NERA
ECONOMIC CONSULTING

The Evidence for Differences in Risk for Fixed vs Mobile Telecoms

For the Office of Communications (Ofcom)

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1. Introduction

In late 2016, Ofcom commissioned us to assess the latest evidence on differences in systematic risk between fixed and mobile telecom operators (NERA 2017). [1] This report was published alongside Ofcom's March 2017 Wholesale Local Access (WLA) consultation.[2] Based on an assessment of qualitative indicators and empirical data on demand and asset beta risk for fixed and mobile operators, we found that at the time, there was no evidence of a difference in the systematic risk of fixed and mobile telecoms operators.[3]

In June 2017, Ofcom published its mobile call termination (MCT) consultation (2017 MCT consultation), which included a consideration by Ofcom of the asset betas of mobile companies.[4]

Subsequently, Ofcom has asked us to:

- Update the asset beta analysis it undertook in the 2017 MCT consultation; and
- Revisit the empirical evidence on systematic risks of fixed versus mobile telecoms operators, with a view to assessing the possibility that the acquisition of EE by BT in early 2016 could have led to a change in BT's beta.

In this report, we revisit the empirical evidence on the systematic risk of fixed vs mobile telecoms operators. As discussed in NERA (2017), direct evidence on the true asset betas of "pure-play" fixed and mobile network activities is limited. Given the trend of market consolidation in the telecommunications sector, very few (listed) telecoms operators engage in offering solely fixed or mobile services. In fact, most telecoms groups are integrated, with a mixed portfolio of fixed and mobile services, and with varying exposure to each. Therefore, methods that test the difference in asset betas of fixed vs. mobile telecoms operators have to address this challenge.

Expanding on NERA (2017), in this report we specifically consider the following:

- In section 2, we update the mobile beta evidence assessed by Ofcom in their 2017 MCT Consultation;
- In section 3, we assess whether there is evidence that the cross-sample variation in asset betas of European telecoms operators could be explained by their respective differences in exposure to mobile demand risk. We explored this issue in NERA (2017), and we update this evidence below;

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1 NERA (February 2017), *Differences in the beta for fixed vs mobile telecommunications operators.* See here: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/99640/Annex-21.pdf

2 See Annex 21, Wholesale Local Access Market Review Consultation, 31March 2017, https://www.ofcom.org.uk/__data/assets/pdf_file/0028/99640/Annex-21.pdf

3 NERA (February 2017), *Differences in the beta for fixed vs mobile telecommunications operators.* See here: https://www.ofcom.org.uk/__data/assets/pdf_file/0028/99640/Annex-21.pdf

4 See Annex 10 here: https://www.ofcom.org.uk/consultations-and-statements/category-1/mobile-call-termination-market-review

- In section 4, we assess whether when forcing a partitioning of the sample into "predominantly fixed network" vs "predominantly mobile network" businesses, there is statistically significant evidence that the average asset beta of these two samples differs; and
- In section 5, we set out our concluding remarks.

2. Update of the Asset Beta Assessment in Ofcom's 2017 MCT Consultation

In this section, we update the 2-year asset betas calculated by Ofcom in the 2017 MCT Consultation (which considered data up to 31 December 2016), using the same debt beta assumption of 0.1.

Following the approach set out in the 2017 MCT Consultation, we first update the 2-year asset betas for the three main UK mobile providers: BT Group (EE), Vodafone and Telefonica (O2), using September 29, 2017 as the cut-off date. Our results are shown in table 2.1 below.

Table 2.1
Update of UK Mobile Comparators data

	2y ag. Gearing	2Y avg. mobile revenue share	2Y Asset beta - FTSE All Share		2Y Asset beta - FTSE All Europe		2Y Asset beta - FTSE All World	
			Nera (Sep 2017)	MCT Consultation (Dec 2016)	Nera (Sep 2017)	MCT Consultation (Dec 2016)	Nera (Sep 2017)	MCT Consultation (Dec 2016)
BT	26%	10%	0.78	0.76	0.63	0.64	0.86	0.81
Vodafone	42%	64%	0.60 *	0.57	0.37 *	0.41	0.52 *	0.53
Telefonica	56%	62%	N/A	N/A	0.60 *	0.60	0.86 *	0.77

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

As shown above, with respect to the UK Telecoms sample, asset betas are slightly higher than those in the 2017 MCT Consultation when calculated against the All Share index, and broadly in line with, or slightly lower than those in the 2017 MCT Consultation when calculated against the FTSE All Europe Index. In general, we place greater emphasis on the betas against the local / regional reference indices (FTSE All Share and FTSE All Europe) by comparison to the global index (FTSE All World), to the extent that the data continues to support the existence of an equity home bias in the UK and European equity markets, and to the extent that these operators have some UK, though mainly European operations.[5] Given that the changes in the betas calculated against the relevant indices are minor and move in the opposite direction (an increase against the All Share, and a decrease against the All Europe index), we do not consider that these latest movements in the asset betas alone constitute sufficient grounds for Ofcom to change the range proposed in the 2017 MCT Consultation, based on the latest data.

