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The beta in the WACC for regulated fixed and mobile telecommunications services: its role and robust estimation¹

Stephan Schmitt² and Werner Neu³

Abstract

It is a highly controversial topic, both in the regulatory as well as the scientific research environment, whether the beta factor – as a measure for systematic risk – for fixed line and that for mobile operations has actually the same value. Since most telecommunications operators are today integrated, offering both types of services, It is difficult to address this empirical question directly. This paper contributes to the discussion by providing new empirical evidence with an approach that is a bit more sophisticated than is typically the case. Using an especially derived panel data set for 16 European telecommunications operators, covering the period 2010 through 2016, we tested the main hypothesis regarding the impact of mobile operations on risk, as well as carried out a preliminary test regarding the validity of the Modigliani/Miller formula needed for the main hypothesis. We do not find any empirical evidence that the risk parameters of fixed line and mobile network operators are different. Instead, they seem to be rather similar or within in the same range. Second, as a byproduct, we are not able to empirically confirm the Modigliani/Miller formula according to which the transformation of the equity betas into asset betas depends essentially on the debt/equity ratio assuming in the process a debt beta equal to zero. Our results rather confirm the findings of other studies suggesting that the debt beta is strictly positive.

¹ The views expressed in this paper are purely those of the authors and may not be regarded as stating an official position of WIK-Consult.

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1 Introduction⁴

In the terminology of the European Commission, many telecommunications operators have significant market power for some of their network services, typically fixed network operators for providing access to their local networks and mobile operators for the termination of calls originating in networks other than their own. This provides the justification for national regulatory authorities (NRAs) to regulate the prices of these services in an effort to make them correspond to those that would rule under effective competition. For arriving at this end, the NRAs usually determine the cost of the service in question and base the price on this cost, the rationale being that under effective competition prices would be equated to that level.⁵

There are essentially two approaches that an NRA may choose to estimate the cost of a telecommunications service. One is the so-called top-down approach, for which the cost analysis starts from the cost accounting records of the regulated operator. The costs found in these records are allocated to the operators' various services and per-unit costs are derived by dividing these costs by the volumes of these services. The other approach is the so-called bottom-up approach, for which the NRA – using engineering and economic cost principles – simulates the regulated operator's network and the volumes of services delivered thereon, and based on this, and information of the prices for the resources used, determines the cost of the regulated service.

Given the large capital intensity of telecommunications networks, the cost of financing the invested capital plays a large role in the analysis. For this reason, independent of which of the two above approaches is used, NRAs typically determine the value of the relevant interest rate on the basis of an own analysis (instead of taking information from regulated operator), carrying out the analysis within the framework of the so-called weighted average cost of capital (WACC). The WACC consists of the weighted sum of the return on equity capital, i.e. the return required by shareholders in the company, and the interest payable on the debt held by banks and bond holders. It is usually represented by the following equation:

$$WACC = w_E * r + w_D * i * (1 - t) \quad (1)$$

In this equation r and i stand for the return on equity and the interest on debt, w_E and w_D for the weights of equity and debt in total capital, while t stands for the corporate tax rate given that the cost of debt is tax-deductible.

The challenge of determining the value of the WACC consists in taking proper account of the level of risk that investors or lenders engage in, when providing capital to tele-

⁴ This introductory section is primarily intended for readers not familiar with financial analysis. Other readers may skip to the end of the section, where the objective and the organization of the paper is stated.

⁵ See Vogelsang (2003).

communications operators. If there were no risk, both r and i could, except for small administrative costs, be set equal to the risk-free rate obtainable on appropriate government bonds. Like all economic activity, however, the operation of telecommunications networks is risky so that providers of capital require a premium on top of what would be obtainable on a risk-free investment.

In financial analysis, the level of risk of a company is expressed by a coefficient, called beta (β), which shows the riskiness of a company relative to the level of risk inherent in the total economy, for which the level of risk is set equal to one. Thus if a company's β has a value lower than one, this means its risk is lower than that on average of the whole economy, and vice versa. As shown below, the value of beta determines the level of the WACC, it being higher or lower depending on whether the beta value is high or low.

The next point to make is that the β of the company's operation, referred to as asset beta (β_A) is to be borne by the providers of capital, equity shareholders and lenders. This is expressed by the following equation:

$$\beta_A = \left[\frac{E}{E+(1-t)*D} \right] * \beta_E + \left[\frac{D}{E+(1-t)*D} \right] * \beta_D \quad (2)$$

Here β_E and β_D stand for the levels of risk of the equity shareholders and lenders and E and D for the levels of equity capital and debt.⁶ Given that – except when the company goes bankrupt – lenders are guaranteed to be paid their interest and get their loans back on maturity, it is usually assumed that β_E is larger than β_D , and actually the latter is often assumed to be equal to zero. Accordingly, in most econometric analyses for determining the values of the betas, the focus is on β_E and β_A .

