Estimates of Equity and Asset Betas for UK Mobile Owners

PREPARED FOR

Office of Communications ("Ofcom")

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January 2015



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Acknowledgement: We acknowledge the valuable contributions of many individuals to this report and to the underlying analysis, including members of The Brattle Group for peer review.

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I. Introduction

Ofcom has asked us to update our estimates of the equity betas for the parent companies of the mobile network operators ("MNOs"): Vodafone, Telefonica (O2), Orange and Deutsche Telekom (EE).¹ We understand that Ofcom intends to use these estimates to inform its forthcoming decision on the level of UK mobile call termination charges. We perform various analyses and present equity and asset beta estimates for the four parent companies.

Interpretation of the updated results requires care. As we highlighted in our June 2014 report, none of the above three UK MNOs has a dedicated tracking stock.² The closest available stock market data relates to the four parent companies and those companies engage in a diverse range of telecoms and IT activities in addition to UK mobile. It remains unclear the extent to which the observed betas for the parent companies reflect the particular risks associated with UK mobile or the risks associated with the parent companies' other activities.

Moreover, interpretation of the observed betas for Vodafone requires particular care at present. Vodafone sold its US business to Verizon for US\$130 billion (£84 billion), and paid out 71% of the sale proceeds to shareholders in the form of Verizon shares and cash. It has used part of the remaining proceeds to purchase two European cable companies, under a new strategy. The Verizon transaction was announced on 2 September 2013 and ultimately closed on 24 February 2014. The transaction fundamentally altered both the composition of Vodafone's assets and its capital structure. We examine the transaction in detail below and assess its impact on the observed beta for Vodafone.

To provide economic context and aid interpretation, we examine equity and asset betas for three further reference samples³:

¹ Ofcom did not ask us to consider Hutchison Whampoa, the owner of 3 since it is a diversified conglomerate operating across a number of sectors including retail, ports and telecoms. Beta estimates for Hutchison Whampoa are therefore unlikely to convey any useful information about a UK mobile operator.

² Neither has H3G. The stock of its parent, Hutchison Whampoa, is traded on the Hong Kong stock exchange.

³ In our previous report for Ofcom, Estimate of Equity Beta for UK Mobile Owners (June 2014), we included a UK utilities reference sample containing firms subject to UK price regulation. We do not update the UK utilities reference sample and exclude it from this report, because we understand that Ofcom does not intend to refer to the UK Utilities sample when deriving an allowed return for an efficient UK MNO.

- 1. UK telecoms The first reference sample comprises UK telecoms companies: BT, Talk Talk Group, BSkyB, and Colt. BT operates a fixed line network, serving both retail and wholesale consumers. Talk Talk now offer quadruple play services to UK consumers, providing fixed line, broadband, mobile and pay-TV. A sizeable proportion of Talk Talk's customer base is unbundled at the local loop. BSkyB competes with Talk Talk, providing fixed line, broadband and TV services to customers, but not mobile. Colt is somewhat distinct from the other three UK telecoms companies, providing telecom and data services to businesses based in many large European cities. Colt's primary operations are in the City of London.
- 2. US Telecoms The second reference sample comprises a sample of liquidly traded US telecommunications stocks. Some of the companies in the US sample, such as AT&T and Verizon, resemble the four mobile network owners: large diversified telecommunications companies, engaging in a mixture of wireline and wireless activities. In contrast, others of the US sample, such as US Cellular, focus only on the provision of wireless services. The US telecommunications sample is interesting for two reasons: in part because it provides a reference sample of wireless only stocks, and in part because it enables comparison of the relative risks of wireless and wireline telecommunications services.
- 3. *EU Telecoms* The third reference sample comprises a group of liquidly traded European telecommunications stocks, other than those owning UK mobile networks. Like the US sample, the European sample includes both large diversified telecoms companies and smaller companies focusing predominantly on wireless activities. We use the European sample also to examine the relative riskiness of mobile-only and diversified companies.

In this report, we adopt the same methodology as in other previous engagements for Ofcom.⁴ We calculate daily returns from holding stock in each of the companies under consideration, and from holding a broad market index. We examine data for three market indices: the FTSE All-Share reflecting all stocks trading on the London Stock Exchange, the FTSE All-World reflecting a large proportion of publicly traded stocks around the world, and the FTSE All-Europe reflecting the European portion of the All-World. As is standard, we perform a regression of the daily returns on each company against the daily returns on the market index. The regression coefficient is the equity beta. We use market data up to and including the 31st October 2014.

⁴ See, for example, Estimate of BT's Equity Beta (March 2014) and Estimate of Equity Beta for UK Mobile Owners (June 2014).

Previous work for Ofcom examined beta estimation methods.⁵ One issue concerned the frequency with which to measure stock returns: whether to use daily, weekly or even monthly returns. Analysts might use weekly or monthly returns if there is a concern about the liquidity of stock trading. No such concern exists with the MNOs in this case. All four parent companies of the UK MNOs are amongst the most liquid stocks around. All of our estimates therefore focus on daily returns. Another methodological choice relates to the duration of the data window. We focus on a two-year window in this report, while also reporting the results from a one-year window. Two-years provides a sizeable sample of daily stock returns without extending so far back in time as to include data from periods before the four companies made significant operational changes.

Chapter II presents equity and asset beta estimates for the UK MNOs, the UK Telecom, US Telecom and EU Telecom samples. Chapter III reports the results of several tests of the statistical reliability of the beta estimates.

II. Equity and Asset Beta Estimates

II.A. PARENT COMPANIES OF UK MNOS

II.A.1. Up-to-date Equity Beta Estimates

Each of the four parent companies of the UK MNOs is involved in numerous activities. Vodafone's operations span Europe and Asia, and are predominantly mobile. Between 2007 and the end of 2012, wireless activities accounted for around 90% of Vodafone's revenues. Over the same period, Vodafone's UK operations accounted for approximately 7% of revenues.

The sale of Vodafone's stake in Verizon has effected a significant change in the relative importance of different businesses. During the first half of 2014, Vodafone's UK activities accounted for a slightly higher proportion of revenues than previously, up to roughly 14% of revenues; 10% of Vodafone's revenues related to UK mobile. At the same time, the transaction effected a shift in relative focus towards Africa, Middle East, Asia and Pacific ("AMAP"). AMAP activities accounted for close to 35% of Vodafone's post-transaction revenues, up from roughly 20% between 2007 and 2012.

Mobile activities remain Vodafone's predominant focus. Mobile accounted for around 80% of revenues in the financial year to March 2014. However, Vodafone has used part of the

⁵ See *Issues in beta estimation for UK mobile operators*, July 2002.

proceeds from the sale of Verizon (over €15 billion) to acquire a German cable company ("Kabel") and a Spanish cable company ("Ono"), reflecting Vodafone's stated desire to achieve deeper integration in key markets and offer data and phone services to consumers. The sale of Verizon together with Vodafone's recent strategy shift is likely to have had consequences for its risk profile and the observed equity beta.

The other three MNO parents have not seen such significant changes since our last update. Telefonica's operations continue to span Europe and Latin America, and to focus on mobile services, which continue to account for two thirds of revenues. Latin America accounted for just over half of revenues in the first half of 2014, Spain a quarter, and the rest of Europe the remaining quarter. Telefonica's UK activities (almost entirely O2) contributed just under 14% of group revenues in the first half of 2014.

Orange's principal operations continue to be in France, Spain and Poland, in addition to EE in the UK. Wireless activities contribute roughly 50% of revenues, and EE roughly 15%. Deutsche Telekom's principal segments are in Germany, the US and the rest of Europe. In the first half of 2014, Deutsche Telekom obtained just over 60% of revenues from mobile activities. EE accounted for just over 10% of Deutsche Telekom's revenues.

Table 1 reports up-to-date equity beta estimates for the four parent companies of the UK MNOs. All of the estimates rely on daily return data. We report separate one and two year equity beta estimates as well as separate estimates against the three market indices. A one-year equity beta relies on the previous year of trading activity. A two-year equity beta relies on the previous two years. All of the various estimates reflect data up to and including the end of October 2014⁶.

⁶ EE has suggested that Ofcom implement the Vasicek adjustment to the raw OLS equity betas. We have checked if the introduction of a Vasicek adjustment would materially affect our equity beta estimates for the MNO parents. In Chapter III, we confirm that the introduction of a Vasicek adjustment would not materially change our results in this case. We continue to report unadjusted betas in the main text.

		1 Yr				2 Yr		
-	Beta	SE	Low	High	Beta	SE	Low	High
Deutsche Telekom								
All World	1.18	0.10	0.98	1.38	0.97	0.07	0.83	1.12
All Share	1.02	0.08	0.87	1.18	0.92	0.06	0.81	1.04
All Europe	1.08	0.06	0.95	1.21	0.97	0.05	0.87	1.07
Orange								
All World	1.26	0.13	1.00	1.52	1.17	0.09	0.99	1.35
All Share	0.94	0.10	0.74	1.14	1.02	0.08	0.86	1.18
All Europe	1.12	0.09	0.95	1.29	1.15	0.07	1.02	1.29
Telefonica								
All World	1.11	0.09	0.94	1.29	1.04	0.07	0.90	1.18
All Share	0.85	0.07	0.71	0.98	0.91	0.06	0.80	1.02
All Europe	0.94	0.07	0.81	1.07	1.02	0.05	0.92	1.12
Vodafone								
All World	1.22	0.13	0.96	1.48	0.91	0.08	0.75	1.06
All Share	1.27	0.10	1.08	1.47	1.05	0.07	0.92	1.18
All Europe	0.94	0.09	0.75	1.12	0.72	0.06	0.61	0.83
MNO Average (excludir	ng Vodafone)						
All World	1.18				1.06			
All Share	0.94				0.95			
All Europe	1.05				1.05			

Table 1: Up-to-date equity beta estimates⁷

Note:

We report OLS betas except where diagnostic tests indicate the presence of either heteroskedascity or auto-correlation. In which case we report GLS betas. We identified autocorrelation for the one and two year equity betas of all parent companies of the UK MNOs against all three indices, so we report GLS betas for all MNOs.

Figure 1 illustrates the development of Vodafone's equity beta against the FTSE All-Share over time. Figure 2 plots Vodafone's one year equity beta against the FTSE All-Share, FTSE All-World and FTSE All-Europe. Figure 3 plots Vodafone's two-year equity beta against the same indices. In each case, the plot keeps the duration of the equity beta estimation window constant through time. It simply shifts the one or two-year data window forward as time passes. It illustrates the relative changes in both Vodafone's one-year and two-year equity beta sover the past several years. Vodafone's one-year equity beta against the FTSE All-Share has fallen, risen, fallen again and risen again since the collapse of Lehman in September 2008. The recent rise – since late 2012, has seen Vodafone's one-year equity beta against the FTSE All-Share before the collapse of Lehman in 2008. The two-year equity beta against the FTSE All-

⁷ Low and high refer to the 95% confidence interval and not to the lowest and highest one and twoyear betas observed throughout the year.

Share also has risen sharply since around the end of 2013. Figure 2 and Figure 3 show the same progression in the equity betas calculated against the other two indices, although the equity betas against the FTSE All-Share come in consistently above those against the other indices.⁸

⁸ In its consultation response, EE urge Ofcom to consider placing more weight on betas computed against the FTSE All-Share. EE consider the FTSE All-Share especially relevant because of UK investors' home bias. EE does not consider Vodafone's current 3% weighting in the FTSE All-Share to be a sufficient reason to ignore betas computed against the All-Share. EE, Mobile call termination market review 2015-18: EE response to Ofcom's consultation, (13 August 2014), pp. 54-55.