Furthermore, we also consider the updated evidence from European telecoms operators that are predominantly active in the mobile business. We use the same comparator sample as used

[5] For an updated discussion, see NERA (November 2017), Update of the Equity Beta and Asset Beta for BT Group and Comparators.

by Ofcom in their 2017 MCT Consultation, and show the updated asset betas calculated against the FTSE All Europe and FTSE All World indices in table 2.2 below.[6]

Table 2.2
Update of asset betas of European Mobile Comparators

	2y ag. Gearing	2Y avg. mobile revenue share	2Y Asset beta - FTSE All Europe		2Y Asset beta - FTSE All World	
			Nera (Sep 2017)	MCT Consultation (Dec 2016)	Nera (Sep 2017)	MCT Consultation (Dec 2016)
Tele2	24%	76%	0.60 *	0.64	0.82 *	0.8
Telefonica Deutsche	14%	87%	0.54	0.52	0.86	0.75
Telekom Austria	43%	64%	0.29 *	0.27	0.42 *	0.39
Elisa	17%	63%	0.56 *	0.64	0.75 *	0.78
Orange Belgium	25%	82%	0.39 *	0.37	0.51	0.42
Telenor	28%	79%	0.51 *	0.54	0.72 *	0.69
Teliasonera	36%	46%	0.49 *	0.55	0.68 *	0.69
Deutsche Telekom	46%	60%	0.42 *	0.48	0.69 *	0.73
Minimum		46%	0.29	0.27	0.42	0.39
Maximum		87%	0.60	0.64	0.86	0.80
Average		70%	0.48	0.50	0.68	0.66

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

Against the FTSE All World index, the asset betas of the European comparators range from 0.42 to 0.86 with an average of 0.68, a slight increase from the 0.39 to 0.80 range with an average of 0.66 in the 2017 MCT Consultation. Against the All Europe, the range has slightly converged to 0.29 – 0.60, compared to Ofcom's 0.27 – 0.64. At 0.48, the updated average asset beta of the sample calculated against the All Europe index remains very close to the average of 0.50 calculated in Ofcom's 2017 MCT Consultation.

It is important to note that each of the asset betas above is calculated within a margin of error. For example, the equity beta of the eight comparators above is estimated with an average standard error of 0.07 against the All World index, and 0.04 against the All Europe index. At an average gearing of c.30%, this results in an asset beta error of 0.05 and 0.03 respectively.[7] On the other hand, we observe that the average asset beta of the group has moved by 0.02 when compared to the average in the 2017 MCT Consultation, when calculated against both

[6] Consistent with the methodology in previous updates, we perform diagnostic tests on the CAPM regressions, assessing the possible existence of heteroscedasticity and autocorrelation in the data. In the presence of such anomalies in the data, we use the Generalized Least Squares (GLS) betas. See Appendix A for details.

[7] The average standard error of the mobile set of comparators is c. 0.07 against the All World index; 0.04 against the All Europe index; and their average gearing is c.30%. Asset beta can be derived as: Asset beta = Gearing * Debt beta+ (1-Gearing) * Equity beta. By making use of this equation, treating the debt beta as a constant and by properties of the variance (and standard error) of a random variable, it can be shown that the standard error of X on the equity beta translates into a standard error of X * (1- Gearing) on the asset beta. In our example, an equity beta standard error of 0.07 at 30% gearing, translates into an asset beta error of 0.05, calculated against the All World index. Similarly, an equity beta standard error of 0.04 at 30% gearing translates to an asset beta standard error of 0.03, against the All Europe index.

the All Europe and All World indices (i.e. from 0.50 to 0.48 against the All Europe, and 0.66 to 0.68 against the All World). Therefore, we find that the change in the average asset beta of these comparators is on average within one standard error, and consequently, we find no evidence that the range for mobile comparators has significantly changed, based on the latest data.

3. Method 1: Cross-sectional Regressions for Testing the Difference in the Asset Betas of Fixed vs. Mobile Telecoms

In this section, we assess whether there is evidence that the variation of the asset betas for a number of European telecoms operators can be explained by the extent of their exposure to mobile activities.

The analysis in this section considers a sample of Western European telecoms network companies which operate in similar geographies and under similar regulatory rules as in the UK. We used the same two-step filtering procedure as in NERA (2017) to select relevant comparators and to ensure robustness of the sample of data (see NERA 2017). We conduct the analysis against both the All Europe and the All World indices.

Our filtering procedure (NERA 2017) resulted in a sample of 15 European telecoms operators which we use as comparators in our analysis below. The comparators are: Telenor, TeliaSonera, Vodafone, Deutsche Telekom, Telefonica, Orange, Tele2, TDC, Telecom Italia, Swisscom, Telefonica Deutschland, Elisa, Proximus (formerly Belgacom), Telekom Austria and Orange Belgium (formerly Mobistar).

3.1. Visual inspection and simple Cross-sectional OLS Regression

This section updates the analysis in NERA (2017) with the latest data.

As a first step in assessing whether exposure to mobile activities contributes to the cross-sectional difference in the asset betas of EU telecoms operators, we visually inspect the data on a scatter plot, to examine whether there are observable systematic patterns in the data. In a second step, we use statistical techniques to test whether any such relationship is statistically significant. We conduct the analysis with asset betas calculated both against the All Europe and All World indices.

Figure 3.1 and Figure 3.2 show the scatter plots of the companies' latest 1-year and 2-year asset betas (calculated against the FTSE All Europe index), plotted against their respective revenue shares coming from mobile activities.[8] If mobile telecoms products and services were associated with greater cyclicality and systematic risk than fixed telecoms products and services, then we would expect companies with greater shares of revenues coming from

[8] We have used daily data to estimate equity betas with a cut-off date of December 2016, for consistency with the mobile revenue data which is available annually from the companies' Annual Reports. We estimate betas against a regional, FTSE All Europe Index as well as against the All World index, and use the Miller formula ($\beta_{equity} = \beta_{asset} * (1 + D/E)$ to derive asset betas from equity betas, assuming a debt beta of 0.1. 1Y asset betas estimated using December 2016 as a cut off are plotted against the latest (2016) annual data on shares of revenues from mobile activities, whereas the 2Y asset betas are plotted against the average share of revenues from mobile activities taken over the relevant 2Y period used to calculate the beta. Betas were calculated using the standard OLS technique. We show in Appendix A (albeit for a different cut-off date, namely 29 September 2017, the cut-off Ofcom asked that we use for the MCT Comparator update) that for these comparators, the difference between the OLS and GLS estimates that correct for anomalies in the data (e.g. heteroscedasticity), are not material.

mobile activities to also have higher asset betas, and vice versa (i.e. a positive correlation), all else being equal.[9]

As shown in the scatter plots below, both the 1-year and the 2-year charts seem to suggest a positive pattern between the asset beta and mobile shares of the telecoms companies in our sample, where the mobiles shares in the 1-year scatter plot are based on the latest available data (2016) in the companies' Annual Reports, and in the 2-year scatter plot, as the simple average of the 2015 and 2016 figures.[10]

For the 2-year timeframe, however, after a more careful inspection of the data, we note a concentration of asset betas (against the FTSE All Europe) around the 0.45 - 0.62 cluster, even though the mobile share for these companies displays a wide range of 23 to 87%.

