.e. disproportionate allocation of capital to domestic equities, continues to be a feature of equity portfolios even in developed markets. Despite the downward trend in "home bias" shown over the period up to the financial crisis, more recent evidence for the UK finds that a significant home bias of 76% continues to feature in UK portfolios.

Therefore, given that the representative UK investor is likely to experience such significant home bias, we consider that a local reference market would produce more relevant estimates of beta risk for UK equities.

To the extent that the UK remains a member of the EU single market, which institutionalizes the free movements of goods, services, people and capital, and given the extent of correlations between the members of the EU single market discussed above, a European index for UK equity represents an alternative to the UK domestic index. However, the relationship between Britain and Europe will likely be renegotiated over the next few years following the Brexit vote by the British public. These negotiations may affect the extent of capital mobility between Britain and the continent, and may lead to increased transaction costs and barriers to trade, which would limit the ease with which UK investors gain access to the European market. As such, in the future, the choice of the index will depend on the institutional and trade arrangement between the UK and the EU, and therefore, a local index for the UK may be the only appropriate measure, especially in the event that a "hard Brexit" arrangement is pursued.

We note that some European regulators that sit outside of the Eurozone (e.g. Norway and Sweden) have opted for globally diversified market benchmarks. This choice assumes that the marginal investor in these stocks has unrestricted and low cost access to the entire set of

[66] As examples: the CMA in its Final Determination for Northern Ireland Electricity used the FTSE All Share Index as a proxy for the market portfolio when estimating equity beta for GB utility comparators. See Competition Commission (March 2014), Northern Ireland Electricity Limited Price Determination – A reference under Article 15 of the Electricity (Northern Ireland) Order 1992, Final determination, Appendix 13.3.Similarly, the most recent CAA Determination of the Cost of Capital for Q6 (2014-2019) used a local market index to estimate equity betas of international comparators. See the report from its Consultants, PWC (April 2013), Estimating the cost of capital in Q6 for Heathrow, Gatwick and Stansted, A report prepared for the Civil Aviation Authority (CAA), p.67.

globally traded stocks.[67] In our view, the evidence above does not support this implicit assumption of unbounded global diversification.

Finally, we note that given the appropriate reference index for each stock depends on the investment opportunity set of the marginal investor, it is entirely plausible that for certain stocks (telecoms or other), beta risk will be more appropriately measured against a more diversified index (e.g. a regional, European market index for Euro stocks) while for others a local market may be more appropriate (e.g. a local, UK stock index for UK stocks, in the event of a hard Brexit). In theory, the comparability of the betas (as a reflection of relative risk vis-a-vis the appropriate reference market) will *not* be affected by the difference in the index used to calculate those betas, so long as the indices represent the respective relevant investment opportunities of the marginal investors in these assets. As discussed above, at present, our view is that for the UK, that market is the local UK market, whereas for European stocks, that market is the European (or regional) market, to the extent that the European Union institutionalizes the free movement of goods, services, labour, *and capital*, and therefore minimizes transaction costs for European stocks (as well as currency risk, for those in the Eurozone).

However, we recognize as some regulators have noted, the choice of using a global index may be appealing if the intention is to compare betas for companies from different jurisdictions against the same reference market. Given that beta is measured as the covariance of the asset and the market return *divided by the variance of the market return* (a measure that depends on the extent of diversification of the market index), using a common index for all assets would remove the impact from differences in volatility between different market indices.[68] Thus, from a purely empirical perspective, a common index would introduce the same market volatility in the beta calculation and would leave the covariance between the stock return and the market index as the sole differentiating factor between the betas.

In conclusion, in response to Frontier's suggestion that the "home" reference market may be more appropriate when calculating the betas for European comparators, we agree that the evidence suggests a more local index – in this case European index – may be more appropriate for the European comparators. However, we note that an argument can be made that introducing a common ("world") reference market is justified to the extent it introduces the same degree of investor diversification (market volatility) in the beta estimates.

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[67] For example, a potential investor in telecoms stocks may compare BT's beta with that of Orange against a consistent world index to assess the relative riskiness of the two companies.

[68] As we have shown in Section 3.4 of NERA (2015), Update of the Equity and Asset Beta for BT Group and Comparators, generally, the more diversified indices (such as the World index) will have lower volatility compared to the less diversified local / regional indices.

B.3. Sampling variation as an explanation for BT Group having a higher asset beta than telco comparators (Frontier pages 21 and 25)

Frontier's position on sampling variation

Frontier suggests that sampling variation in the estimates could mean that BT's true asset beta is in line with comparators. To support this further, Frontier cite Brattle (2014), which stated that: *"We normally recommend a range of +/- approximately two standard deviations around our mid-point figures: the standard error [for estimates of the equity beta] being 0.11 for the last year of data, and 0.07 for the last two-years."*[69]

NERA Response

The standard error of an estimate relates to the uncertainty or precision with which a certain unknown parameter is estimated. It is important to note that all beta estimates, i.e. BT's beta as well as the betas of all other comparators considered by Ofcom, have central beta estimates that are found within ranges produced by their respective standard errors. These standard errors can be used to derive the plausible ranges within which the true beta estimate can be found. However, the central estimate of the parameter remains the best prediction for that parameter, because this estimate is the estimate which minimizes the standard error of the regression model (technically, it minimizes the sum of squared residuals, or squared deviations between the observed values and those predicted by the regression).

Thus, a central estimate of e.g. 0.5, with a standard error of 0.10, means that the data supports 0.5 as the best beta estimate based on the sample at hand, but that the true beta can be found within the range 0.4 – 0.6 in 68% of the cases (i.e. within one standard error), and 0.3 – 0.7 in 95% of the cases (i.e. within two standard errors) (numbers for illustrative purposes only).

If BT's central beta estimate has been found to lie above the central estimates for other comparators, this means that the plausible range which contains BT's true beta lies above the plausible ranges of the betas for other comparators, since they too are estimated with standard errors. We do not dispute the fact that this plausible range may overlap with the plausible range of the comparators, which is Frontier's point (in the present case that the low end of BT's plausible beta range may very well be within the range estimated for the UK comparators for example). However, this doesn't change the fact that on average, or in expectation, the best estimate for BT's beta currently lies *higher* than the best estimates of a number of comparators.

[69] Estimate of BT's Equity Beta Mach 2014.

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