The standard theoretical approach on the basis of which the determination of the beta values is carried out is that of the Capital Asset Pricing Model (CAPM).⁷ It assumes that a particular relationship holds between the level of risk of a company and the level of risk within the whole economy. The equation showing this relationship is as follows:

$$r = i_{RF} + \beta_E * (r_M - i_{RF}) \quad (3)$$

According to (3), the required return on equity, r , is a function of the risk-free interest rate, i_{RF} , and the risk premium, r_M , that is observed for the whole market. For estimating the value of β_E of a particular company, one runs a regression of a sufficient number

⁶ Note that here the weights $\left[\frac{E}{E+(1-t)*D} \right]$ and $\left[\frac{D}{E+(1-t)*D} \right]$ do not add to one. This is due to the fact that a share of a company's earnings will go to the government in the form of taxes for which the government bears the corresponding risk. For determining the value of the WACC, only the risk borne by equity shareholders and lenders are to be taken into account.

⁷ See Brealey, Myers and Allen (2011). We are fully aware of the criticisms levelled at the CAPM. Our paper does not assume the validity of the model. It addresses questions of econometric methodology given that it has been decided to determine the value of r , i.e. the required return on equity, within the framework of the CAPM.

of (daily, weekly or monthly) observations of the company's stock return on the corresponding number of observations of the changes in the appropriate capital market index. The resulting coefficient is the estimate of β_E . Estimates arrived at this way are routinely available for many listed companies from rating agencies and other organizations. Here, since the objective of the paper is to throw light on risk aspects that hold for the industry as a whole, the analysis is based on beta estimates for an especially assembled sample of 16 European telecommunications operators, covering the period from 2010 through 2016, from which conclusions can be drawn that are generally representative for the industry.

The paper addresses two issues that analysts face when econometrically estimating the values of the betas for telecommunications operators. The particular questions asked are as follows:

- Does the risk of telecommunications operators differ for providing fixed line services and for providing mobile services? Are therefore the betas for these two business fields different?
- To what extent do the values of β_E , β_A and β_D actually differ? This issue is subsidiary to the one above that must be answered before the influence of the share of mobile activities on either β_E or β_A can be tested.

The remainder of the paper is organized as follows. The next section motivates in detail the two above research questions, introducing the particular hypotheses and relationships to be tested. In Section 3 the data set used for the tests is presented and in Section 4 our econometric approach. Section 5 reports the results and Section 6 concludes.

2 Motivation

2.1 Hypothesis regarding the impact of the mobile share

Historically, regulators have specified different costs of capital for regulated fixed network and mobile services. The reason for setting a higher cost of capital for mobile operations was risk that was assumed to be higher for mobile operations, as mobile services were seen as a “luxury good” with a relative high immaturity when first introduced. In contrast, the well-established fixed-network telephony was associated with less risk due to a relatively high and inelastic demand as the result of a widespread distribution among households and firms. Higher risk on the mobile market was also seen to have been the result of more competitive pressure among mobile operators, as there had always been three or more network operators active in the market, implying a high degree of infrastructure competition. Fixed-line operators on the other hand had mostly

only to compete with one other actual competitor having its own physical network, as e.g. a cable operator, while in many areas this may not even have been the case.

By now it is often being claimed that risks and therefore the cost of capital of fixed and mobile operations are converging or even have already converged. Mobile services are no more seen as a “luxury good” for a small group of clients, but as a mass product with a high penetration of mobile products and services. Moreover, with time the number of mobile operators has been decreasing in many EU countries, while concurrently fixed to mobile substitution is taking place,⁸ leading to more and more people with no fixed-line connection. Ultimately, this may lead to a convergence of the competitive levels on both markets.

It is even now sometimes claimed that fixed network operators bear a larger risk. This is explained by a higher proportion in fixed costs of fixed network operators in comparison to mobile operators, implying a higher level of systematic risk due to a higher variability in profits.⁹

As has recently been pointed out in a report for the European Commission, NRAs across the EU use different approaches for setting the WACC.¹⁰ This is also true regarding the question as to whether to apply the same beta value for fixed and mobile operations. In some countries, as e.g. Norway, regulators apply different beta values for fixed and mobile services, while in other countries regulators do not see different risk profiles, as e.g. in Germany.

Whatever the case, it seems to be an empirical question as to whether mobile operations are associated with higher/lower risk characteristics than fixed network operations. In the CAPM methodology higher operational risks are reflected in higher beta values. As the large majority of European telcos are integrated companies with both, fixed and mobile operations, it has been difficult to disentangle the separate effects on risk of fixed and mobile operations. On the one hand, we have thus the following hypothesis:

Hypothesis: *A higher degree in mobile operations has a direct impact on the beta value of a telecommunications operator.*

On the other hand, we need an especially focused approach that is able to empirically test this hypothesis. Our approach is such an attempt by using a specific econometric technique, running panel data regressions of a large number of beta estimates on the corresponding mobile shares. The beta estimates and the mobile shares used are for 16 telecommunications operators, one for each of the years 2010 through 2016.