To examine the relationship more rigorously, we revert to conducting statistical tests on the data.

To statistically test whether the cross-sectional variation in asset betas of the telecoms operators in our sample can be explained by the differences in their exposure to mobile activities, we fit Ordinary Least Squares (OLS) regressions for both the 1-year and 2-year data samples. Both regressions have positive slope coefficients, indicating that greater exposure to mobile demand risk is associated with higher asset betas in this sample:

$$Asset\ beta_{1Y} = 0.10 \times Mobile\ share\ of\ revenue_{1Y} + 0.41 \qquad \text{Equation 1}$$

$$Asset\ beta_{2Y} = 0.06 \times Mobile\ share\ of\ revenue_{2Y} + 0.46 \qquad \text{Equation 2}$$

However, the slope coefficients are not statistically significant in either regression.[11] This means that based on this sample of data, we cannot reject the null hypothesis that mobile shares do not systematically affect the asset betas of telecoms companies. Therefore, we conclude that there is not enough evidence in this latest sample to support the view that greater exposure to mobile demand risk increases a company's asset beta. [12] We also note that the R-squared statistics of these regressions are low, which indicates that the exposure to mobile activities alone explains only a small portion of the cross-sectional variation in asset betas in the sample.[13]

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9 Note this initial assessment assumes that the entire variation in asset betas could be explained by the companies' exposure to mobile services. See NERA (2017) for an expanded version of the tests that includes other explanatory variables, which were also found not to be statistically significant.

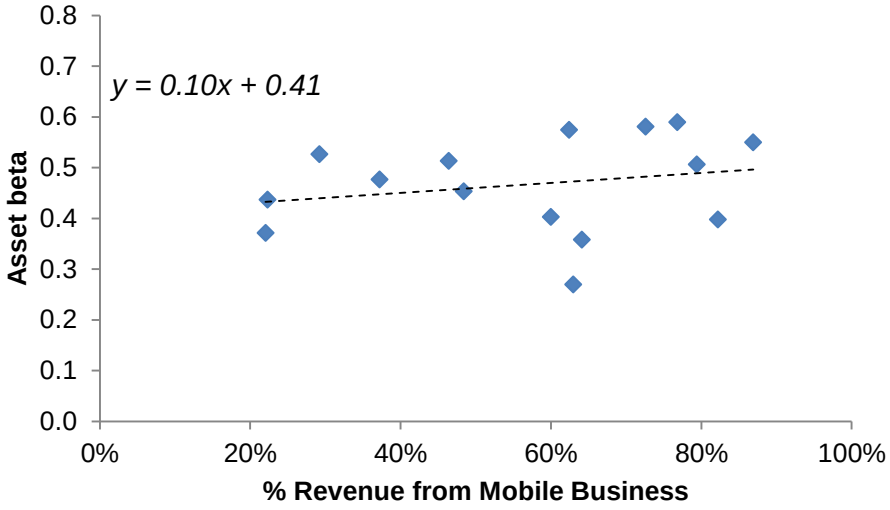
10 We download mobile shares data from Bloomberg , who draw on the companies' Annual Reports. For Deutsche Telekom and Telekom Austria, Bloomberg does not give a sufficiently granular disclosure of the revenue breakdown; hence we used financial reports in the public domain for these companies.

11 For the 1Y regression, p-val = 0.42; for the 2Y regression, p-val = 0.65.

12 Formally, the null hypothesis in this regression is that the coefficient on the mobile share of revenues is 0.

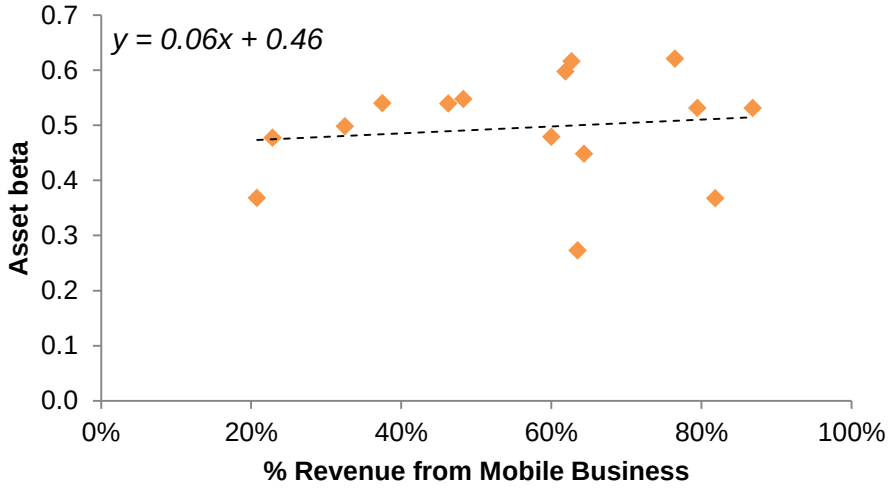
13 For the 1Y regression, R-squared = 0.05; for the 2Y regression, R-squared = 0.02.

Figure 3.1
1Y Asset beta vs. Mobile revenue share – FTSE All Europe



Source: NERA analysis

Figure 3.2
2Y Asset beta vs. Mobile revenue share – FTSE All Europe



Source: NERA analysis

Similarly, we regressed the stock returns against the FTSE All World Index to examine whether the above observations are altered in any meaningful way if betas are calculated against a globally diversified index.