UK investors' home bias is well established, notwithstanding the integration of global financial markets and the possibilities for UK investors to invest overseas. However, the presence of home bias does not immediately prompt reference to the betas against the FTSE All-Share. Rather it highlights the two generic options: compute betas either against an international index such as the FTSE All-World or against a home index such as the FTSE All-Share. The home index may be the FTSE All-Share for Vodafone, in line with EE's reasoning, but it would be the FTSE All-Europe (or MADX) for Telefonica, reflecting the comparable home bias of Spanish investors. Computing a beta for Telefonica against the FTSE All-Share could conceivably generate a lower beta than the result obtained against Telefonica's home index, because holding Telefonica would contribute some international diversification for home biased UK investors, which would prompt a lower beta and required return.

In our case, the asset betas against the FTSE All-World for Deutsche Telekom, Orange and Telefonica are higher in all cases than those computed against either the FTSE All-Share or All-Europe. Only for Vodafone are the asset betas computed against the FTSE All-Share higher than the All-World.

One possible explanation for the pattern of results for Vodafone relates to its weighting within the FTSE All-Share. According to the FTSE Factsheet from November 28, 2014, Vodafone remained the sixth largest constituent by market cap of the FTSE All-Share, representing just under 3% of the All-Share total. It remains possible that Vodafone's 3% weighting in the FTSE All-Share raises the possibility of enhanced correlation, relative to the broader international indices, resulting in a slight uplift in the observed beta.



Figure 1: Vodafone rolling equity betas against the FTSE All-Share – one-year and two-years





The sharp upward movement at least in Vodafone's two-year equity beta corresponds with the announcement and completion of the Vodafone's sale of its Verizon stake. We suspect that the sale of the Verizon stake may have represented a "structural break", where a different relationship between Vodafone stock returns and the market emerges after the transaction, implying a different level of equity beta. The sale effected a shift in Vodafone's geographic focus, formed part of a new strategy to pursue more integrated operations in key markets, and as we describe below increased Vodafone's financial leverage.

We focus on two possible candidates to test for the presence of a structural break: the announcement of the transaction on 2 September 2013 and the closing of the transaction on 24 February 2014. We test the equity betas for the periods before and after the relevant date for a structural break using the standard "Chow test". We find that the data supports the hypothesis of a structural break at both dates, and that the equity beta after the structural break has been significantly higher than before.

The apparent rise in Vodafone's equity beta since the announcement and closing of the Verizon transaction can relate to two generic factors: an increase in financial leverage and/or a fundamental change in business risk. We examine the change in financial leverage in a subsequent section and conclude that it cannot fully explain the observed increase in Vodafone's equity beta. At least some of the observed increase therefore appears to signal an increase in business risk.

Table 2 reports the results of the Chow test. At 90% confidence, p-values less than 10% support the hypothesis concerning the presence of a structural break. At 95% confidence, p-values less than 5% support the hypothesis of a structural break. At both 90% and 95% confidence, the analysis indicates a different slope (beta) and a different intercept (alpha) after the transaction than before.⁹

⁹ The only exception relates to the beta against the All-World, which indicates a structural break at the 2 September 2013 announcement for the slope coefficient only at 90% confidence and no evidence of a structural break at 95%.

Date of structural break	02-Sep-13				24-Feb-14		
	All World	All Share	All Europe	All World	All Share	All Europe	
All period equity beta	0.91	1.05	0.72	0.91	1.05	0.72	
Pre-break equity beta	0.77	0.88	0.57	0.78	0.92	0.61	
Post-break equity beta	1.07	1.24	0.89	1.23	1.33	0.98	
p-value for structural break F test*	0.12	0.03	0.03	0.01	0.02	0.01	
p-value for slope coefficient	0.07	0.01	0.01	0.02	0.01	0.01	
Structural break (90% level)?	Yes	Yes	Yes	Yes	Yes	Yes	
		Slope &	Slope &	Slope &	Slope &	Slope &	
Type of structural break	Slope	intercept	intercept	intercept	intercept	intercept	

Table 2: Chow test for Vodafone Two Year Equity Beta Regressions¹⁰

* We test whether there is any difference between the coefficients resulting from the regression on pre-break data and the regression on the post-break data.

Figure 4 to Figure 9 plot one and two-year rolling equity betas for the other three parents for the UK MNOs against the FTSE All-Share, FTSE All-World and FTSE All-Europe. Deutsche Telekom's one and two-year equity betas have followed an upward trend since our last update, albeit at a more modest rate than Vodafone. In contrast, both Telefonica and Orange have seen their one and two year equity betas either remain constant or decline, depending on the reference index, since our last update.

Figure 4: Deutsche Telekom rolling equity betas – one-year



¹⁰ Table 2 applies the Chow test to the raw OLS equity betas. At the second decimal place, both GLS and OLS result in the same two-year equity beta estimates for Vodafone.





Figure 7: Orange rolling equity betas – two-year



Figure 8: Telefonica rolling equity betas – one-year



Figure 9: Telefonica rolling equity betas - two year



In Chapter III, we identify which particular data points exert the greatest influence on the one and two-year equity beta estimates and investigate the impact of those particular points on the estimates. We find that the standard OLS betas for Vodafone and the UK MNO parent companies are broadly robust to the exclusion or underweighting of influential data points.

II.A.2. Financial Leverage

Equity risk reflects the combination of underlying business risk (principally to do with the cyclicality of revenues and the extent of fixed costs) and financial risk (to do with the presence of fixed debt obligations). Other things equal, the more debt a company has outstanding, the greater the equity risk and the higher the equity beta. In general, extreme changes in financial leverage throughout the measurement window prompt the need for further analyses and checks.

We obtained data on the amount of debt outstanding for the four mobile network owners between 2000 and the present from company annual reports, half-yearly reports and quarterly earnings announcements. We supplement with data from Bloomberg. We use the available data to estimate the companies' capital structures at various points in time between 2000 and the present. In principle, we would use market values of both debt and equity rather than book values, since market values better indicate earnings power. That being said, we follow the approach adopted in previous reports and assume that the market value of debt of the parent companies remained relatively close to its face value throughout the period in question. This assumption appears reasonable given that the parent companies of the four UK MNOs all maintained investment grade credit ratings throughout the measurement period.¹¹ We use the market value of equity.

We compute financial leverage in the same way as in our previous updates, with reference to the book value of outstanding debt and a working capital screen, rather than "net debt" which equals the book value of debt (and financial leases) less cash.¹² The use of the face value of outstanding debt and a working capital screen finds support in a leading corporate finance textbook.¹³ First we compute working capital (current assets less current liabilities) for each company. If working capital is positive, analysts should zero out short-term debt and estimate financial leverage with reference to long-term debt only. But if working capital is negative, analysts should estimate financial leverage with reference to the sum of long-term plus short-term debt. For example, since current liabilities consistently exceed current assets (including cash) for all four parent companies, we end-up using the face value of both long-term and short-term debt in the leverage computation.¹⁴

¹¹ In previous updates, a possible concern was whether the market price of the mobile network owners' debt diverged somewhat from face value during the height of the credit crisis. We perceive no such significant concerns at present.

If a significant market-to-book difference emerged, then a failure to use market values could bias, probably upward, our estimates of the companies' financial leverage. For example, as credit spreads spiked during the credit crisis, the price on Vodafone's debt may have declined somewhat, reflecting investors' concerns about the prospects for the UK and world economy. Incorporating the reduced market price of the debt in the calculation would reduce the appearance of financial leverage at Vodafone. Overstating leverage could lead us to effectively understate Vodafone's overall asset beta, since we would always expect leverage to add to the equity beta.

We previously checked the potential impact of the financial crisis on financial leverage by estimating the market price of the mobile network owners' debt during 2007-2009. A substantial portion of the mobile network owners' long-term debt is publicly traded. We obtained available data concerning debt prices and yields. The available data relates to debt currently outstanding and indicates that the market price of this debt has remained relatively close to its face-value since 2007. Market prices declined somewhat at the end of 2008 during the height of the crisis. Adjusting the amount of debt by less than 10% either way could have only a small impact (less than 3%) on Vodafone's apparent leverage ratio, and even less on the average leverage over an extended measurement window.

¹² See, for example, Estimate of BT's Equity Beta (March 2014).

¹³ Brealey, Richard A, Myers, Stewart C, and Allen, Franklin, *Principles of Corporate Finance, Ninth Edition,* McGraw Hill (2006), p. 539.

¹⁴ We also include financial leases in the leverage calculation.

Figure 10 plots our resulting estimates of financial leverage for the MNO parent company reference sample. The upward trend in Orange and Telefonica's equity betas since 2011 was correlated with an upward trend in their financial leverage, and the more recent turn in their equity betas is correlated with a slight reduction in financial leverage. Deutsche Telekom's financial leverage has remained broadly flat since our last update.





Vodafone's leverage decreased at the end of 2013¹⁵ and then sees a step increase following the completion of the sale of its Verizon stake on 24 February 2014. Figure 11 illustrates the impact of the Verizon transaction on Vodafone's capitalization. Vodafone exchanged a long-term asset for cash and shares in Verizon, and then distributed to shareholders a large

¹⁵ Vodafone paid down roughly £10 billion of outstanding debt in the last quarter of 2013. It also changed the accounting of its Verizon stake. Previously the Verizon stake had been considered a long-term asset but in the last quarter of 2013 Vodafone changed it to a current asset ("current assets held for sale"). In our last update, the working capital screen picked up the apparent rise in Vodafone's current assets in the last quarter and then excluded short term debt. The exclusion of short-term debt contributed to the downward move in financial leveraged in the last quarter of 2013. In this update, we ignore the change in accounting for the Verizon stake and exclude it from Vodafone's current assets and the working capital screen. The result is that we continue to include short-term debt in our financial leverage calculation in the last quarter of 2013. Vodafone's financial leverage at the end of 2013 appears slightly higher in Figure 10 than in the comparable figure in our last update.

proportion of the cash and Verizon shares. The transaction shrunk Vodafone's asset base, while leaving the existing debt unaffected, prompting a step increase in financial leverage. Vodafone remains relatively less levered than the others even after the Verizon transaction, but its leverage appears to have been edging upwards.

Pre-transaction				Post-transaction				
Financial Ass	ets	Claims		Financial Assets		Claims	Claims	
Verizon	78	Debt	30	Undistributed Sale Proceeds	30	Debt	30	
Other	67	Equity	115	Other	67	Equity	67	
	145		145		97		97	
Financial Lev	erage		0.21				0.31	

Figure 11: The Impact of the Verizon Transaction on Vodafone's Capital Structure, £bn

Sources:

Vodafone press release 19 February 2014; Bloomberg

II.A.3. Up-to-date Asset Beta Estimates

A further table and figures explore the effect of financial leverage on the observed equity betas of the four UK MNO parent companies. We use two separate approaches to re-lever the raw equity beta estimates. The first approach uses the simplest possible re-levering formula and assumes that the debt beta is zero.¹⁶ The second approach is much the same as the first but is more realistic in that it recognises some correlation between the returns to debt-holders and the broader economy. It assumes a debt beta of 0.10. Table 3 reports asset beta estimates under the two approaches. Under both approaches, we estimate average leverage across the relevant measurement window for the equity betas. In other words, when focusing on one-year equity betas, we estimate average leverage across the one-year measurement window. When focusing on two-year equity betas, we estimate average leverage across the two-year measurement window.

¹⁶ We use a standard relevering formula (see *Principles of Corporate Finance* (8th edition), Brealey Myers and Allen, p. 518): $\beta_a = \beta_e \times \left(\frac{E}{D+E}\right) + \beta_d \times \left(\frac{D}{D+E}\right)$, where β_a , β_e , and β_d represent asset beta, equity beta and debt beta respectively, and D and E represent the market values of outstanding debt and equity.