⁸ See Barth and Heimeshoff (2012).

⁹ See NERA (2017).

¹⁰ See The Brattle Group (2016).

There exists already some empirical evidence on that research question using in part similar but more limited approaches. They have mostly been undertaken by consultants. The two most recent reports do not find any positive and significant interrelation between the two. It is argued that risk profiles for fixed and mobile operations are rather similar suggesting the usage of equal risk parameters and, consequently, comparable costs of capital in the regulatory context. However, in another earlier study evidence for a mobile premium on the beta is reported.

NERA (2017) looking at the income elasticity of demand as key determinant of systematic risk of a company argue that a number of qualitative indicators indicate a convergence in the income elasticity of demand for fixed and mobile services over the last decade. In the first part of their empirical analysis they regress asset betas of 13 European telcos on the mobile share of revenues in the year 2015 in a simple OLS framework. Controlling for firm size and country risk they are not able to find any significant relation. In the second part of their study, using a time-series model in first differences, they focus on four operators that experienced a significant (i.e. greater than 10 %) change in their mobile revenues share in the period 2005-2015. Again, they do not find significant effects. Although econometric cross-sectional and time-series analyses are carried out in this report, the two dimensions are not fully exploited, as would be the case in an analysis using panel data.

Frontier Economics (2016) in a different approach regress the asset beta of 13 European telcos on the corresponding revenue shares of fixed lines, mobile and other business activities with a simple OLS regression. The results of the coefficients of the artificial pure play betas are not significant, indicating that there is no difference between the asset beta of fixed line and mobile services. A drawback of this analysis is the fact that their results are based on a regression with only 13 observations. A study based on panel data with a much larger number of observations appears more appropriate to derive at a conclusive robust conclusion.

Johnsen (2013) empirically derives different asset betas for mobile and integrated operators looking at 19 European telecommunications companies over the period 2008 through 2013. Splitting the sample into a group of six “pure mobile companies” with a mobile sales share of more than 60 % and a second group of 13 “integrated operators” with less than 60 % of mobile sales, Johnson finds for various specifications that equity and asset betas of mobile operators are substantially higher than for integrated companies. Ultimately, he suggests an asset beta for nordic mobile operators of 0.9, while the asset beta of the Norwegian fixed network operator is 0.5. A comparison of equity and asset betas from Johnsen (2013) with beta values from other studies for recent years shows that the beta values of his mobile group declined, while at the same time the beta values of the integrated group increased.¹¹ Thus, it is highly questionable if

¹¹ This observation is also confirmed by the beta estimates of our study.

Johnsen's analysis would provide similar results if executed with more recent data. In addition, the threshold for the sample split appears to be rather ad hoc and not based on sound scientific principles. This for example leads to the fact that the three smallest firms in terms of firm value, that may be expected to face large risk on other grounds, are all members in the mobile group.

Note that in most of the studies reviewed above, the tests were carried out on the basis of values for the asset beta derived from estimates of the equity beta according to the Modigliani/Miller formula,¹² i.e.

$$\beta_A = \left[\frac{E}{E+(1-t)*D} \right] * \beta_E \quad (4)$$

As shown, this formula depends only on the equity beta, the asset beta, the corporate tax rate and the debt/equity ratio, in other words it is assumed that there is no separate risk for debt. By assuming this linear relationship between the asset beta on the one side and the equity beta and the debt/equity ratio on the other side as given, its validity is accepted without any empirical verification. As discussed in the following section, our perspective on this is a different one.

2.2 Preliminary test regarding the impact of the debt/equity ratio

In the preceding section we derived our hypothesis claiming that the impact on risk due to a higher degree of mobile operations can be determined by an appropriate test relating telecommunications operators' beta estimates to their mobile shares. As just noted, the hypothesis has in earlier studies been formulated in terms of an operator's asset beta. The asset beta is supposed to catch the risk of the actual operations of the company, and it is therefore in its value that the influence of a higher or lower share of mobile operations should be observed most directly. We intend to follow suit and would therefore also need to transform our estimated equity betas into asset betas as a function of the debt/equity ratio. In lieu, however, of running the tests for our main hypothesis with asset beta values obtained using uncritically the Modigliani/Miller relationship, we will check empirically to what extent this relationship actually exists, so that on the strength of these findings the test can correctly be carried out.

To repeat, from the Modigliani/Miller formula follows that the debt beta is zero. However, there is a literature according to which it is not zero but positive, which is in part the motivation to our approach in this subsection. A review of the corresponding literature by Skardziukas (2010) refers to studies that arrive at values for the debt beta that de-

¹² Modigliani and Miller (1958) derive this relationship on theoretical grounds. In actual exercises determining the cost of capital, the equation is usually derived from one like equation (2) in the introduction by setting $\beta_D = 0$. In their study, NERA (2017) use instead the so-called Miller formula which is $\beta_A = \left[\frac{E}{E+D} \right] * \beta_E$. It differs insofar as the tax rate is not taken into account.

pending on the degree of leverage range between 0.1 and 0.4. Ignoring this could thus lead to an underestimation of the asset beta value.