Figure 3.3 and Figure 3.4 show the scatter plots of the companies' latest 1-year and 2-year asset betas plotted against their respective revenue shares coming from mobile activities. The asset betas in the sample are generally higher when regressed against the All World index.

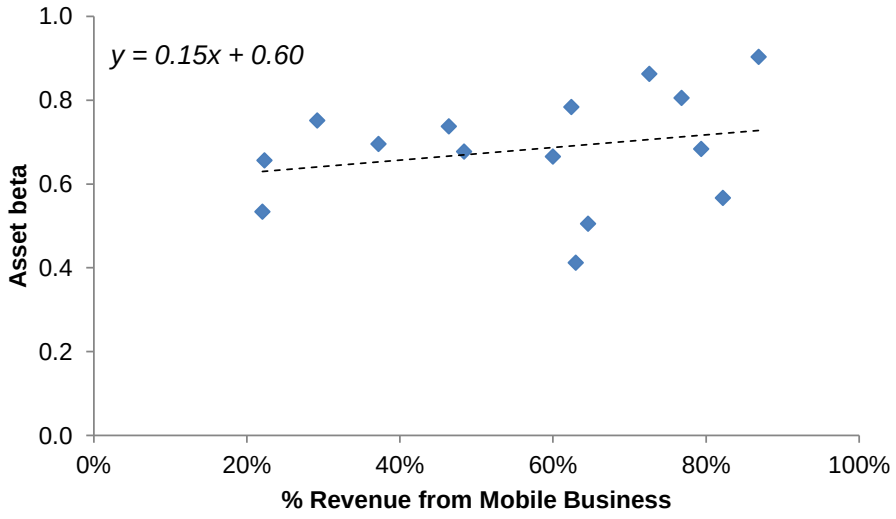
As was the case in the scatter plots using FTSE All Europe as the reference index, the scatter plots using the All World index seem to exhibit a positive trend, as confirmed by the positive regression coefficients.

$$Asset\ beta_{1Y} = 0.15 \times Mobile\ share\ of\ revenue_{1Y} + 0.60 \qquad \text{Equation 1}$$

$$Asset\ beta_{2Y} = 0.10 \times Mobile\ share\ of\ revenue_{2Y} + 0.58 \qquad \text{Equation 2}$$

However, when we revert to statistical testing, we find that the regression coefficients for both 1-year and 2-year are also not statistically significant.[14] In addition, R-squared statistics of these regressions are low; hence the exposure to mobile activities alone explains only a small portion of the cross-sectional variation in asset betas in this sample.[15]

Figure 3.3
1Y Asset beta vs. Mobile revenue share – FTSE All World

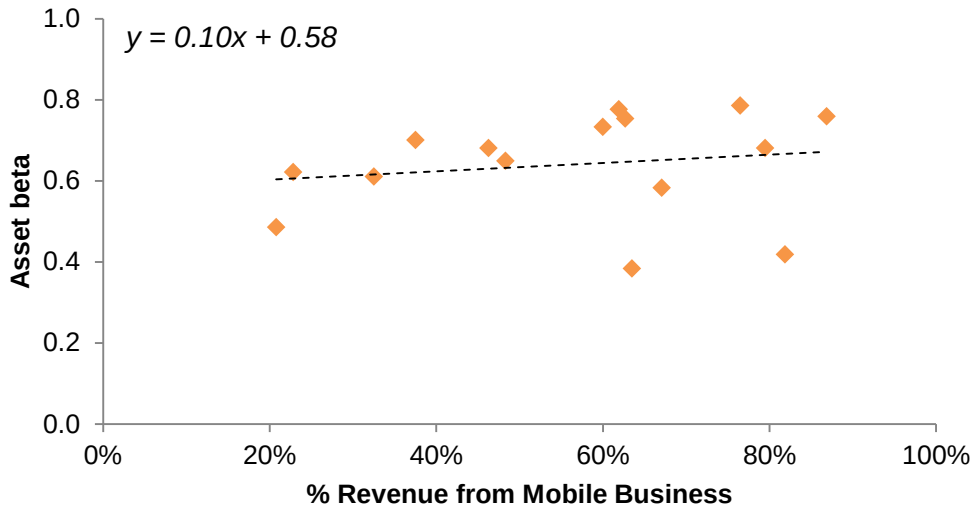


Source: NERA Analysis

[14] For the 1Y regression, p-val = 0.39; for the 2Y regression, p-val = 0.54

[15] For the 1Y regression, R-squared = 0.24; for the 2Y regression, R-squared = 0.32.

Figure 3.4
2Y Asset beta vs. Mobile revenue share – FTSE All World



Source: NERA Analysis

We test the robustness of the conclusions above in the following section, where we assess whether there is evidence that certain observations are outliers, which could be distorting the results above.

3.2. Assessment of Outliers in Cross-sectional Regression

In this section, we test the robustness of our cross-sectional regression results against outliers. Outliers are observations that significantly differ from the rest of the observations in a sample of data, and therefore could substantively alter the results in an ordinary least squares regression.

To test for outliers, we use the Cook's Distance test, a standard statistical test that can identify potential outliers in a cross-sectional regression, and assess whether excluding the outliers materially changes the regression results.[16] For the regression against the FTSE All Europe, we identify TDC to be an outlier only when considering the 2-year timeframe.[17] We then re-run the 2-year OLS regression excluding TDC.

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[16] The Cook's D test defines a data point as outlier if the Cook's Distance measure exceeds four divided by the number of observations in the regression. Cook's $D \equiv \frac{(\hat{\beta}_{(-i)}-\hat{\beta})' \boldsymbol{X}' \boldsymbol{X} (\hat{\beta}_{(-i)}-\hat{\beta})}{\rho s^2}$, where ρ is the number of fitted parameters in the model; s^2 is the mean squared error of the regression model.