Table 3 confirms that the latest asset beta estimates for Deutsche Telekom, Orange and Telefonica have remained in a relatively narrow band since our last update (data up to January 2014), and that two-year asset betas (assuming a debt beta of 0.1) across the three companies come in around 0.46 to 0.53, depending on the choice of market index. In contrast, Vodafone's two-year asset beta against all three indices now comes in higher than the others, ranging from 0.53 against the FTSE All Europe to as high as 0.76 against the FTSE All-Share. Vodafone's one year asset betas come in even higher at present.

Figure 12 to Figure 15 then plot rolling one and two-year asset betas for the four companies against the FTSE All-Share and against the FTSE All-World. They illustrate a) the relative volatility in the one-year asset betas over the past several years, b) the relative stability in the two-year betas over the past several years, including in the last eight months, and c) the distinct upward movement in Vodafone's one and two-year asset betas during 2013 and 2014.

	1 Yr		2 \	′r			
	в debt = 0 в debt = 0.1		в debt = 0	в debt = 0.1			
Deutsche Telekom							
All World	0.60	0.65	0.47	0.52			
All Share	0.52	0.57	0.44	0.49			
All Europe	0.55	0.60	0.46	0.52			
Orange							
All World	0.54	0.60	0.46	0.52			
All Share	0.41	0.46	0.40	0.46			
All Europe	0.48	0.54	0.46	0.52			
Telefonica							
All World	0.54	0.59	0.47	0.53			
All Share	0.41	0.46	0.42	0.47			
All Europe	0.46	0.51	0.47	0.52			
Vodafone							
All World	0.84	0.87	0.64	0.67			
All Share	0.88	0.91	0.73	0.76			
All Europe	0.65	0.68	0.50	0.53			
MNO Average (excludi	ng Vodafone)						
All World	0.56	0.61	0.47	0.52			
All Share	0.45	0.50	0.42	0.48			
All Europe	0.50	0.55	0.46	0.52			

Table 3: UK MNO asset betas

Asset betas calculated using GLS equity beta.





Figure 13: Two-year asset betas against the FTSE All-Share





Figure 14: One-year asset betas against the FTSE All-World

Figure 15: Two-year asset betas against the FTSE All-World



In the previous section, we identified the presence of a structural break in the Vodafone equity beta regression at 24 February 2014, the closing of the Verizon transaction. Vodafone's

stock returns display a statistically different relationship to the market after the Verizon transaction than they did before, with the post-transaction period indicating a higher equity beta than before. However, the question remains whether the observed change in relationship and attendant increase in equity beta are explained by the underlying change in Vodafone's financial leverage due to the transaction, or whether the change in relationship and increase in equity beta is signaling an increase in underlying business risk.

We compute separate equity beta coefficients pre- and post- the assumed structural break. We focus only on the closing of the transaction on 24 February 2014 because financial leverage only changed upon transaction closing and not before. We compute average financial leverage pre- and post- the structural break. For example, for the two year beta regression, the pre-break period extends from 1 November 2012 to 23 February 2014, and the post-break period from 24 February 2014 to 31 October 2014. For the one year beta regression, the pre-break period extends from 1 November 2013 to 23 February 2014, and the post-break period from 24 February 2014 to 31 October 2014. Table 4 reports the pre- and post-break equity betas and uses the pre- and post-break financial leverage to compute pre- and post-break asset betas.

Date of structural break Pre-structural break leverage	24-Feb-14 27.3%						
Post-structural break leverage	35.2%						
All period leverage	30.0%						
					2 Yr p-value		
				2 Yr p-value	for structural	Structural	
	All period	Pre-break	Post-break	for structural	break	break(90%	Type of structural
	beta	beta	beta	break F test*	coefficient	level)?	break
Equity betas (Table 2)							
All World	0.91	0.78	1.23	0.01	0.02	Yes	Slope & intercept
All Share	1.05	0.92	1.33	0.02	0.01	Yes	Slope & intercept
All Europe	0.72	0.61	0.98	0.01	0.01	Yes	Slope & intercept
Asset betas (unlevered equity bet	as)						
All World	0.67	0.59	0.83	0.05	n/a	No	n/a
All Share	0.76	0.70	0.90	0.06	n/a	No	n/a
All Europe	0.53	0.47	0.67	0.03	n/a	Yes	n/a
Asset betas (regession on unlever	red return)						
All World	0.63	0.56	0.78	0.04	0.08	Yes	Slope & intercept
All Share	0.72	0.66	0.85	0.11	0.09	No	None
All Europe	0.49	0.44	0.63	0.06	0.05	No	None

Table 4: Pre- and Post-Break Asset Betas for Vodafone

* For the equity beta we test whether there is any difference between the coefficients resulting from the regression on prebreak data and the regression on the post-break data. For the asset beta, the test is whether there is a significant difference between the pre-break asset beta calculated using pre-break leverage and the post break asset beta calculated using post break average leverage. For the asset beta resulting from the regression on unlevered returns the test is the same as for the equity beta.

We then apply a standard t-test to determine if Vodafone's pre- and post-break asset betas are statistically different. If the change in Vodafone's equity betas over time were fully attributable to the leverage change due to the transaction, we would expect to see no structural break in the corresponding asset (unlevered) betas. We conclude that Vodafone's asset betas before and after the 24 February 2014 are statistically different in all cases at 90% confidence, (and in two out of six cases at 95% confidence), implying that the step change in financial leverage due to the Verizon transaction can explain only a part of the observed increase in Vodafone's equity beta.¹⁷

In Table 4, we perform a second exercise to provide further confirmation. Instead of regressing equity returns on the market, testing for a structural break in the equity beta regression, and then unlevering the observed equity betas to obtain the underlying asset betas, we first unlever Vodafone's stock returns and then regress the unlevered stock returns against the market returns to obtain a direct estimate of Vodafone's asset beta. We then test for the presence of a structural break in the asset beta regression directly. We also identify the presence of a structural break in the asset beta regression at the closing of the Verizon transaction on 24 February 2014.

What could have prompted a rise in Vodafone's asset betas and business risk? Vodafone changed overall strategy in 2012-3, consistent with the upward movement in the betas. Since then, Vodafone has sold its stake in Verizon for US\$130 billion (£84 bilion)¹⁸, spent over £15 billion on acquisitions including cable companies Kabel and Ono, spent a further £25 billion on network upgrades and expansion, and £7.9 billion on new spectrum. Vodafone intends to invest a further £19 billion in its networks between now and March 2016, and to pursue attractive acquisitions as and when they arise, such as those for Kabel and Ono¹⁹. Vodafone's stated strategy is to invest and make acquisitions aimed at enabling an integrated service offering to consumers, covering mobile, fixed, data and TV.

The impact of the new strategy on business risks is not at all obvious. The sale of the Verizon stake has increased relative exposure to emerging markets, which might be perceived as more risky. However, even after the Verizon sale, Vodafone's overall exposure to emerging markets (35%) remains much lower than Telefonica's (over 50%) and Telefonica's asset beta is currently below Vodafone's, so the emerging market explanation does not appear convincing.

¹⁷ We repeated the same Chow test to the results of our robust regressions, rather than standard OLS. The Chow test indicates the presence of a structural break at the 95% confidence level for robust asset betas calculated against all three indices.

¹⁸ See 2 September 2013 Press Release, "Vodafone to realize US\$130 billion for its 45% interest in Verizon Wireless".

¹⁹ See Vodafone's 2014 Annual Report, page 4 for the value of Kabel, page 7 for the value of ONO and page 13 for the planned investment in Project Spring.

We would have expected a shift towards more wireline activities to have potentially reduced business risks, given the typical view that wireline involves slightly less risks than wireless.²⁰ However, the new strategy appears to involve Vodafone's entry into various wireline and data markets, in which it previously has not been a major player.

The significant extent of Vodafone's acquisition and investment programme over the past few years and its intention to continue investing heavily over the next several years may have increased perceptions of capital leverage. Capital leverage typically is associated with the appearance of higher risks.

II.A.4. Conclusion: MNOs

Vodafone's equity and asset betas appear to have risen following the completion of the sale of its stake in Verizon. However, it remains too early to draw definitive conclusions about the new level of Vodafone's equity and asset betas. We have only eight months of data since the completion of the Verizon sale, which our analysis suggests could represent a structural break. The rise in Vodafone's equity and asset betas does not appear generally reflective of UK MNOs given the relative stability of the two year asset betas for the other UK MNOs. Possible explanations for the apparent rise in Vodafone's business risk relate to Vodafone's particular investment and acquisition strategy, while the evolution of Vodafone's equity and asset betas has been unique among UK MNOs. Two year asset betas for Deutsche Telekom and Orange have also increased although to a much lesser extent than for Vodafone. Asset betas for Telefonica have reduced in recent months, see Figure 13 and Figure 14. Summary asset betas and ranges are given in Table 5.

²⁰ Predominantly wireless companies display slightly higher asset betas than predominantly wireline or diversified companies (see Table 13 and Table 16).

	1 Yi	r	2 Yr						
	Range	Average	Range	Average					
Sample excluding Vodafone									
All World	0.59 to 0.65	0.61	0.52 to 0.53	0.52					
All Share	0.46 to 0.57	0.50	0.46 to 0.49	0.48					
All Europe	0.51 to 0.60	0.55	0.52 to 0.52	0.52					
Sample inclu	ding Vodafor	ne							
All World	0.59 to 0.87	0.68	0.52 to 0.67	0.56					
All Share	0.46 to 0.91	0.60	0.46 to 0.76	0.55					
All Europe	0.51 to 0.68	0.58	0.52 to 0.53	0.52					

Table 5: Summary of Asset Betas for UK MNOs²¹

Note:

All figures above are for asset betas calculated assuming a debt beta of 0.1.

II.B. UK TELECOMS SAMPLE

We also examined the stock performance of five UK telecoms companies: BT, Talk Talk Group, BSkyB, and Colt. None of these UK companies derive a majority of revenues or EBITDA from mobile activities, but they still represent an obvious reference point for a UK MNO. BT derives the majority of its revenues from fixed lines, broadband, and corporate network services. Talk Talk offer quadruple play to retail customers, involving fixed line, broadband, TV services and mobile. Talk Talk obtains over 90% of revenues from broadband and corporate services. Just over 5% of Talk Talk's subscriber base related to mobile. BSkyB competes with Talk Talk, providing triple play (fixed line, broadband and TV services) to customers, but not mobile. Only 14% Sky's subscribers obtain fixed phone lines from Sky²². Colt is somewhat distinct from the other three UK telecoms companies, providing telecom and data services to businesses based in many large European cities. Colt's primary operations are in the City of London.

We again estimated equity and asset betas for each of the five UK telecom companies in Table 6 and Table 7 respectively.²³ Comparing asset betas in Table 3 with those in Table 7

²¹ Results for Vodafone are for the regression over the whole time period (pre- and post-structural break)

²² Segment data from Bloomberg.

²³ Like for the UK MNOs, we measured one-and two-year equity betas for the UK telecom peer group against the FTSE All-Share, FTSE All-World and FTSE All-Europe indices. We computed daily returns for each company and the indices and applied standard ordinary least squares without adjustment. We then re-levered the observed OLS betas based on each company's average Continued on next page

indicates that the average two year asset beta estimate (assuming debt beta of 0.1) for the UK MNO parent companies excluding Vodafone (0.48 to 0.52 depending on index) comes in below that for the UK telecom peer group (0.59 to 0.68 depending on index), with the majority of the UK telecom sample reporting two-year asset betas above 0.5^{24} .