Estimating separately the debt beta for our sample in order to use it in equation (2) would have been beyond the scope of the study. Our approach to dealing with the issue is an indirect one. We start with the initial assumption that $\beta_D = 0$ so that the Modigliani/Miller formula according to equation (4), i.e. $\beta_A = \left[\frac{E}{E+(1-t)*D} \right] * \beta_E$, holds. From this equation we obtain the inverse relation between β_E and β_A as follows:

$$\beta_E = \left[\frac{E+(1-t)*D}{E} \right] * \beta_A \quad \text{or} \quad \beta_E = \left[1 + (1-t) * \frac{D}{E} \right] * \beta_A$$

which can finally be transformed into

$$\beta_E = \beta_A + \beta_A * (1-t) * \left(\frac{D}{E} \right) \quad (5)$$

This validity of the relation will be tested by regressing the β_E estimates for the operators on corresponding observations of $(1-t) * (D/E)$. As regression results we will obtain the estimated intercept, and the estimated coefficient of $(1-t) * (D/E)$. Both, the estimate of the intercept and that of the coefficient of $(1-t) * (D/E)$, will according to the model specification in equation (4) be estimates of the asset beta. Therefore, if the initial assumption proved to be correct, both estimates should at least be approximately equal.

If above results are borne out this will be the confirmation of the pragmatic approach of assuming that the debt beta is zero and the Modigliani/Miller formula holds. In this case we will proceed according to our initial assumption and use equation (4) without further qualms for the transformation of the equity beta estimates into corresponding asset betas, for use in the test of the main hypothesis. In case the results are not consistent with these expectations, depending on the kind of deviations, we will need to take on board additional considerations to assure reliable results from the test of our main hypothesis.

3 Data

The panel data set consists of 16 telecommunications companies from 12 European countries over the period 2010 through 2016. The following firms are part of the analysis: Belgacom (now Proximus), BT, Deutsche Telekom, Elisa, Iliad, KPN, Orange (formerly France Telecom), Sunrise, Swisscom, TDC, Tele2, Telefonica, Telekom Austria, Telenor, Telia and Vodafone. The composition of the peer group is based on two basic criteria. First, data availability for all relevant variables of our analysis, and second, the fact that the firms operate in the same industry/sector with a similar regulatory environment and operational risk.

The sample incorporates different kinds of telcos, ranging from relatively small companies with a clear focus on their home market (as e.g. Belgacom) up to big European companies with subsidiaries in Europe and elsewhere in the world (as e.g. Telefonica, Vodafone). Incumbent operators are part of the analysis (e.g. Deutsche Telekom, TDC) as well as operators that entered the market after liberalization (e.g. Tele2). Heterogeneity is also given with respect to firm activities. Some of the firms have their main operational focus on fixed-network services (such as Swisscom or TDC), while others concentrate on mobile operations (Vodafone).

For the estimation of the equity betas for the firms in the sample, we use the returns on stock prices for a one year period, which are analyzed against the STOXX Europe 600 index.¹³ All stock prices are taken from the corresponding national stock exchanges and are denominated in local currencies. Since we are interested in the stock market returns measured in percentage changes, different currencies do not pose a problem. We estimate the betas using standard ordinary least squares (OLS) regression techniques and receive up to seven yearly beta values per company.¹⁴ The specific regression equation derived from equation (3) in the introductory section is:

$$r = \hat{\alpha} + \hat{\beta}_E * r_M \quad (6)$$

where r is the observed return on the particular stock and r_M the return on the whole market, while $\hat{\alpha}$ and $\hat{\beta}_E$ are the estimated regression parameters. Of these, $\hat{\beta}_E$ stands for the estimate of the equity beta.¹⁵

The derivation of the asset beta according to the Modigliani/Miller formula depend on the debt/equity ratio, for which both the levels of debt and of equity need to be available. The level of debt is taken from the annual account. In principle, it can either be derived as total debt or as net debt, whereby net debt equals total debt minus cash and cash equivalents. Since net debt takes into account the fact that cash and cash equivalents can be used at short notice to repay any kind of debt, this is the measure of debt that we use. The value of equity can be obtained in terms of book values as well as in terms of market values. While in the former case equity levels are taken from annual accounts, in the latter case equity levels are estimated by multiplying the number of shares outstanding times the share price at the end of corresponding period. Unless otherwise stated, we use the equity levels in market values.

¹³ We hereby follow the approach proposed in The Brattle Group (2016).