See Cook, R. Dennis (March 1979); "Influential Observations in Linear Regression"; Journal of the American Statistical Association.

[17] As the formula in 16 intuitively shows, Cook D value varies inversely with the mean squared error of the regression – the higher the mean squared error, the lower the Cook D values. Because the 2-year sample has lower mean squared error than the 1-year sample (note the closer clustering around the fitted line under the 2-year regression vs the 1-year), the Cook's D statistic for the 2-year sample is more likely to exceed the 4/n threshold which defines outliers.

As shown in Figure 3.5 the slope coefficient in the regression excluding outliers is slightly negative), (-0.02) and is again statistically not significant at the 5% significance level.[18] Another change in the regression parameters is related to the intercept, which increases from 0.46 to 0.52 due to the fact that the outlier stands below the trend line in the original regression. The new regression equation excluding outliers is:

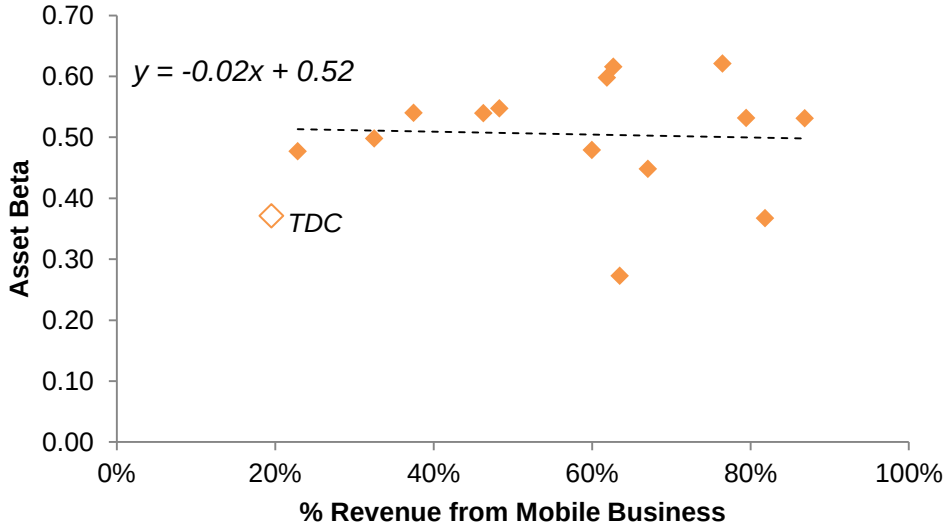
$$Asset\ beta_{2Y} = -0.02 \times Mobile\ share\ of\ revenue_{1Y} + 0.52 \qquad \text{Equation 1}$$

Given this evidence, we consider that our original regression results are robust to outliers, since excluding the outlier results in an outlier-adjusted slope coefficient that is again not statistically significant (and moreover, results in a change in the sign of the slope coefficient).

Finally, we note that even though there is evidence that TDC is statistically different from the remaining companies in the sample, we do not consider that we have sufficient basis to conclude that this observation is not valid, given that it was selected using the same procedure as the rest of the sample and the sample itself is quite small (i.e. 15 observations).

[18] P-val is 0.19, higher than the standard 5% level of significance.

Figure 3.5
2Y Asset beta vs. Mobile revenue share - FTSE All Europe (excluding outliers)



Source: NERA analysis

When conducting the Cook's distance test on the regressions that use asset betas calculated against the FTSE All World index, we identify Telefonica Deutsche to be outlier in the 1-year regression and Orange Belgium to be an outlier in the 2-year regression. Figures 3.6 and 3.7 show the scatter plots of the companies' 1-year and 2-year asset betas and the regression lines obtained by excluding the abovementioned outliers.

The coefficients of the new regressions excluding outliers experience opposing changes, as follows:

- the 1-year regression coefficient decreases, from 0.15 to 0.05; whereas
- the 2-year regression coefficient increases, from 0.10 to 0.22.

This difference is due to the fact that the 1-year regression outlier (Telefonica Deutsche) stands above the trend line, while the opposite is true for the 2-year regression outlier (Orange Belgium).

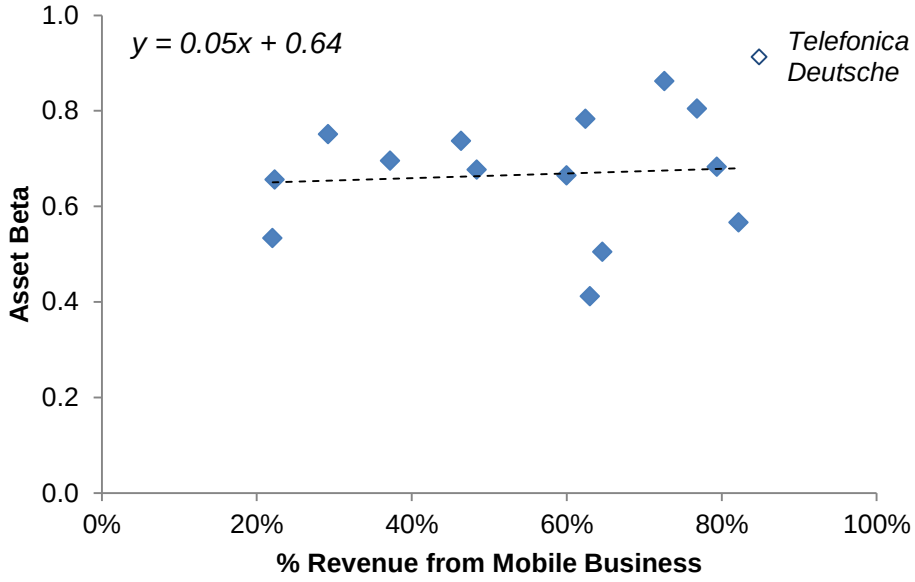
As was the case for the regressions against the FTSE All Europe index, the outlier-adjusted slope coefficients remain not statistically significant.[19]

$$Asset\ beta_{1Y} = 0.05 \times Mobile\ share\ of\ revenue_{1Y} + 0.64 \qquad \text{Equation 1}$$

$$Asset\ beta_{2Y} = 0.22 \times Mobile\ share\ of\ revenue_{2Y} + 0.53 \qquad \text{Equation 2}$$