	1 Yr				2 Yr			
-	Beta	SE	Low	High	Beta	SE	Low	High
BT								
All World	0.66	0.10	0.46	0.86	0.87	0.09	0.70	1.03
All Share	0.83	0.08	0.67	0.99	1.02	0.07	0.88	1.17
Talk Talk								
All World	0.80	0.15	0.50	1.10	0.69	0.11	0.46	0.92
All Share	0.82	0.12	0.59	1.05	0.84	0.09	0.66	1.02
B Sky B								
All World	0.51	0.11	0.30	0.73	0.44	0.07	0.31	0.57
All Share	0.63	0.09	0.45	0.82	0.56	0.06	0.44	0.68
Colt Group								
All World	0.96	0.19	0.58	1.34	0.74	0.12	0.50	0.97
All Share	0.85	0.18	0.49	1.20	0.75	0.11	0.52	0.97
UK Telecoms Average								
All World	0.73				0.68			
All Share	0.78				0.79			

Table 6: UK telecoms equity betas

Note:

We report OLS betas except where diagnostic tests indicate the presence of either heteroskedascity or auto-correlation, in which case we report GLS betas. We identified auto-correlation or heteroskedasticity for all companies except for the two year estimate for BT, against the FTSE All-World in both instances.

Continued from previous page

financial leverage across the one or two-year measurement window. We computed financial leverage based on the market value of equity and the book value of outstanding debt.

²⁴ The average asset beta for the MNO parent companies including Vodafone (0.52 to 0.56 depending on the index) is also below the average asset beta for UK Telecoms.

	1 Yr		2 Yr	
	в debt = 0 в de	ebt = 0.1	в debt = 0 в de	ebt = 0.1
BT				
All World	0.50	0.53	0.62	0.65
All Share	0.63	0.65	0.74	0.76
Talk Talk				
All World	0.68	0.69	0.58	0.60
All Share	0.70	0.71	0.71	0.73
B Sky B				
All World	0.43	0.45	0.36	0.38
All Share	0.53	0.55	0.46	0.48
Colt Group				
All World	0.96	0.96	0.74	0.74
All Share	0.85	0.85	0.75	0.75
UK Telecoms Average				
All World	0.64	0.66	0.58	0.59
All Share	0.68	0.69	0.67	0.68

Table 7: UK telecoms asset betas

Averages may vary due to rounding.

Figure 16 and Figure 17 plot rolling one and two-year asset betas for the UK telecom reference sample. They illustrate the relative instability and cross-company variation of the asset betas for the period after pre-credit crisis data has dropped out of the data window. Asset betas for BT and Colt remain above Talk Talk and BSkyB, although the asset beta for Talk Talk has recently been rising towards those for BT and Colt. Vodafone's post-Verizon transaction asset beta is currently at the levels seen for BT and Colt.



Figure 16: One-year asset betas for UK telecoms reference sample – Vs FTSE All-World





	1 Yr		2 Yr	
	Range	Average	Range	Average
All World All Share	0.45 to 0.96 0.42 to 0.85	0.66 0.69	0.38 to 0.74 0.42 to 0.76	0.59 0.68

Table 8: Summary of Asset Betas for UK Telecoms Reference Sample

Note:

All figures above are for asset betas calculated assuming a debt beta of 0.1.

II.C. US TELECOMS SAMPLE

As in previous updates, we also examined data for eleven US telecoms companies. Three of the companies were pure-play wireline (CenturyLink, Frontier, and Windstream), meaning that the core business of these companies involved local loop access and the provision of associated telephone services such as local telephone calls and retail broadband. Wireline activities accounted for just about half the revenues of AT&T, with wireless accounting for the remaining revenues. The majority of revenues come from wireless activities for seven further companies (Verizon, Sprint, Leap, Clearwire, Metro PCS – now T-Mobile - TDS and US Cellular). Data for the US telecoms companies is relevant for our purpose to the extent that it reflects businesses whose principal activity is the provision of wireless services.

Several of our US sample have been acquired in the last year and a half. Sprint was acquired by Softbank in July 2013, but minority shares continue to trade. At the same time as the Softbank acquisition, Sprint acquired the remaining 50% of the shares in Clearwire that it did not already own. AT&T acquired Leap Wireless also in July 2013. T-Mobile purchased MetroPCS in May 2013, merging its existing operations with MetroPCS's. We include T-Mobile in our analysis, reflecting the new merged entity and MetroPCS prior to the merger.

We continue to include TDS and US Cellular separately in the sample, even though TDS is the majority owner of US Cellular, and US Cellular continues to contribute the majority of TDS's earnings. Therefore, even though we begin by considering eleven US telecoms companies, we can compute an up-to-date beta for only eight of the companies (CenturyLink, Frontier, Windstream, AT&T, Verizon, Sprint, T-Mobile and US Cellular).

Table 9 and Table 10 report equity and asset betas for the US Telecom sample. Figure 18 to Figure 19 then plot the development of the US Telecom asset betas over time. The asset beta estimates for the pure-play fixed line companies – CenturyLink, Frontier and

Windstream – continue to come in slightly lower than those of the other companies where wireless activities account for at least 50% of earnings.

The up-to-date one year and two year asset betas for the US companies with significant wireless earnings excluding Leap Wireless, Clearwire and TDS range in a relatively narrow band between 0.4 and 0.7, apart from the two-year asset beta for Sprint which exceeds 0.7.

Two year asset betas (assuming debt beta of 0.1) of the US companies with significant wireless earnings average between 0.58 and 0.61 depending on the market index, and thus are slightly higher than the asset beta estimates for the UK MNO parent companies excluding Vodafone (average of 0.48-0.52 depending on the market index). We exclude Leap and Clearwire from the averages since they were acquired during 2013. We also exclude TDS to avoid double counting.

		1 Yr				2 Yr		
	Beta	SE	Low	High	Beta	SE	Low	High
US Wireline								
Century Link								
SPX	0.69	0.10	0.59	1.00	0.72	0.09	0.50	0.83
All World	0.95	0.13	0.55	1.06	0.84	0.12	0.44	0.81
Frontier								
SPX	0.63	0.17	0.54	1.11	0.79	0.11	0.52	0.96
All World	0.81	0.22	0.48	1.14	0.86	0.13	0.42	0.91
Windstream								
SPX	0.61	0.13	0.59	1.02	0.76	0.09	0.62	0.94
All World	0.80	0.17	0.54	1.05	0.89	0.11	0.61	0.95
Average of US W	'ireline							
SPX	0.64				0.76			
All World	0.85				0.86			
US Wireless								
AT&T								
SPX	0.59	0.09	0.57	0.81	0.70	0.06	0.57	0.75
All World	0.69	0.11	0.51	0.80	0.73	0.07	0.46	0.69
Clearwire								
SPX	0.81	0.46	-0.09	1.70	0.82	0.32	0.19	1.45
All World	1.14	0.46	0.24	2.04	0.91	0.33	0.26	1.56
Leap Wireless								
SPX	1.10	0.28	0.55	1.65	1.86	0.29	1.28	2.44
All World	1.44	0.34	0.76	2.12	1.91	0.33	1.27	2.55
Sprint								
SPX	0.90	0.23	0.91	1.50	1.43	0.16	1.13	1.74
All World	1.27	0.35	0.92	1.57	1.43	0.16	1.10	1.75
TDS								
SPX	0.74	0.15	0.65	1.17	0.99	0.17	0.77	1.38
All World	0.91	0.22	0.81	1.34	1.13	0.17	0.79	1.32
T-Mobile								
SPX	1.04	0.21	0.58	1.27	1.03	0.15	0.83	1.46
All World	1.21	0.30	0.30	1.37	1.03	0.19	0.89	1.57
US Cellular								
SPX	0.54	0.19	0.37	0.87	0.73	0.14	0.47	0.97
All World	0.70	0.24	0.40	0.98	0.83	0.16	0.48	0.94
Verizon								
SPX	0.62	0.07	0.47	0.81	0.69	0.06	0.50	0.71
All World	0.71	0.10	0.47	0.82	0.76	0.07	0.43	0.65
Average of US W	'ireless (excl	Clearwire	, TDS and	Leap)				
SPX	0.74				0.92			
All World	0.91				0.96			

Table 9: US telecoms equity betas

Note:

* Clearwire was acquired by Sprint and Leap Wireless was acquired by AT&T. The betas shown are as of the date when the puchases wwere announced: 17 December 2012 for Clearwire and 12 July 2013 for Leap.

We report OLS betas except where diagnostic tests indicate the presence of either heteroskedascity or auto-correlation, in which case we report GLS betas. We identified autocorrelation or heteroskedasacity for the one and two year equity betas of AT&T, Leap Wireless, Sprint, T-Mobile, and Verizon against the FTSE All-World and the SPX. We also identified autocorrelation or heteroskedasacity for the two year equity betas of Clearwire and US Cellular against the FTSE All-World and the SPX as well as for the one year equity betas of Century Link against both indices and for the one year equity beta of TDS against the FTSE all World.

	1 Yr		2	Yr
	в debt = 0 в d	ebt = 0.1	в debt = 0	в debt = 0.1
US Wireline				
Century Link				
SPX	0.34	0.39	0.36	0.41
All World	0.46	0.52	0.42	0.47
Frontier				
SPX	0.26	0.32	0.30	0.36
All World	0.33	0.39	0.32	0.38
Windstream				
SPX	0.24	0.30	0.28	0.35
All World	0.31	0.37	0.33	0.40
Average of US W	/ireline			
SPX	0.28	0.33	0.31	0.37
All World	0.37	0.43	0.36	0.42
US Wireless				
AT&T				
SPX	0.41	0.44	0.49	0.52
All World	0.48	0.51	0.52	0.55
Clearwire*				
SPX	0.28	0.35	0.33	0.39
All World	0.40	0.46	0.37	0.43
Leap Wireless*				
SPX	0.14	0.23	0.27	0.36
All World	0.18	0.27	0.28	0.36
Sprint				
SPX	0.44	0.49	0.67	0.72
All World	0.62	0.67	0.66	0.72
TDS				
SPX	0.46	0.50	0.61	0.65
All World	0.56	0.60	0.69	0.73
T-Mobile				
SPX	0.54	0.59	0.52	0.57
All World	0.63	0.67	0.52	0.57
US Cellular				
SPX	0.43	0.45	0.58	0.60
All World	0.55	0.57	0.66	0.68
Verizon				
SPX	0.40	0.43	0.47	0.50
All World	0.46	0.49	0.51	0.54
Average of US W	/ireless (excl Cle	arwire, Lea	ap and TDS)	
SPX	0.44	0.48	0.54	0.58
All World	0.55	0.58	0.57	0.61

Table 10: US telecoms asset betas²⁵

* Clearwire was acquired by Sprint and Leap Wireless was acquired by AT&T. The betas shown are for the dates when the puchases wwere announced: 17 December 2012 for Clearwire and 12 July 2013 for Leap.

²⁵ We exclude TDS from the average as TDS is the majority owner of and derives most of its earnings from US Cellular.



Figure 18: One-year asset betas for US telecom reference sample – Vs FTSE All-World





	1 Yr		2 Yr	
	Range	Average	Range	Average
US Wireline				
SPX	0.30 to 0.39	0.33	0.35 to 0.41	0.37
All World	0.37 to 0.52	0.43	0.38 to 0.47	0.42
US Wireless (excl Cl	earwire, Leap a	nd TDS)		
SPX	0.43 to 0.59	0.48	0.50 to 0.72	0.58
All World	0.49 to 0.67	0.58	0.54 to 0.72	0.61

Table 11: Summary of Asset Beta Range for US Telecoms Sample

Note:

All figures above are for asset betas calculated assuming a debt beta of 0.1.