¹⁴ The equity beta estimation is also possible with other methods than the simple OLS. However, OLS is the most common method for the beta estimation, which is, in addition, highly popular among regulators and practitioners, who in most cases are the ones that determine the beta values for the cost models.

¹⁵ This is equivalent to the determination of the correlation between the return on the particular stock and the return on the market. The logically precise regression equation should actually be in terms of excess returns, i.e. $r - i_{RF} = \hat{\alpha} + \hat{\beta}_E * (r_M - i_{RF})$, where i_{RF} stands for the risk-free interest rate, which would correspond to equation (3) in the introduction. When, however, eliminating for convenience i_{RF} from both sides of the equation, this does not change the results.

The share in mobile operations of each telecommunications company is equal to the revenue share from mobile operations. It is collected from the yearly annual reports of the companies.

Table 1 presents yearly descriptive statistics for the estimated equity betas. In general, average equity betas tend to increase over the sample period. Of particular importance is a lasting increase in the mean values from the year 2012 to 2013 of approximately 13 %. The picture of increasing equity betas and increasing risk is in line with other studies in the field.¹⁶

Table 1: Descriptive statistics of the equity betas

Year	Mean	Std. Dev.	Min	Max	Obs
2010	0.65	0.22	0.35	1.10	15
2011	0.68	0.20	0.42	1.01	15
2012	0.68	0.27	0.40	1.34	15
2013	0.77	0.23	0.50	1.26	15
2014	0.76	0.28	0.23	1.31	15
2015	0.80	0.21	0.44	1.22	16
2016	0.78	0.21	0.51	1.40	16

The descriptive statistics for the other variables are shown in Table 2. The values of the asset beta à la Modigliani/Miller range between 0.12 and 0.83 with an average of 0.50. Three different debt/equity ratios are presented; it is highest with book values for equity together with total debt, lower with market values for equity together with total debt, and lowest with market values for equity together with net debt. The average mobile share of the telcos that are part of the analysis is 50 %.

¹⁶ Chalmeau (2013) for example finds that equity betas increased from the year 2009 onwards until 2012 from 0.52 to 0.71. Before that period, he reports that beta values decreased substantially after the year 2000 with the turnaround in the year 2009.

Table 2: Descriptive statistics of the other variables

Variable	Mean	Std. Dev.	Min	Max	Obs
Asset beta	0.50	0.16	0.12	0.83	107
Debt/equity ratio (equity in book values and total debt)	4.03	9.52	0.45	88.95	111
Debt/equity ratio (equity in market values and total debt)	1.13	0.76	0.19	5.25	112
Debt/equity ratio (equity in market values and net debt)	0.55	0.44	0.06	3.25	112
Mobile share	0.50	0.22	0.00	0.88	107

4 Econometric modelling

For the empirical analysis we make use of standard methods of panel data econometrics.¹⁷ Specifically, we employ a two-way fixed-effects estimator accounting for firm and time (i.e. year-specific) fixed effects. The firm fixed effects control for unobserved time-invariant heterogeneity between firms such as firm size, strategical orientation etc., as long as it is constant over the analyzed period. The year-specific fixed effects, in addition, take into account effects jointly affecting firms in a particular year, such as an economic crisis or technological progress in the telecommunication industry. All regressions are also carried out with the first difference estimator, in which changes in the dependent variable are regressed on changes of the independent variables.¹⁸ Moreover, all estimations include robust standard errors controlling for possible heteroscedasticity that may lead to distorted standard errors.

The model specification for the preliminary test – looking at the impact of the debt/equity ratio on the equity beta – corresponds to equation (5) and has the following form:

$$\beta_{E,i,t} = \alpha_0 + \alpha_1 * de_ratio_{i,t} + \theta_i + \tau_t + \varepsilon_{i,t} \quad (7)$$

¹⁷ See e.g. Baltagi (2008) for an overview.

¹⁸ Theoretically, the fixed effects estimator and the first difference estimator should provide similar results. The fixed effects estimator is more efficient in case of a homoscedastic and serially uncorrelated error term. Under the weaker assumption that the first differences of the error term are serially uncorrelated, the first difference estimator is more efficient. In order to test the robustness of our results, we report both.

The equity beta, $\beta_{E,i,t}$, of company i in year t depends on the constant, α_0 , and the debt/equity ratio, de_ratio . Firm-specific effects, θ_i , and year-specific fixed effects, τ_t , are taken into account. $\varepsilon_{i,t}$ stands for the independent and identical distributed error term.

The preliminary test and with it the initial assumption of the Modigliani/Miller formula are empirically confirmed if the two estimated coefficients α_0 and α_1 are at least approximately equal. In case of different coefficients the assumed relationship of the formula between the asset beta, the equity beta and the debt/equity ratio cannot be verified empirically based on our data set.