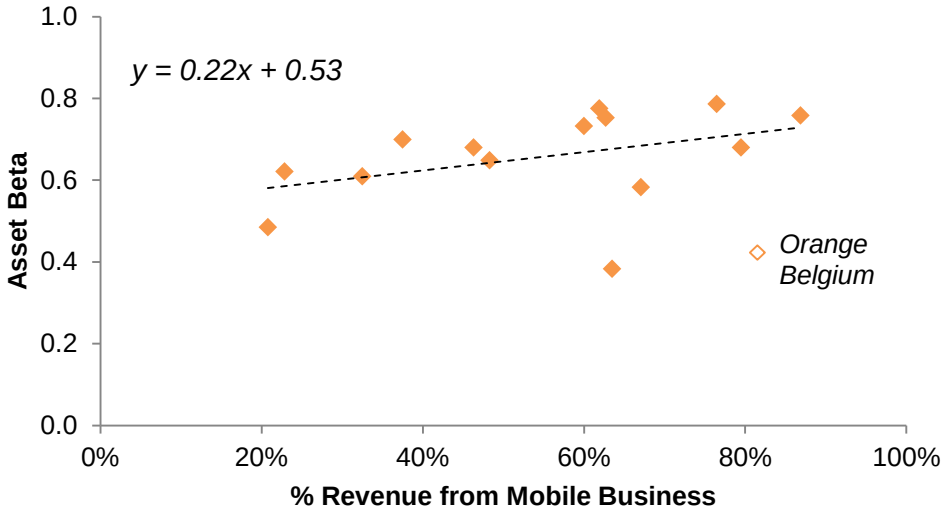
[19] For the 1Y regression, p-val = 0.78; for the 2Y regression, p-val = 0.15

Figure 3.6
1Y Asset beta vs. Mobile revenue share - FTSE All World (excluding outliers)



Source: NERA analysis

Figure 3.7
2Y Asset beta vs. Mobile revenue share - FTSE All World (excluding outliers)



Source: NERA analysis

4. Method 2: Differences in Means Tests for Testing the Difference in the Asset Betas of Fixed vs. Mobile Telecoms

In this section, we use the "difference in means" test to assess whether there are statistically significant differences in the asset betas of companies with substantially different mobile network revenue exposure.

For this analysis, we divided our telecoms sample in two sub-samples by using different cut-off mobile revenue thresholds to determine if a company belongs to the "high share of mobile" sample (and is therefore predominantly a mobile telecoms operator) or to the "low share of mobile" sample (and is therefore not a predominantly mobile operator, i.e. it is predominantly a fixed telecoms and other telecoms products and services provider): companies whose mobile revenue share is lower than the cut-off percentage will be part of the latter subsample, while companies whose mobile revenues represent at least "1 – cut-off percentage" (e.g. 60%, if cut-off is 40%) will be part of the "high share of mobile" sample. This approach aims at neutralizing the impact of median observations in order to better assess if the asset betas vary between companies with a substantially different mobile revenue exposure.

By choosing 50% as the cut-off, we obtain 2 sub-samples with nine observations for the "high-share" sample and six observations for the "low-share" sample. Although the "high-share" sample exhibits a slightly higher mean asset beta than the "low share" sample when measured against the All Europe index (0.47 vs 0.46 for the 1-year period; and 0.50 vs 0.49 for the 2-year period), these differences in means are both statistically not significant.[20]

If we choose a lower cut-off, the number of observations in both samples decreases; as our sample is already relatively narrow consisting of only 15 companies, the fact that we are removing median observations may lead to lower reliability of the results obtained since they are based on a reduced number of observations. In any case, all of the t-tests performed using 40%, 35% and 30% as the cut-off resulted in differences in means which are not statistically significant, as table 5.1 shows.

[20] One-tail p-values are 0.45 for the 1-year period and 0.49 for the 2-year, higher than the standard 5% level of significance.

Table 4.1
Difference in means – Two Sample t-Test assuming Equal Variances (All Europe)

	Cut-off	High-share average	Low-share average	Difference	P-value (one-tail)	Significant (5%)?
1-year	30%	0.52	0.44	0.08	0.11	No
	35%	0.52	0.44	0.08	0.11	No
	40%	0.47	0.45	0.02	0.40	No
	50%	0.47	0.46	0.01	0.45	No
2-year	30%	0.51	0.42	0.09	0.18	No
	35%	0.50	0.45	0.05	0.05	No
	40%	0.50	0.47	0.02	0.35	No
	50%	0.50	0.49	0.00	0.49	No

Based on this analysis, we again conclude that we find no evidence in the present sample of data that there is a statistically significant difference in the asset betas of predominantly mobile vs fixed comparators.

We conducted the same analysis using the Asset Betas calculated against the FTSE All World index. As Table 4.2 shows, there are no statistically significant differences in the asset betas of companies with substantially different mobile network revenue exposure.

Table 4.2
Difference in means – Two Sample t-Test assuming Equal Variances (All World)

	Cut-off	High-share average	Low-share average	Difference	P-value (one-tail)	Significant (5%)?
1-year	30%	0.76	0.65	0.11	0.13	No
	35%	0.76	0.65	0.11	0.13	No
	40%	0.69	0.66	0.03	0.38	No
	50%	0.69	0.68	0.01	0.44	No
2-year	30%	0.66	0.57	0.09	0.22	No
	35%	0.64	0.57	0.07	0.23	No
	40%	0.65	0.60	0.05	0.29	No
	50%	0.65	0.62	0.03	0.34	No

Lastly, we performed the analysis assuming both Equal and Unequal Variances of the sub-samples; although not reported separately, the results are not affected by the type of analysis chosen.