II.D. EU TELECOMS SAMPLE

We also examined data for eight EU telecoms companies, in addition to the parent companies of the UK MNOs. Like for the US sample, the EU companies are engaged in both wireline and wireless activities. Four of the companies are incumbent network operators with diversified operations across wireless and wireline: Belgacom (about 16% of revenues from mobile communications in 2013) KPN (about 75% of revenues from wireless in 2013), Telenor (about 78% of revenues from wireless in 2013) and Telecom Italia (about 24% of revenues from mobile in 2013). Two further companies derive more than two thirds of revenues from mobile services: Mobistar which offers mobile network services in Belgium (about 87% of revenues from mobile in 2013), and Tele2 which offers mobile services in Sweden and a range of other European countries (more than 70% of revenues from mobile in 2013) ²⁶. The penultimate company in our EU sample is Drillisch, a re-seller of mobile network services in Germany. The final company in our sample, Sonaecom, owned Optimus one of the mobile network operators in Portugal. In August 2013 Optimus merged with ZON Multimedia. Sonaecom now owns 27% of the merged entity which obtains roughly half of its revenues from mobile activities. Sonaecom's shareholding interest in the merged entity accounted for under half of its EBITDA in the nine months to September 2014, implying that mobile activities now accounts for under a quarter of Sonaecom's earnings

We segregate our EU sample into two sub samples: "EU wireless" comprising firms that derive more than two thirds of their revenues from mobile (KPN, Mobistar, Telenor and Tele2), "EU diversified" comprising firms offering a spread of services including mobile

²⁶ Segment data from Bloomberg.

(Belgacom, Telecom Italia and Sonaecom). We consider Drillisch in a category by itself, reflecting the distinction between its business model and those of the other firms.

Table 12 and Table 13 report equity and asset betas respectively. Figure 20 and Figure 21 plot the development of the asset betas over time.

Two-year asset beta estimates (assuming debt beta of 0.1) for the three diversified companies range from 0.42 to 0.51, with an average of 0.45 to 0.46 excluding Sonaecom depending on market index. Sonaecom's asset beta is somewhat higher than the other two diversified firms and has increased sharply over the past few months. The increase relative to our previous report appears attributable to a relatively small number of outliers. Sonaecom's asset beta drops back to previous levels with the exclusion of these outliers.²⁷

Two-year asset beta estimates (assuming debt beta of 0.1) for the four firms deriving more than two thirds of revenues from mobile range from 0.42 to 0.66 and average around 0.55 - 0.56 depending on the index, showing a slight increase compared to our last update. Two-year asset beta estimates for KPN continue to come in below average, while Telenor continues to report two-year asset betas above 0.5.

Both the one and two-year asset beta estimates for Drillisch remain significantly higher than for any of the other EU telecoms companies. In fact, Drillisch's one-year asset beta has continued to rise sharply over the last six months and now stands just above 1.5. Its two-year beta now exceeds 1.0, and is higher than at any time over the past seven years. As a re-seller of mobile network services ("MVNO"), Drillisch's business model remains somewhat distinct from any of the other companies and associated with higher business risks than traditional network operators.²⁸ Nevertheless, it is unclear why Drillisch has witnessed a substantial rise in asset betas over the last year and a half. Other than Vodafone, Drillisch is the only company in any of our samples to see a steep rise in its asset beta since our last update.

²⁷ Sonaecom's one year asset beta after removing outliers is 0.70 against the FTSE All World and 0.58 against the FTSE All Europe, while the two year asset beta after taking out outliers is 0.44 against the FTSE All World and 0.52 against the FTSE All Europe.

²⁸ Traditional mobile network operators invested significant sums in the past. Network revenues now reflect compensation for both operating expenses and a return of and on historical capital investment. In contrast, Drillisch purchases network services from the traditional network operators, and must compensate the network operators for their past investment as well as operating costs. It then captures a retail margin, which we would expect to reflect the costs of retailing network services. The implication is that Drillisch is likely to report higher operating leverage (operating costs as a % of revenues) than the network operators. In turn, higher operating leverage is often associated with higher risk and asset betas.

		1 Yr				2 Yr		
-	Beta	SE	Low	High	Beta	SE	Low	High
EU Diversified								
Belgacom								
All World	0.78	0.11	0.56	0.99	0.63	0.08	0.47	0.79
All Europe	0.62	0.08	0.45	0.78	0.59	0.06	0.47	0.70
Sonaecom								
All World	1.09	0.26	0.58	1.59	0.86	0.15	0.57	1.16
All Europe	0.86	0.20	0.46	1.26	0.83	0.13	0.59	1.08
Telecom Italia								
All World	1.48	0.19	1.11	1.85	1.29	0.15	1.00	1.57
All Europe	1.41	0.14	1.14	1.68	1.29	0.12	1.06	1.52
Average of EU Diversifi	ed (excludin	g Sonaeco	om)					
All World	1.13				0.96			
All Europe	1.01				0.94			
EU Wireless								
KPN								
All World	1.06	0.14	0.79	1.33	1.01	0.15	0.71	1.31
All Europe	0.89	0.10	0.69	1.10	0.89	0.11	0.67	1.11
Mobistar								
All World	0.72	0.14	0.44	1.00	0.67	0.10	0.47	0.88
All Europe	0.60	0.11	0.39	0.82	0.69	0.08	0.53	0.86
Telenor								
All World	0.93	0.14	0.66	1.21	0.78	0.08	0.61	0.94
All Europe	0.91	0.09	0.74	1.09	0.82	0.06	0.69	0.94
Tele2								
All World	0.84	0.12	0.60	1.07	0.80	0.10	0.61	0.99
All Europe	0.77	0.09	0.60	0.95	0.76	0.08	0.61	0.91
Average of EU Wireless	;							
All World	0.89				0.82			
All Europe	0.80				0.79			
EU Other								
Drillisch								
All World	1.67	0.16	1.35	2.00	1.32	0.11	1.11	1.52
All Europe	1.44	0.12	1.21	1.67	1.25	0.08	1.09	1.41

Table 12: EU telecoms equity betas

Note:

Diagnostic tests indicate the presence of either heteroskedascity or auto-correlation (or both) for the beta estimates of all companies against the two indices except for Telenor and Tele2 against both the FTSE All World and the FTSE All Europe. We report GLS betas when auto-correlation or heteroskedasticity are present and OLS betas in their abscence.

	1 Yr		2 Yr		
	в debt = 0 в d	ebt = 0.1	в debt = 0 в d	ebt = 0.1	
EU Diversified					
Belgacom					
All World	0.60	0.62	0.48	0.51	
All Europe	0.47	0.50	0.45	0.47	
Sonaecom					
All World	1.05	1.06	0.68	0.70	
All Europe	0.84	0.84	0.66	0.68	
Telecom Italia					
All World	0.46	0.53	0.35	0.42	
All Europe	0.44	0.50	0.35	0.42	
Average of EU Diversif	ied (excluding So	onaecom)			
All World	0.53	0.57	0.42	0.46	
All Europe	0.45	0.50	0.40	0.45	
EU Wireless					
KPN					
All World	0.51	0.56	0.40	0.46	
All Europe	0.42	0.48	0.36	0.42	
Mobistar					
All World	0.44	0.48	0.44	0.47	
All Europe	0.36	0.40	0.45	0.48	
Telenor					
All World	0.72	0.75	0.61	0.63	
All Europe	0.71	0.73	0.64	0.66	
Tele2					
All World	0.69	0.71	0.64	0.66	
All Europe	0.64	0.66	0.61	0.63	
Average of EU Wireles	s				
All World	0.59	0.62	0.52	0.56	
All Europe	0.53	0.57	0.51	0.55	
EU Other					
Drillisch					
All World	1.59	1.59	1.14	1.15	
All Europe	1.37	1.37	1.08	1.10	

Table 13: EU telecoms asset betas





Figure 21: Two-year asset betas for EU telecoms reference sample – Vs FTSE All-World



	1 Yr		2 Yr	
	Range	Average	Range	Average
EU Diversified (excl				
All World	0.53 to 0.62	0.57	0.42 to 0.51	0.46
All Europe	0.50 to 0.50	0.50	0.42 to 0.47	0.45
EU Wireless				
All World	0.48 to 0.75	0.62	0.46 to 0.66	0.56
All Europe	0.40 to 0.73	0.57	0.42 to 0.66	0.55

Table 14: Summary of Asset Beta for EU Telecoms Sample

Note:

All figures above are for asset betas calculated assuming a debt beta of 0.1.

II.E. CONCLUSIONS

The best current estimates for the two-year equity betas of the parent companies of the UK MNOs are:

- 0.97 for Deutsche Telekom. We normally recommend a range of +/approximately two standard deviations around these mid-point figures—i.e., a range of 0.83-1.12 in this case. Given average leverage of 52% over the past two years and assuming a debt beta of 0.1, these figures translate into a range for the asset beta of between 0.45 and 0.59.
- 1.17 for Orange, and 95% confidence interval of 0.99-1.35. Given average leverage of 60% over the past two years and assuming a debt beta of 0.1, these figures translate into a range for the asset beta of between 0.45 and 0.59.
- 1.04 for Telefonica, and 95% confidence interval of 0.90-1.18. Given average leverage of 54% over the past two years and assuming a debt beta of 0.1, these figures translate into a range for the asset beta of between 0.47 and 0.59.
- Significant uncertainty surrounds the current asset beta for Vodafone. We identify a structural break in the equity beta regression around the completion of Vodafone's sale of its Verizon stake. The equity beta for the eight months since the completion of the Verizon sale is as high as 1.33, with a 95% confidence interval of 1.07-1.58. Given average leverage of 35% over the past eight months and assuming a debt beta of 0.1, these figures translate into a range for the asset beta of between 0.73 and 1.06. The Vodafone equity beta in the most recent two

year period before the break²⁹ stood at 0.78 against the FTSE All Share with a 95% confidence interval of 0.66 to 0.89. Using the average leverage during that two year period of 27.6%, the range for Vodafone's corresponding pre-break asset beta was 0.51 to 0.67.

We report two-year betas against the FTSE All-World for Deutsche Telekom, Orange and Telefonica because i) none of the companies represents a significant % of the All-World index by market capitalization, ii) all three companies pull substantial investment from all corners of the globe, iii) all three companies have significant operations spread across the globe, and iv) the betas against the FTSE All-World for all three companies are higher than against either the FTSE All-Share or FTSE All-Europe. For Vodafone, we report the beta against the FTSE All-Share for the last eight months since the completion of the Verizon transaction. The comparable figures for the FTSE All-World and FTSE All-Europe are lower.

Other than Vodafone, the two-year asset beta estimates for the UK MNO's against the FTSE All-World are almost identical at 0.52 and 0.53 (assuming a debt beta of 0.1)³⁰. Since the sale of its Verizon stake, Vodafone's asset beta estimates against the FTSE All-World exceed 0.7 and are significantly higher than the other parent companies of the UK MNOs. Only eight months have passed since the sale of Vodafone's Verizon stake, and we do not yet have sufficient data to determine if the Vodafone beta will remain consistently higher than the other parent companies, or if the result represents noise associated with the major changes in Vodafone's asset composition and capital structure. 11 of 13 companies, where wireless accounts for more than half of revenues, display two-year asset betas against the FTSE All-World above 0.5.³¹ 11 of the 13 companies display two-year asset betas below 0.7.³²

Table 15 and Table 16 compare asset beta ranges and averages for each of our samples. Table 15 reports asset betas against the FTSE All-World with the debt beta equal to 0.1, Table

²⁹ Calculated from 24 February 2012 to 24 February 2014 against the FTSE All-Share, representing the most recent two year period before the closing date for the Verizon transaction.

³⁰ The UK MNOs average beta estimate against the FTSE All-Share is very close to the average observed against the FTSE All-World for the two-year betas.