The basic model specification for the main hypothesis – analyzing the influence of the mobile share on the beta – is derived ad hoc and looks as follows:

$$\beta_{A/E,i,t} = \alpha_0 + \alpha_1 * ms_{i,t} + \theta_i + \tau_t + \varepsilon_{i,t} \quad (8)$$

Here, the asset or equity beta, $\beta_{A/E,i,t}$, depending on the specification is the dependent variable. It is set equal to the constant, α_0 , the mobile share, ms , as well as to the firm-specific, θ_i , and year-specific fixed effects, τ_t .

For the econometric analysis of the main hypothesis, it is important that the sample does not only incorporate companies with a similar share in mobile operations; instead it should include the full variety of possibilities.¹⁹ If for example all telcos in the sample had the same share in mobile operations, it would not be possible to detect any influence of the degree in mobile operation on the beta.

Robustness

In order to test the validity and robustness of the results for the main hypothesis, we perform several robustness checks.

First, we are looking for possible statistical outliers in our data set using the Cook's distance test. The test identifies single data points that have a major impact on the location and slope of the regression line. Accordingly, we exclude those influential data points from our regressions that exceed a certain threshold and run the same regressions without these observations.²⁰

Second, as outlined before, the asset beta of a company depends on the corresponding equity beta and the debt/equity ratio. Diverging from the main specifications, we use total debt instead of net debt for the derivation of the debt/equity ratio, and rerun the same analysis with the modified asset beta.

¹⁹ As shown in Table 2, the shares in mobile operations in our sample range from 0 % to 88 %.

²⁰ We employ the conventional threshold $4/N-k-1$, where N is the number of observations and k the number of regressors.

Finally, we use the book value of equity instead of the market value of equity to derive the debt/equity ratio and – as in the previous robustness check – estimate the same regression with the newly estimated asset beta.

5 Results

5.1 Preliminary test

The test is carried out with three different regression specifications:

- (1) Pooled OLS: the equity beta is regressed solely on the level of the debt/equity ratio.
- (2) Two-way fixed effects: the equity beta is regressed on the debt/equity ratio taking into account the firm- and year-specific effects.
- (3) First differences: percentage difference from one day to the other in the equity beta is regressed on corresponding difference of the debt/equity ratio.

The results of the regressions are listed in Table 3.

Table 3: Regression results for preliminary test

	(1) Equity beta <i>Pooled OLS</i>	(2) Equity beta <i>Fixed effects</i>	(3) Diff_Equity beta <i>First differences</i>
Constant	0.69*** (18.88)	0.65*** (15.71)	0.03 (1.54)
Debt equity ratio	0.01 (0.98)	-0.04 (-0.39)	
Diff_Debt equity ratio			-0.03 (-0.27)
Average of company dummies		-0.01	
Average of year dummies		0.11	0.10
F-Test	0.96	3.55	0.92
R ² -within	0.02	0.19	0.07
Number of observations	107	107	91

Robust t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01

Most important are the estimated values of the coefficient for the debt/equity ratio. In all three specifications, they are small relative to any expected value of the asset beta, and these estimates are highly insignificant. This is on first sight contrary to the initial assumption and would thus not corroborate the use of the Modigliani/Miller formula.

Next, we consider the estimated values for the constant. Note that when adding the averages of the fixed effects to the constant of specification (2), we obtain a value of

0.74. Note further that this value and the one obtained for the constant of specification (1) average to 0.72. As stated in Section 2.2, the constants represent estimates of the asset beta, where the values obtained here are relatively high but lie only slightly above the asset beta range of 0.50-0.67 proposed by The Brattle Group (2016).

Before interpreting the results any further, let us look at the theoretical relationship between the betas, in particular the determinants of the equity beta as derived from equation (2), without making any assumption regarding the value of the debt beta. Solving for β_E from this equation, we have:

$$\beta_E = \left[\frac{E+(1-t)*D}{E} \right] * \beta_A - \left[\frac{D}{E} \right] * \beta_D \quad \text{or}$$

$$\beta_E = \beta_A + \beta_A * (1 - t) * \left(\frac{D}{E} \right) - \beta_D * \left(\frac{D}{E} \right) \quad (9)$$

We observe that, if the initial assumption does not hold and we now assume $\beta_D > 0$, the estimated coefficient from the regression of β_E on (D/E) , which initially was supposed to be an estimate of the asset beta, would now reflect two countervailing effects of the debt/equity ratio. There would be one, the one of interest here, via the asset beta which is positive, and another one via the debt beta which, because the term is deducted, is negative. Since all three regression results for the coefficient of the debt/equity ratio, reflecting the balance of the two effects, are essentially zero, one might conclude that if one had been able to actually estimate the values for $\beta_A * (1 - t)$ and β_D separately, these would be equal.

Accepting this as a final result would, however, be a premature interpretation. Given the relatively high estimates for the asset beta derived from the constants of specifications (1) and (2), which average to 0.72, and given the average tax rate in the sample of 0.22, this would amount to a value of the debt beta near 0.55. Such a value would substantially be higher than the estimates lying between 0.1 and 0.4 referred to in the review by Skardziukas (2010) cited above.