5. Conclusions

In this report, we updated the mobile beta evidence assessed in Ofcom's 2017 MCT Consultation and revisited the empirical evidence on the possible difference in systematic risk and asset betas of fixed vs. mobile telecoms operators.

Our mobile beta evidence update used the sample of comparators in Ofcom's 2017 MCT Consultation and updated the data up to September 29, 2017. The latest beta evidence does not indicate that there has been a significant change in the betas of mobile comparators since Ofcom's latest update. We found that the asset betas of the UK Telecoms companies have mildly increased against the All Share index, but have remained broadly stable or mildly decreasing against the All Europe index. Similarly, the asset betas of European mobile telecoms operators have slightly changed against the All Europe and All World indices, but in both cases, the change is within the standard error of the sample. Therefore, we find no evidence that the range for mobile telecoms operators has changed since Ofcom's latest update.

With respect to the empirical evidence of a possible difference in the betas of mobile vs. fixed comparators, we assessed:

- Whether there is evidence that the cross-sample variation in asset betas of European telecoms operators could be explained by their respective differences in exposure to mobile demand risk; and
- When forcing a partitioning of the sample into "predominantly mobile" vs. "predominantly fixed and other" telecoms businesses, whether there is statistically significant evidence that the average asset beta of these two samples differs.

Both of the assessments above found that at present, and using the latest data, there is no evidence of statistically significant difference in the betas of fixed vs. mobile telecoms network operators.

From this, we might also infer that BT's acquisition of EE is unlikely to have significantly affected the systematic risk of BT as a whole

Appendix A. Statistical Tests

In this appendix, we set out the statistical tests carried out to test the assumptions underpinning our equity beta estimation. Based on the set of formal statistical diagnostic tests carried out for this assignment, we conclude that the GLS estimates used to correct for autocorrelation and heteroskedasticity are generally similar to the OLS estimates across the samples.

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 the 95% confidence level for both tests (as reported below). As shown in Table A.1, the GLS estimates are generally very similar to the OLS estimates across the entire set of comparators.

Table A.1
European Fixed and Mobile Heteroscedasticity/Autocorrelation Tests

	FTSE All Europe							FTSE All World					
	White Stat	P-val	Durbin Watson	Heteroske dasticity	Serial Correlati on	GLS?		White Stat	P-val	Durbin Watson	Heterosked asticity	Serial Correlat ion	GLS?
BT													
1Y	0.40	0.82	2.07	NO	NO	NO	1Y	1.43	0.49	2.09	NO	NO	NO
2Y	1.35	0.51	2.07	NO	NO	NO	2Y	4.13	0.13	2.06	NO	NO	NO
Telefonica													
1Y	1.97	0.37	1.89	NO	NO	NO	1Y	0.48	0.79	1.99	NO	NO	NO
2Y	148.81	0.00	2.18	YES	YES	YES	2Y	224.67	0.00	2.29	YES	YES	YES
Vodafone													
1Y	0.89	0.64	1.73	NO	YES	YES	1Y	2.80	0.25	1.75	NO	YES	YES
2Y	134.92	0.00	1.98	YES	NO	YES	2Y	63.21	0.00	2.07	YES	NO	YES
Orange													
1Y	2.46	0.29	2.01	NO	NO	NO	1Y	7.28	0.03	2.08	YES	NO	YES
2Y	2.97	0.23	2.03	NO	NO	NO	2Y	7.41	0.02	2.09	YES	NO	YES
Tele2													
1Y	2.10	0.35	2.22	NO	YES	YES	1Y	3.73	0.15	2.25	NO	YES	YES
2Y	37.75	0.00	2.03	YES	NO	YES	2Y	9.79	0.01	2.12	YES	NO	YES
Tdc A/S													
1Y	0.36	0.83	2.07	NO	NO	NO	1Y	0.02	0.99	2.08	NO	NO	NO
2Y	0.28	0.87	1.94	NO	NO	NO	2Y	0.83	0.66	1.94	NO	NO	NO
Telecom Italia													
1Y	2.64	0.27	1.96	NO	NO	NO	1Y	0.79	0.67	1.92	NO	NO	NO
2Y	16.36	0.00	2.08	YES	NO	YES	2Y	40.45	0.00	2.10	YES	NO	YES
Swisscom													
1Y	11.03	0.00	2.02	YES	NO	YES	1Y	3.36	0.19	2.07	NO	NO	NO
2Y	78.29	0.00	1.98	YES	NO	YES	2Y	21.67	0.00	2.10	YES	NO	YES
Telefonica Deutsche													
1Y	1.45	0.48	2.07	NO	NO	NO	1Y	0.37	0.83	2.15	NO	NO	NO
2Y	2.49	0.29	2.02	NO	NO	NO	2Y	0.10	0.95	2.05	NO	NO	NO
Proximus													
1Y	1.81	0.40	2.04	NO	NO	NO	1Y	2.11	0.35	2.09	NO	NO	NO
2Y	13.54	0.00	2.00	YES	NO	YES	2Y	11.24	0.00	2.07	YES	NO	YES
Telekom Austria													
1Y	0.16	0.92	2.17	NO	NO	NO	1Y	0.51	0.77	2.16	NO	NO	NO
2Y	0.08	0.96	2.22	NO	YES	YES	2Y	0.25	0.88	2.24	NO	YES	YES
Elisa													
1Y	6.54	0.04	2.20	YES	Inconc	YES	1Y	0.09	0.96	2.25	NO	YES	YES
2Y	220.32	0.00	2.08	YES	NO	YES	2Y	106.07	0.00	2.16	YES	YES	YES
Orange Belgium													
1Y	0.04	0.98	1.91	NO	NO	NO	1Y	0.06	0.97	2.02	NO	NO	NO
2Y	0.27	0.87	1.83	NO	YES	YES	2Y	0.30	0.86	1.93	NO	NO	NO
Telenor													
1Y	0.82	0.66	2.36	NO	YES	YES	1Y	0.17	0.92	2.45	NO	YES	YES
2Y	1.71	0.43	2.17	NO	YES	YES	2Y	0.32	0.85	2.29	NO	YES	YES
Teliasonera													
1Y	0.04	0.98	2.21	NO	Inconc	YES	1Y	0.43	0.81	2.29	NO	YES	YES
2Y	249.82	0.00	2.25	YES	YES	YES	2Y	140.27	0.00	2.38	YES	YES	YES
Deutsche Telekom													
1Y	0.61	0.74	1.95	NO	NO	NO	1Y	0.71	0.70	1.93	NO	NO	NO
2Y	5.38	0.07	1.85	NO	Inconc	YES	2Y	2.64	0.27	1.77	NO	YES	YES