³¹ Deutsche Telekom, Orange, Telefonica, Vodafone, AT&T, Sprint, T-Mobile, US Cellular, Verizon, Telenor and Tele2 get more than half of their revenues from wireless and have asset betas higher than 0.5. The other companies with more than half of mobile revenues are KPN and Mobistar. Asset betas for these two companies ranged between 0.46 and 0.47.

³² Deutsche Telekom, Orange, Telefonica, AT&T, T-Mobile, US Cellular, Verizon, KPN, Mobistar, Telenor and Tele2 get around half or more of their revenue from wireless and have asset betas below 0.7. The other companies with more than half of mobile revenues are Vodafone and Sprint. The asset beta for Sprint was 0.72. Vodafone's asset beta over the eight months since the completion of the Verizon transaction was 0.90.

16 reports the comparable asset betas ranges for betas computed against home indices (FTSE All-Share for UK companies, FTSE All-Europe for European companies and S&P 500 for US companies). The average two-year asset betas against the FTSE All-World for the parent companies of the UK MNOs (excluding Vodafone) stand around 0.52-0.53, higher than the average two-year asset betas for the US fixed line telecom companies (0.42), but broadly comparable to UK telecom companies (0.59), and US and Europe telecom companies with a significant mobile focus (0.61 and 0.56 respectively). The recent rise in Vodafone's beta leaves it out of line with other wireless companies.³³

	1 Yr		2 Yr	
	Range	Average	Range	Average
UK MNO	0.59 to 0.65	0.61	0.52 to 0.53	0.52
UK Telecoms	0.45 to 0.96	0.66	0.38 to 0.74	0.59
US Wireline	0.37 to 0.52	0.43	0.38 to 0.47	0.42
US Wireless	0.49 to 0.67	0.58	0.54 to 0.72	0.61
EU Diversified	0.53 to 0.62	0.57	0.42 to 0.51	0.46
EU Wireless	0.48 to 0.75	0.62	0.46 to 0.66	0.56

Table 15: Summary of Asset Beta Ranges against the FTSE All World

Note:

All figures above are for asset betas calculated against FTSE All World and assuming a debt beta of 0.1.

UK MNO excludes Vodafone.

US Wireless excludes Clearwire, Leap and TDS and EU Diversified excludes Sonaecom.

³³ We could have made similar observations in respect of the asset betas computed against home indices.

		1 Yr		2 Yr	
_		Range	Average	Range	Average
-	UK MNO	0.51 to 0.60	0.55	0.52 to 0.52	0.52
	UK Telecoms	0.42 to 0.85	0.69	0.42 to 0.76	0.68
	US Wireline	0.30 to 0.39	0.33	0.35 to 0.41	0.37
	US Wireless	0.43 to 0.59	0.48	0.50 to 0.72	0.58
	EU Diversified	0.50 to 0.50	0.50	0.42 to 0.47	0.45
	EU Wireless	0.40 to 0.73	0.57	0.42 to 0.66	0.55

Table 16: Summary of Asset Beta Ranges against the home index

Note:

All figures above are for asset betas calculated assuming a debt beta of 0.1.

UK MNO excludes Vodafone.

US Wireless excludes Clearwire, Leap and TDS and EU Diversified excludes Sonaecom.

The asset betas for the UK MNO excluding Vodafone as well as for the EU Diversified and EU Wireless are calculated against the FTSE All Europe, The asset betas for the UK Telecoms are against the FTSE All Share and the betas for the US Wireless and Wireline peer groups are calculated against the SPX.

Based on this evidence, we recommend an asset beta range of 0.4 to 0.7 for an efficient UK MNO.³⁴ Our recommended range is consistent with the asset betas of the parent companies of the UK MNOs themselves. The recommended range reflects the statistical uncertainty inherent in our two-year asset beta estimates (see discussion above). Our recommended asset beta range also is consistent with both US and European telecom companies displaying a significant mobile focus. However, the range does not include estimates of Vodafone's asset beta since the completion of the Verizon transaction and the implementation of its new strategy. It remains too early to draw definitive conclusions about whether Vodafone's asset beta will remain at the currently elevated level and if so whether the rise reflects UK mobile or non-UK related risks associated with Vodafone's ongoing business and strategy.

³⁴ Our June 2014 report suggested a range of 0.4 to 0.6. We have increased the top end of the range by 0.1 because two year asset betas against the All World for as many as five out of 13 firms who obtain more than half of revenue from wireless now exceed 0.6. Two year asset betas against the home index for four out of 13 firms also exceeded 0.6. In contrast, only two out of 13 firms who obtain more than half revenues from wireless now see two year asset betas against the All World and the home indices above 0.7, and one of these, Vodafone, currently is based on only a relatively limited period of stock trading, given the significant corporate changes ushered in by the Verizon transaction.

III. Statistical Reliability

The use of daily returns data in regressions to estimate equity beta can risk introducing statistical problems, for example in relation to thin trading. We discussed these problems in earlier papers for Ofcom.³⁵ We perform a number of standard statistical tests to check for potential problems in this case. Below we report the results of our statistical tests for the parent companies of the UK MNOs.³⁶ We performed exactly the same tests for the betas computed above for the companies in the four reference samples. We confirm the statistical robustness of all of the betas presented in Chapter II of this report.

III.A. VASICEK ADJUSTMENT

In its consultation response, EE urges Ofcom to consider making a Vasicek adjustment to the raw OLS betas, even though the Competition Commission rejected the need for a Vasicek adjustment in the case of NIE.³⁷ The CC allowed that a Vasicek adjustment might be relevant if it was estimating the beta for a single quoted firm. However, the CC saw no need for an adjustment in the case of NIE because it was "estimating a beta for a portfolio of utility companies to apply to an unquoted utility company (NIE) and therefore we see no role for a Bayesian or Vasicek adjustment".³⁸

Our analysis of numerous quoted telecom firms in the UK, Europe and US resembles the CC's exercise in NIE. We therefore see no reason to adopt a Vasicek adjustment in this particular case. We nevertheless perform a Vasicek adjustment for the four parent companies of the UK MNOs, and confirm that the adjustment would not materially affect our conclusions.

The Vasicek adjustment attempts to correct OLS betas for possible over or under estimation with reference to a prior expectation. The extent of the correction depends on the prior expectation, the variance of the distribution of true betas and the standard error attached to the OLS beta measurement in question. EE suggest that the prior expectation

³⁵ See *Issues in beta estimation for UK mobile operators*, July 2002.

³⁶ For Vodafone, we computed betas by inserting a slope and intercept dummy variables to reflect the period after 24 February 2014 and the sale of its Verizon stake.

³⁷ EE, Mobile call termination market review 2015-18: EE response to Ofcom's consultation, (13 August 2014), pp. 56-57.

³⁸ CC, Northern Ireland Electricity Final Determination, (26 March 2014), ¶13.177.

would be one, reflecting the average equity beta for quoted firms on the market.³⁹ Others have argued that the prior expectation should be industry specific, and reflect the average OLS beta for a sample of companies drawn from the same industry.⁴⁰

Table 17 performs a Vasicek adjustment for the four parent companies of the UK MNOs, and adopts a prior expectation of one. The inclusion of a Vasicek adjustment does not materially change the equity beta estimates, from those reported earlier in this report. The use of an industry specific prior expectation is likely to reduce the impact of the Vasicek adjustment still further.⁴¹

³⁹ "The Vasicek adjustment shifts the beta estimate towards a prior expectation (typically a beta of one)". EE, Mobile call termination market review 2015-18: EE response to Ofcom's consultation, (13 August 2014), p. 57.

⁴⁰ Lally, M, "An Examination of Blume and Vasicek Betas", The Financial Review, (1998), vol. 33, pp. 183-198.

⁴¹ *Ibid.*, pp. 190-194. Lally simulates the impact of using a prior expectation of one and an industry average beta for high and low beta stocks, and shows that the use of an industry prior would tend to result in more modest adjustments for high and low beta stocks than a prior expectation of one.

		1 Yr			2 Yr	
	Vasicek					Vasicek
			adjusted			adjusted
	Beta	SE	beta	Beta	SE	beta
Deutsche Telekom						
All World	1.18	0.10	1.17	0.97	0.07	0.97
All Share	1.02	0.08	1.02	0.92	0.06	0.93
All Europe	1.08	0.06	1.08	0.97	0.05	0.97
Orange						
All World	1.26	0.13	1.24	1.17	0.09	1.16
All Share	0.94	0.10	0.94	1.02	0.08	1.02
All Europe	1.12	0.09	1.12	1.15	0.07	1.15
Telefonica						
All World	1.11	0.09	1.11	1.04	0.07	1.04
All Share	0.85	0.07	0.85	0.91	0.06	0.92
All Europe	0.94	0.07	0.94	1.02	0.05	1.02
Vodafone						
All World	1.22	0.13	1.20	0.91	0.08	0.91
All Share	1.27	0.10	1.26	1.05	0.07	1.05
All Europe	0.94	0.09	0.94	0.72	0.06	0.73

Table 17: UK MNO Equity Betas - Vasicek Adjustment⁴²

Note:

The Vasicek adjusted betas are adjusted to a prior estimate of 1. The prior estimate of standard deviation is assumed to be the market standard deviation. This is 0.48 for the one year betas against FTSE All Share and 0.32 for the two years betas against the FTSE All Share. We assume the standard deviation for the FTSE All World and FTSE All Europe is the same as for the FTSE All Share.

III.B. DIMSON ADJUSTMENT

To test for possible bias relating to trading illiquidity and to assess if time differences⁴³ caused distortions, we perform the "Dimson" adjustment to the estimated betas by including a one period lag and a one period lead. For the four UK MNOs, one out of 24 lead terms was significantly different from zero (one-year equity betas for Vodafone against the FTSE All-Europe). No lag term was statistically significant. In no case were the Dimson adjustments overall significantly different from zero. A similar picture emerges for the US Telecom

⁴² Vodafone's beta is calculated for the whole period (without separating into pre- and post-break)

⁴³ The London Stock Exchange closes at 5pm BST, while the markets in other countries may close earlier or later. Broad index data may therefore combine closing prices relating to different times of day. Timing adjustments therefore may be relevant for betas versus the FTSE All-World.

sample, where two of the Dimson adjustments are significant (the one-year lag term for AT&T against the S&P 500 and the one-year lag term for Sprint against the S&P 500). The EU telecoms sample has only two out of 32 lead adjustments significant (for Sonaecom the one-year beta against the FTSE All-Europe and the one-year beta against the FTSE All-Europe for Telenor) and one out of 32 lag adjustments significant (the two-year beta against the FTSE All-Europe for All-Europe for Telenor).