One particular problem that needs to be considered when interpreting the above results is the one of measurement errors. This problem may beset any econometric investigation, also any one by which the value of the WACC is determined, and in particular in the present case the measurement of the debt/equity ratio. Assuming that there were such measurement errors when determining the values of the debt/equity ratio for our sample, we know from econometric analysis that then the estimate of the coefficient in our regression equation is inconsistent, which means that it is biased downwards.

One might now argue that the measurement errors are so pervasive that alone on their account the estimate of the coefficient is biased down to zero and that without the measurement errors and the consequent bias, one would obtain a result supporting the initial assumption. This, however, would be an equally premature conclusion as the one

above regarding $\beta_A * (1 - t) = \beta_D$. It is more likely that there is a positive asset beta and a positive but lower debt beta, while due to some measurement errors the estimate of the balance of the two is biased down to zero.

In sum, it appears that there is scant support for the Modigliani/Miller formula, while there appears to be support for the assumption of a positive debt beta. It cannot even be excluded that the true value of the asset beta is closer to the estimated equity beta than to the value arrived at by using the Modigliani/Miller formula. Since as stated earlier, it is beyond the scope of this study to also estimate the debt beta for the operators in the sample, we take the supposition just stated as a clue to test the main hypothesis, i.e. regarding the impact of the mobile share of operations on the beta, not only (a) with as dependent variable the asset beta derived in the conventional way, but also (b) with as dependent variable the equity beta from which the asset beta for (a) was derived. If the supposition is correct, the estimated relationship between the equity beta and the share of mobile operations, if it exists, should under (b) appear to be even stronger. This expectation rests on the effects of measurement errors. If there are such errors and if the supposition holds, these errors would be less when using the equity beta values than the conventionally derived values of the asset beta.²¹

To conclude the section, we offer two final observations. We would consider it worthwhile that other researchers in their investigations take up the question of this subsection again, refining the approach and in particular endeavoring to estimate the debt beta together with the equity beta in a consistent way. In line with this would follow that analysts that set out in future to determine the value of the WACC, should reconsider whether it is justified to rely on the Modigliani/Miller formula for deriving the asset beta, and whether it may not be advisable to put in some effort into determining the value of the debt beta, to arrive thereby at more reliable estimates of the parameter values they are looking for.

5.2 Main hypothesis

Following the interpretation of our preliminary results, we have two versions for the regressions of betas on shares of mobile operations:

- (a) As dependent variable the asset beta derived via Modigliani/Miller.
- (b) As dependent variable the equity beta.

²¹ Note in this context that while our test is on the basis of the Modigliani/Miller formula, it could also have been carried out, as for example NERA (2017) in its limited approach does, using the Miller version of the formula, i.e. $\beta_A = \left[\frac{E}{E+D} \right] * \beta_E$. Since this formula does not involve the tax rate, our empirical result might in this case not only suggest that $\beta_D = \beta_A$, but also that $\beta_E = \beta_A = \beta_D$, which would even give a stronger reason to use the estimate of the equity beta as the dependent variable in the test of the main hypothesis.

The econometric analysis is carried out using the same three specifications as for the preliminary test. In both cases we have 102 observations for the regressions that are performed in levels and 86 observations for the regressions in first differences.

The results for version (a) are listed in Table 4. In specifications (1) and (2), in which the conventionally derived asset beta value is regressed on the level of the mobile share, we note that even though the coefficient is in each case slightly positive, it is in both cases highly insignificant, which means that it is not possible from that regression to draw any conclusions on the causal relationship between the mobile share and the asset beta. Looking at the specification (3), where the changes in the asset beta are regressed on changes in the mobile shares, this finding gets confirmed. The signs of the year dummy coefficients for specifications (1) and (2) are within expectations, having in mind that there was a jump in the asset beta values from the year 2012 to 2013 and onwards (see Table 1).

Given that in all three specifications, the estimated coefficients of the mobile share are statistically not different from zero, it follows that there is no empirical evidence for the hypothesis according to which a higher degree in mobile operations would affect the beta value of the telcos.