Source: NERA analysis

Table A.2
OLS vs. GLS equity beta estimates for European Fixed and Mobile Comparators

	FTSE All Europe				FTSE All World				FTSE All Share			
	OLS		GLS		OLS		GLS		OLS		GLS	
BT	Beta	SE	Beta	SE	Beta	SE	Beta	SE	Beta	SE	Beta	SE
1Y	0.43	0.19	0.41	0.19	0.44	0.30	0.42	0.30	0.61	0.22	0.61	0.22
2Y	0.82	0.07	0.82	0.07	1.13	0.11	1.12	0.11	1.03	0.08	1.02	0.08
Telefonica												
1Y	0.95	0.10	0.94	0.10	1.50	0.16	1.50	0.16	N/A	N/A	N/A	N/A
2Y	1.25	0.05	1.25	0.05	1.84	0.09	1.85	0.08	N/A	N/A	N/A	N/A
Vodafone												
1Y	0.53	0.09	0.52	0.09	0.77	0.15	0.75	0.14	1.05	0.09	1.04	0.09
2Y	0.57	0.04	0.57	0.04	0.82	0.07	0.82	0.07	0.96	0.05	0.97	0.05
Orange												
1Y	0.81	0.08	0.81	0.08	1.06	0.14	1.06	0.14	N/A	N/A	N/A	N/A
2Y	0.80	0.05	0.80	0.05	1.14	0.08	1.14	0.08	N/A	N/A	N/A	N/A
Tele2												
1Y	0.74	0.10	0.76	0.10	1.13	0.17	1.17	0.16	N/A	N/A	N/A	N/A
2Y	0.76	0.05	0.76	0.05	1.04	0.09	1.04	0.08	N/A	N/A	N/A	N/A
Tdc A/S												
1Y	0.67	0.11	0.68	0.11	1.12	0.17	1.14	0.17	N/A	N/A	N/A	N/A
2Y	0.65	0.06	0.64	0.06	1.01	0.10	1.01	0.10	N/A	N/A	N/A	N/A
Telecom Italia												
1Y	1.02	0.14	1.02	0.14	1.46	0.22	1.47	0.22	N/A	N/A	N/A	N/A
2Y	1.41	0.08	1.40	0.08	1.98	0.13	1.96	0.13	N/A	N/A	N/A	N/A
Swisscom												
1Y	0.45	0.06	0.45	0.06	0.65	0.10	0.66	0.10	N/A	N/A	N/A	N/A
2Y	0.57	0.03	0.57	0.03	0.83	0.05	0.84	0.05	N/A	N/A	N/A	N/A
Telefonica Deutsche												
1Y	0.67	0.13	0.67	0.13	1.03	0.22	1.07	0.21	N/A	N/A	N/A	N/A
2Y	0.62	0.06	0.62	0.06	0.99	0.09	0.98	0.09	N/A	N/A	N/A	N/A
Proximus												
1Y	0.50	0.09	0.51	0.09	0.76	0.15	0.77	0.15	N/A	N/A	N/A	N/A
2Y	0.58	0.04	0.58	0.04	0.85	0.07	0.85	0.07	N/A	N/A	N/A	N/A
Telekom Austria												
1Y	0.32	0.11	0.34	0.11	0.46	0.18	0.48	0.17	N/A	N/A	N/A	N/A
2Y	0.43	0.05	0.43	0.05	0.66	0.08	0.65	0.08	N/A	N/A	N/A	N/A
Elisa												
1Y	0.58	0.09	0.59	0.08	0.83	0.14	0.85	0.14	N/A	N/A	N/A	N/A
2Y	0.65	0.04	0.65	0.04	0.88	0.07	0.89	0.07	N/A	N/A	N/A	N/A
Orange Belgium												
1Y	0.48	0.11	0.48	0.11	0.68	0.17	0.68	0.17	N/A	N/A	N/A	N/A
2Y	0.48	0.05	0.49	0.05	0.65	0.08	0.65	0.08	N/A	N/A	N/A	N/A
Telenor												
1Y	0.52	0.11	0.53	0.11	0.80	0.18	0.90	0.17	N/A	N/A	N/A	N/A
2Y	0.67	0.05	0.67	0.05	0.91	0.09	0.96	0.08	N/A	N/A	N/A	N/A
Teliasonera												
1Y	0.57	0.08	0.58	0.08	0.88	0.12	0.92	0.12	N/A	N/A	N/A	N/A
2Y	0.72	0.04	0.71	0.04	1.00	0.07	1.00	0.07	N/A	N/A	N/A	N/A
Deutsche Telekom												
1Y	0.66	0.08	0.66	0.08	1.18	0.12	1.17	0.12	N/A	N/A	N/A	N/A
2Y	0.70	0.04	0.69	0.04	1.18	0.06	1.19	0.06	N/A	N/A	N/A	N/A
Mobile and Fixed Comparators Avg.												
	0.63		**0.64**		**0.95**		**0.97**					
	0.72		**0.72**		**1.05**		**1.06**					

Source: NERA analysis

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