			1 Yr				2 Yr	
		Dimson	Dimson		-	Dimson	Dimson	
	OLS Beta	Beta	SE	Significance	OLS Beta	Beta	SE	Significance
Deutsche Telekom								
All World	1.18	1.22	0.13	Neither lag nor lead	0.97	1.00	0.09	Neither lag nor lead
All Share	1.02	1.06	0.10	Neither lag nor lead	0.92	0.93	0.07	Neither lag nor lead
All Europe	1.08	1.19	0.08	Neither lag nor lead	0.97	0.96	0.06	Neither lag nor lead
Orange								
All World	1.24	1.17	0.17	Neither lag nor lead	1.16	1.17	0.12	Neither lag nor lead
All Share	0.93	1.15	0.13	Neither lag nor lead	1.01	0.98	0.09	Neither lag nor lead
All Europe	1.11	1.19	0.11	Neither lag nor lead	1.15	1.17	0.09	Neither lag nor lead
Telefonica								
All World	1.11	1.04	0.10	Neither lag nor lead	1.03	0.97	0.08	Neither lag nor lead
All Share	0.85	0.87	0.08	Neither lag nor lead	0.91	0.88	0.07	Neither lag nor lead
All Europe	0.94	0.96	0.07	Neither lag nor lead	1.02	1.07	0.06	Neither lag nor lead
Vodafone								
All World	1.22	1.12	0.13	Neither lag nor lead	0.91	0.91	0.09	Neither lag nor lead
All Share	1.27	1.20	0.11	Neither lag nor lead	1.05	1.00	0.08	Neither lag nor lead
All Europe	0.93	0.90	0.10	Only lead	0.72	0.64	0.07	Neither lag nor lead

Table 18: UK MNOs, Dimson adjustments – up-to-date data

III.C. TESTS FOR HETEROSCEDASTICITY AND AUTO-CORRELATION

We perform a series of diagnostic tests to assess if the equity beta estimates satisfy the standard conditions underlying ordinary least squares regression. The standard conditions are that the error terms in the regression follow a normal distribution and that they do not suffer from heteroscedasticity (differences in variance within sample) or auto-correlation (follow some pattern over time). Failure to meet these conditions would not invalidate the beta estimates, but would have the following consequences:

- 1. Although OLS is still an unbiased procedure in the presence of heteroscedasticity and/or autocorrelation, it is no longer the best or least variance estimator.
- 2. In the presence of heteroscedasticity and/or autocorrelation, the standard error calculated in the normal way may understate the true uncertainty of the beta estimate.
- 3. Heteroscedasticity and/or auto-correlation may indicate that the underlying regression is mis-specified (i.e. we have left out some explanatory variable).

4. Failure of normality does not *per se* undermine the validity of OLS, but the presence of outliers raises difficult questions about the robustness of the beta estimates.

III.C.1. Heteroscedasticity

Figure 22 to Figure 25 show scatter plots of the residuals against the returns predicted by the regression, for two-year regressions against the FTSE All-World. We constructed comparable plots for our regressions against the other indices and for our one-year beta estimates. Visual inspection does not reveal any obvious pattern - the "vertical spread" does not appear to change in any systematic way as we move horizontally across the graph. However, there are clearly a number of outliers.





⁴⁴ This graph plots the residuals against the fitted values for the regression including a time dummy switching on as of 24 February 2014 and an interactive term for the time dummy and the FTSE All-World Index.



Figure 23: Deutsche Telekom - residuals against fitted values







Figure 25: Telefonica - residuals against fitted values

We also examine whether there is change in the pattern of residuals over time. Figure 26 to Figure 29 do not show an apparent pattern of the residuals for the two-year estimation window. The plots again relate to two-year beta estimates calculated against the FTSE All-World.



Figure 26: Vodafone - residuals over time⁴⁵

⁴⁵ This graph plots the residuals over time for the regression including a time dummy switching on as of 24 February 2014 and an interactive term for the time dummy and the FTSE All-World Index.



Figure 27: Deutsche Telekom - residuals over time







Figure 29: Telefonica - residuals over time

Even though simple inspection suggests that heteroscedasticity cannot be a major concern, we apply a formal test (White's test) to investigate further. Table 19 reports the results of the standard diagnostic test. It indicates the absence of heteroskedascity in all of the one- and two-year equity beta estimates.

		1 yr			2 yr	
	White		Heterosk-	White		Heterosk-
	Stat	p-value	edascity	Stat	p-value	edascity
Deutsche Telekom						
All World	0.25	0.88	No	1.16	0.56	No
All Share	0.78	0.68	No	1.08	0.58	No
All Europe	1.33	0.52	No	0.78	0.68	No
Orange						
All World	1.37	0.50	No	1.38	0.50	No
All Share	1.64	0.44	No	1.39	0.50	No
All Europe	0.81	0.67	No	1.07	0.59	No
Telefonica						
All World	4.85	0.09	No	0.92	0.63	No
All Share	0.23	0.89	No	0.22	0.90	No
All Europe	2.75	0.25	No	0.08	0.96	No
Vodafone*						
All World	7.16	0.21	No	3.32	0.65	No
All Share	4.81	0.44	No	2.63	0.76	No
All Europe	5.85	0.32	No	2.11	0.83	No

Table 19: White's test for heteroskedasticity – up-to-date data, UK MNOs

*The values for Vodafone are for the modified regression including a time dummy to separate the periods between before and after the Verizon spinoff.

III.C.2. Auto-correlation

We also perform a formal test for auto-correlation (the Durbin-Watson test). This test indicates a degree of autocorrelation in all of the regressions. The effects of this auto-correlation are that standard errors will over-estimate the precision of the regression and that the OLS betas no longer represent the least variance estimator.

	1	L yr	2	2 yr
	Auto-			Auto-
	DW Stat	Correlation	DW Stat	Correlation
Deutsche Telekom				
All World	1.61	Yes	1.54	Yes
All Share	1.65	Yes	1.52	Yes
All Europe	1.61	Yes	1.54	Yes
Orange				
All World	1.55	Yes	1.59	Yes
All Share	1.54	Yes	1.58	Yes
All Europe	1.48	Yes	1.55	Yes
Telefonica				
All World	1.61	Yes	1.51	Yes
All Share	1.64	Yes	1.52	Yes
All Europe	1.57	Yes	1.48	Yes
Vodafone*				
All World	1.62	Yes	1.76	Indecisive
All Share	1.61	Yes	1.73	Yes
All Europe	1.62	Yes	1.72	Yes

Table 20: Durbin–Watson test for autocorrelation – up-to-date data, UK MNOs

*The values for Vodafone are for the modified regression including a time dummy to separate the periods between before and after the Verizon spinoff.

III.C.3. Robust regression and Generalised Least Squares

We performed a robust regression that accommodates the presence of some heteroscedascity in the data. The robust regression is a standard feature of computerised statistical packages like STATA. The robust regression derives the same coefficients as standard OLS, but calculates standard errors robust to heteroscedascity. We find that the robust standard errors are close to the OLS ones (see Table 21). We also performed a fix for the presence of autocorrelation. In the presence of autocorrelation, the standard OLS and robust regression betas are unbiased, but they are no longer least variance estimators. We therefore performed a generalised least squares regression, which addresses the presence of autocorrelation in the residuals and results in an unbiased and least variance estimator.⁴⁶ The similarity in results provides confidence that neither heteroscedascity nor autocorrelation are significantly affecting our beta estimates.

⁴⁶ The GLS results are robust to heteroscedascity as well as autocorrelation.

			1 Yr					2 Yr		
	OLS Beta	SE R	obust SE	GLS Beta	GLS SE	OLS Beta	SE I	Robust SE	GLS Beta	GLS SE
Deutsche Telekom										
All World	1.18	0.11	0.10	1.18	0.10	0.97	0.08	0.07	0.97	0.07
All Share	1.02	0.08	0.08	1.02	0.08	0.92	0.07	0.06	0.92	0.06
All Europe	1.08	0.07	0.06	1.08	0.06	0.97	0.06	0.05	0.97	0.05
Orange										
All World	1.24	0.15	0.13	1.26	0.13	1.16	0.11	0.09	1.17	0.09
All Share	0.93	0.12	0.10	0.94	0.10	1.01	0.09	0.08	1.02	0.08
All Europe	1.11	0.11	0.09	1.12	0.09	1.15	0.08	0.07	1.15	0.07
Telefonica										
All World	1.11	0.08	0.09	1.11	0.09	1.03	0.07	0.07	1.04	0.07
All Share	0.85	0.07	0.07	0.85	0.07	0.91	0.06	0.06	0.91	0.06
All Europe	0.94	0.06	0.07	0.94	0.07	1.02	0.05	0.05	1.02	0.05
Vodafone post struct	ural break*									
All World	1.23	0.15	0.15	1.23	0.15	1.23	0.16	0.15	1.23	0.15
All Share	1.33	0.12	0.11	1.33	0.11	1.33	0.13	0.11	1.33	0.11
All Europe	0.98	0.11	0.10	0.98	0.10	0.98	0.12	0.10	0.98	0.10
Vodafone, all period										
All World	1.22	0.13	0.13	1.22	0.13	0.91	0.08	0.08	0.91	0.08
All Share	1.27	0.10	0.10	1.27	0.10	1.05	0.07	0.07	1.05	0.07
All Europe	0.93	0.09	0.09	0.94	0.09	0.72	0.06	0.06	0.72	0.06

Table 21: Robust and GLS equity betas and standard errors – up-to-date data, UK MNOs

*These values for Vodafone are for the modified regression including a time dummy to separate the periods between before and after the Verizon spinoff.

III.D.NORMALITY OF RESIDUALS

We plot histograms of the "studentised residuals" to test for the normality of the residuals. The curve superimposed on the histograms is a standard normal distribution. If the error terms follow a standard normal distribution then the studentised residuals should follow the t-distribution, which for our size of sample is practically indistinguishable from the standard normal distribution. The histograms broadly resemble standard normal distributions except for the outliers: there are a few too many points a large number of standard deviations away from zero. Figure 30 to Figure 33 show histograms for two-year FTSE All-World regressions.

Figure 30: Studentized residuals – Vodafone⁴⁷



Figure 31: Studentized residuals – Deutsche Telekom



⁴⁷ This chart plots the Studentized residuals for the regression including a time dummy switching on as of 24 February 2014 and an interactive term for the time dummy and the FTSE All-World Index.



Figure 32: Studentized residuals – Orange





III.E. OUTLIERS

We perform two analyses to understand the influence of particular points on our beta estimates. We repeat the standard OLS regressions but only after removing "influential outliers". We also perform an iterative regression that gives less weight to data points reporting large residuals and thus having a large influence on the regression line).

To identify potential outliers we calculate the 'Cook's D' measure of the influence of each point on the regression outcome. A usual threshold is to classify points with a Cook's D score over 4/N (number of observations) as influential. Table 22 to Table 25 list such

influential dates for the one and two-year betas calculated using up-to-date data for the four UK MNOs.

Vodafone							
All W	orld	AllS	hare	All Eu	All Europe		
1 Yr	2 Yr	1 Yr	2 Yr	1 Yr	2 Yr		
20-May-14	26-Jun-14	11-Feb-14	24-Jan-13	24-Feb-14	24-Feb-14		
07-Feb-14	20-May-14	27-Jan-14	02-Sep-13	11-Feb-14	03-Apr-13		
20-Feb-14	08-Jul-14	20-Feb-14	24-Feb-14	20-Feb-14	20-May-14		
07-Oct-14	19-Mar-14	20-May-14	25-Sep-14	07-Mar-14	22-Aug-14		
15-Oct-14	24-Feb-14	24-Feb-14	24-Sep-14	15-Oct-14	29-Aug-13		
06-Feb-14	09-Oct-14	10-Jan-14	13-May-14	27-Jan-14	19-Feb-13		
17-Jan-14	03-Sep-13	19-Dec-13	19-Jun-14	21-Feb-14	03-Sep-13		
21-Feb-14	29-Aug-13	24-Jan-14	29-Aug-13	15-Jul-14	12-Mar-14		
10-Mar-14	27-Jan-14	06-Feb-14	27-Jan-14	29-Jan-14	04-Jul-13		
24-Feb-14	06-Mar-13	09-Oct-14	03-Apr-13	03-Dec-13	07-Oct-14		
27-Jan-14	04-Jul-13	10-Mar-14	19-Feb-13	06-Feb-14	15-Oct-14		
19-Dec-13	03-Apr-13	07-Mar-14	06-Mar-13	10-Mar-14	09-Oct-14		
09-Oct-14	08-Aug-14	21-Feb-14	23-Apr-13	20-May-14	15-Jul-14		
	17-Oct-14	12-Mar-14	06-Feb-14	26-Jun-14	01-Nov-13		
	06-Feb-14		20-May-14	19-Dec-13	24-Sep-14		
	18-Apr-13		10-Mar-14	25-Jul-14	27-Jan-14		
	15-Oct-14		08-Jul-14		19-Sep-13		
	19-Feb-13		24-Oct-14		10-Mar-14		
	08-Mar-13		09-Oct-14		24-Jan-13		
	10-Mar-14		25-Jul-14		25-Jul-14		
	07-Oct-14		25-Mar-14		26-Jun-14		
	05-Jul-13		03-Sep-13		07-Mar-14		
	15-Jul-14		07-Mar-14		06-Feb-14		
:	13-May-14		28-Oct-14		08-Jul-14		
	24-Sep-14		31-Oct-14		07-Feb-13		
	25-Jul-14		07-Oct-14		02-Sep-13		
	25-Sep-14		12-Mar-14		28-Oct-14		
	07-Mar-14				06-Mar-13		
	28-Oct-14						

Table 22: Influential outliers⁴⁸

⁴⁸ The values for Vodafone shown here are for the regression including a time dummy, switching on as of 24 February 2014, and an interactive term between the time dummy and the index returns.

Deutsche Telekom								
All World	All S	hare	All Eu	All Europe				
1 Yr 2 Yr	1 Yr	2 Yr	1 Yr	2 Yr				
13-Feb-14 28-Oct-14	19-Dec-13	29-May-13	15-Oct-14	20-Jun-2				
02-Jul-14 15-May-14	25-Aug-14	06-May-13	26-Nov-13	20-Sep-2				
26-Nov-13 16-May-13	26-Nov-13	10-Oct-14	02-Jul-14	04-Oct-2				
06-Mar-14 10-Oct-13	26-May-14	10-Oct-13	06-Mar-14	06-Aug-				
03-Mar-14 05-Jun-13	19-Sep-14	03-Mar-14	15-May-14	26-Nov-				
10-Oct-14 20-Sep-13	15-Oct-14	05-May-14	28-Oct-14	09-Jan-				
19-Sep-14 02-Nov-12	06-Mar-14	23-Apr-13	16-Dec-13	02-Jul-				
28-Oct-14 15-Oct-14	23-Jan-14	26-Aug-13	06-Aug-14	04-Jul-				
15-May-14 03-Mar-14	10-Oct-14	09-Jan-13	19-Sep-14	24-Oct-				
23-Jan-14 17-May-13	03-Mar-14	06-Mar-14	24-Jan-14	08-Aug-				
19-Dec-13 19-Dec-13	28-Oct-14	20-Sep-13	19-Dec-13	06-Mar-				
17-Oct-14 02-Jul-14	15-May-14	28-Oct-14	25-Jun-14	15-May-				
16-Dec-13 03-Feb-14	24-Oct-14	02-Jul-14	24-Oct-14	06-Jun-				
09-Jan-13	05-May-14	08-Feb-13		02-Nov-				
26-Mar-13	16-Dec-13	16-Dec-13		28-Oct-				
08-Aug-13	02-Jul-14	26-May-14		29-May-				
15-Feb-13	08-Sep-14	08-May-13		03-Feb-				
17-Oct-14		04-Apr-13		16-Dec-				
15-May-13		24-Oct-14		08-Feb-				
08-May-13		26-Nov-13		23-Apr-				
10-Oct-14		08-Aug-13		31-Oct-				
26-Nov-13		25-Aug-14		10-Oct-				
06-Dec-12		01-Jul-13		08-May-				
07-Oct-13		27-May-13		19-Dec-				
31-Oct-14		02-Nov-12		15-Feb-				
04-Apr-13		04-Oct-13		04-Apr-				
15-Apr-13		19-Sep-14		19-Sep-				
23-Jan-14		15-Feb-13						
29-May-13		19-Dec-13						
05-Jul-13		15-May-14						
04-Oct-13								
16-Dec-13								
06-Mar-14								
19-Sep-14								

Table 23: Influential outliers

Orange								
All World		All S	hare	All Europe				
1 Yr	2 Yr	1 Yr	2 Yr	1 Yr	2 Yr			
03-Dec-13	05-Jul-13	06-Mar-14	25-Aug-14	20-Dec-13	23-Oct-14			
23-Oct-14	03-Dec-13	05-May-14	01-Oct-14	21-May-14	04-Mar-13			
26-Feb-14	02-Jul-14	10-Mar-14	03-Apr-13	02-Jul-14	03-Apr-13			
23-Jan-14	15-Oct-14	07-Mar-14	08-Sep-14	17-Oct-14	23-Oct-13			
30-Apr-14	14-Mar-13	05-Nov-13	08-Oct-13	21-Oct-14	04-Feb-13			
15-Oct-14	21-May-14	08-Sep-14	21-May-14	05-Nov-13	05-Sep-13			
10-Mar-14	05-Sep-13	15-Oct-14	05-May-14	01-Oct-14	10-Mar-14			
02-Jul-14	23-Oct-13	23-Jan-14	05-Sep-13	06-Mar-14	29-Nov-12			
01-Oct-14	01-Oct-14	21-May-14	04-Feb-13	03-Dec-13	14-Mar-13			
21-May-14	30-Apr-14	01-Oct-14	10-Mar-14	23-Oct-14	02-Jul-14			
06-Mar-14	06-Mar-14	25-Aug-14	26-May-14	10-Mar-14	05-Nov-13			
	23-Jan-14	02-Jul-14	27-May-13	30-Apr-14	06-Jun-13			
	27-Mar-13	26-May-14	07-Mar-14	07-Mar-14	07-Mar-14			
	06-Dec-12	03-Dec-13	02-Jul-14		20-Dec-13			
	26-Feb-13	23-Oct-14	23-Jan-14		21-Feb-13			
	10-Mar-14		06-Mar-14		21-May-14			
	03-Apr-13		10-Oct-13		09-Jan-13			
	23-Oct-14		06-Feb-13		06-Mar-14			
	04-Mar-13		05-Apr-13		22-Jan-13			
	10-Oct-13		17-Oct-14		01-Oct-14			
	29-Nov-12		29-Nov-12		30-Apr-14			
	22-Jan-13		14-Mar-13		06-Dec-12			
	08-Mar-13		06-May-13		21-Oct-14			
	20-Jun-13		22-Jan-13		17-Oct-14			
			04-Mar-13					
			23-Oct-14					
			26-Aug-13					
			03-Dec-13					
			09-Jan-13					
			05-Nov-13					
			23-Oct-13					

Table 24: Influential outliers

	Telefonica							
All World		All S	hare	All Eu	All Europe			
1 Yr	2 Yr	1 Yr	2 Yr	1 Yr	2 Yr			
31-Oct-14	16-Oct-14	05-Aug-14	08-Mar-13	16-Oct-14	17-Oct-14			
25-Mar-14	26-Feb-13	06-Mar-14	20-Jun-13	28-Mar-14	25-Jul-13			
30-Oct-14	02-Oct-14	25-Mar-14	04-Mar-13	24-Mar-14	04-Apr-13			
02-Oct-14	26-Mar-13	16-Oct-14	05-Apr-13	25-Mar-14	04-Jul-13			
24-Jan-14	24-Jan-14	07-Apr-14	09-Oct-13	28-Oct-14	26-Mar-13			
15-Oct-14	20-Jun-13	31-Oct-14	26-Aug-13	09-May-14	24-Jan-14			
16-Oct-14	25-Feb-13	12-Feb-14	14-Mar-13	24-Jan-14	04-Feb-13			
03-Mar-14	05-Apr-13	26-May-14	26-May-14	20-Nov-13	01-Feb-13			
06-Mar-14	28-Oct-14	09-May-14	05-May-14	31-Oct-14	23-Jul-13			
23-Jan-14	26-Jun-13	25-Aug-14	25-Aug-14	14-Nov-13	09-May-14			
09-May-14	15-Oct-14	28-Oct-14	16-Oct-14	17-Oct-14	27-Feb-13			
28-Mar-14	07-Apr-14	10-Mar-14	06-Feb-13	07-Apr-14	14-Mar-13			
20-Nov-13	14-Nov-12	24-Jan-14	26-Jun-13		08-Mar-13			
03-Oct-14	10-Apr-13	20-Nov-13	25-Jul-13		28-Oct-14			
07-Apr-14	09-May-14	17-Oct-14	05-Mar-13		16-Oct-14			
28-Oct-14	08-Mar-13	05-May-14	17-Oct-14		24-Mar-14			
	04-Feb-13		04-Jul-13		26-Feb-13			
	04-Jul-13		06-May-13		25-Mar-14			
	06-Feb-13		24-Jan-14		09-Oct-13			
	27-Feb-13		10-Apr-13		23-May-13			
	07-Mar-13		25-Mar-14		05-Mar-13			
	05-Jul-13		12-Feb-14		04-Mar-13			
	04-Mar-13		09-Jan-13		09-Jan-13			
	05-Mar-13		04-Feb-13		19-Nov-12			
	14-Mar-13		27-Feb-13		07-Apr-14			
	09-Jan-13		26-Mar-13		-			
	15-Apr-13		27-May-13					
			23-Jul-13					
			26-Feb-13					
			29-Aug-13					
			10-Mar-14					

Table 25: Influential outliers

Table 26 compares the equity beta estimates obtained using standard OLS and GLS techniques with those obtained through the iterative regression giving less weight to outliers and through a regression with all influential outliers removed. Figure 34 to Figure 37 then plot the rolling two-year estimates of the betas for the UK MNOs against the FTSE All-World. They compare the results of the standard OLS and GLS regressions, the weighted

robust regressions and the regressions omitting all "outliers". The close similarity between the standard equity beta estimates and the other estimates provides confidence that outliers are not driving the shape of our results.

	1 yr				2 yr					
	Number				Number					
	Standard			No	of	Standard			No	of
	OLS	GLS	Robust	Outliers	Outliers	OLS	GLS	Robust	Outliers	Outliers
Deutsche Telekom										
All World	1.18	1.18	1.18	1.14	13	0.97	0.97	0.97	0.95	34
All Share	1.02	1.02	1.03	1.03	17	0.92	0.92	0.92	0.91	30
All Europe	1.08	1.08	1.06	1.10	13	0.97	0.97	0.95	0.96	27
Orange										
All World	1.24	1.26	1.34	1.30	11	1.16	1.17	1.18	1.12	24
All Share	0.93	0.94	1.05	1.06	15	1.01	1.02	1.01	1.03	31
All Europe	1.11	1.12	1.13	1.18	13	1.15	1.15	1.09	1.12	24
Telefonica										
All World	1.11	1.11	1.07	1.06	16	1.03	1.04	1.03	0.98	27
All Share	0.85	0.85	0.84	0.88	16	0.91	0.91	0.89	0.88	31
All Europe	0.94	0.94	0.92	0.95	12	1.02	1.02	0.98	1.01	25
Vodafone post structural break*										
All World	1.23	1.23	1.13	1.09	13	1.23	1.23	1.13	1.12	29
All Share	1.33	1.33	1.26	1.22	14	1.33	1.33	1.26	1.30	27
All Europe	0.98	0.98	0.97	0.95	16	0.98	0.98	0.97	0.93	28

Table 26: The effect of influential outliers on equity betas- up-to-date data, UK MNOs

*The values for Vodafone are for the modified regression including a time dummy to separate the periods between before and after the Verizon spinoff.



Figure 34: Two-year equity beta against the FTSE-All World - Deutsche Telekom





Figure 36: Two-year equity beta against the FTSE-All World - Telefonica



Figure 37: Two-year equity beta against the FTSE-All World - Vodafone⁴⁹



⁴⁹ Rolling betas presented here are the same as for the other companies, excluding any structural break adjustment.

CAMBRIDGE NEW YORK SAN FRANCISCO WASHINGTON LONDON MADRID ROME

THE Brattle GROUP