Table 4: Regression results for the main hypothesis

	(1) Asset beta <i>OLS</i>	(2) Asset beta <i>Fixed Effects</i>	(3) Diff_Asset beta <i>First Differences</i>
Mobile share	0.09 (1.19)	0.01 (0.03)	
Diff_Mobile share			0.13 (0.57)
Year dummy _2011		-0.01 (-0.32)	
Year dummy _2012		-0.04 (-0.94)	-0.01 (-0.19)
Year dummy _2013		0.05 (0.92)	0.11* (1.66)
Year dummy _2014		0.08 (1.22)	0.16 (1.60)
Year dummy _2015		0.12 (1.74)	0.23* (1.82)
Year dummy _2016		0.09* (1.76)	0.20 (1.32)
Constant	0.50*** (12.67)	0.49** (2.68)	-0.03 (-0.92)
F-Test	1.42	3.12	4.77
R ² -within	0.02	0.21	0.19
Number of observations	102	102	86

Robust t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01

The results for version (b) are shown in Table 5. Specification (4), regressing the equity beta on the mobile share only, provides a mobile share coefficient that is positive with a value of 0.15 and is barely significant with a p-value of 0.093. However, in specification (5), which takes into account firm-fixed as well as time-fixed effects, the coefficient of the mobile share variable turns negative and is highly insignificant. Given that this specification is a substantial improvement over specification (5), this result is to be considered as the more relevant one. The coefficient that is estimated for the mobile share in specification (6), the one in first differences, is with 0.17 positive, however, highly insignificant.

For the relevant specifications (5) and (6) it follows also for version (b) that the estimated coefficients of the mobile share are statistically not different from zero so that again there is no empirical evidence for the hypothesis according to which a higher degree in mobile operations would affect the beta value of the telcos.

Table 5: Regression results for the main hypothesis with the equity beta

	(4) Equity beta <i>OLS</i>	(5) Equity beta <i>Fixed Effects</i>	(6) Diff_ Equity beta <i>First Differences</i>
Mobile share	0.15* (1.70)	-0.04 (-0.13)	
Diff_Mobile share			0.17 (0.58)
Year dummy _2011		0.04 (0.93)	
Year dummy _2012		0.04 (0.66)	-0.02 (-0.33)
Year dummy _2013		0.13 (1.71)	0.07 (0.74)
Year dummy _2014		0.12 (1.59)	0.05 (0.38)
Year dummy _2015		0.18** (2.57)	0.10 (0.62)
Year dummy _2016		0.14** (2.88)	0.03 (0.16)
Constant	0.65*** (13.05)	0.65*** (3.97)	0.01 (0.25)
F-Test	2.88	2.01	3.59
R ² -within	0.02	0.18	0.13
Number of observations	102	102	86

Robust t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01

In sum, we do not find any empirical evidence for a significant causal interrelation between the beta and the mobile share of European telecom operators, irrespective of whether we take the asset beta or equity beta as dependent variable. Figure 1 illustrates this finding graphically for the asset betas and Figure 2 for the equity betas. In each case the figure shows the scatter plot of the average yearly beta, averaged over the period 2010 through 2016, for each of the 16 telecommunications companies

against the corresponding average mobile share values. It is difficult to identify a positive or negative relation between the mobile shares and the betas of the companies. Instead, either appears to be randomly distributed, which is in line with our regression results.

Figure 1: Average asset betas vs. mobile shares

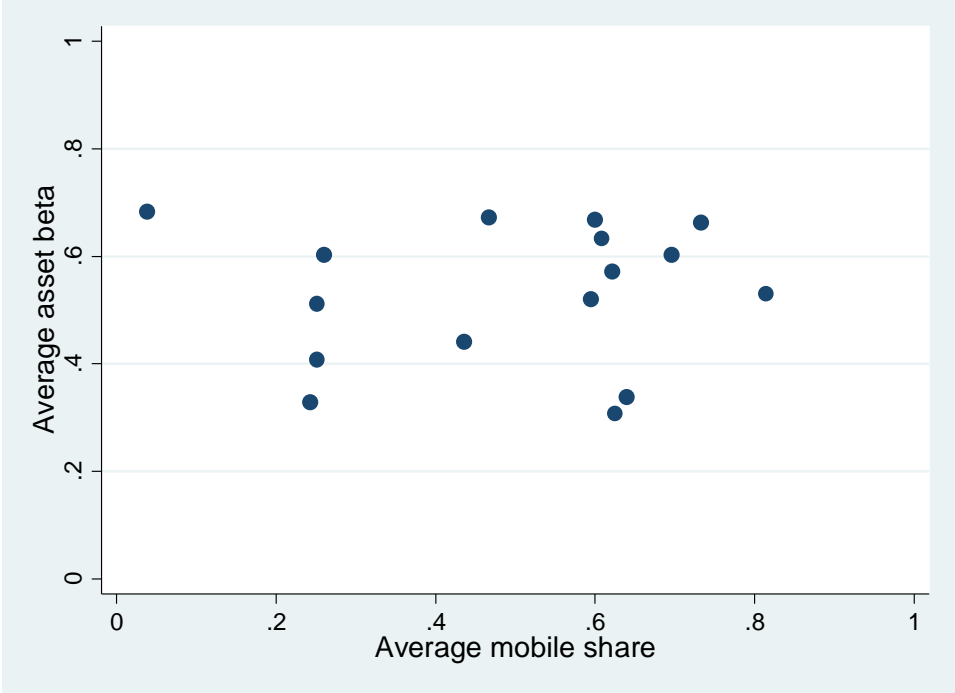
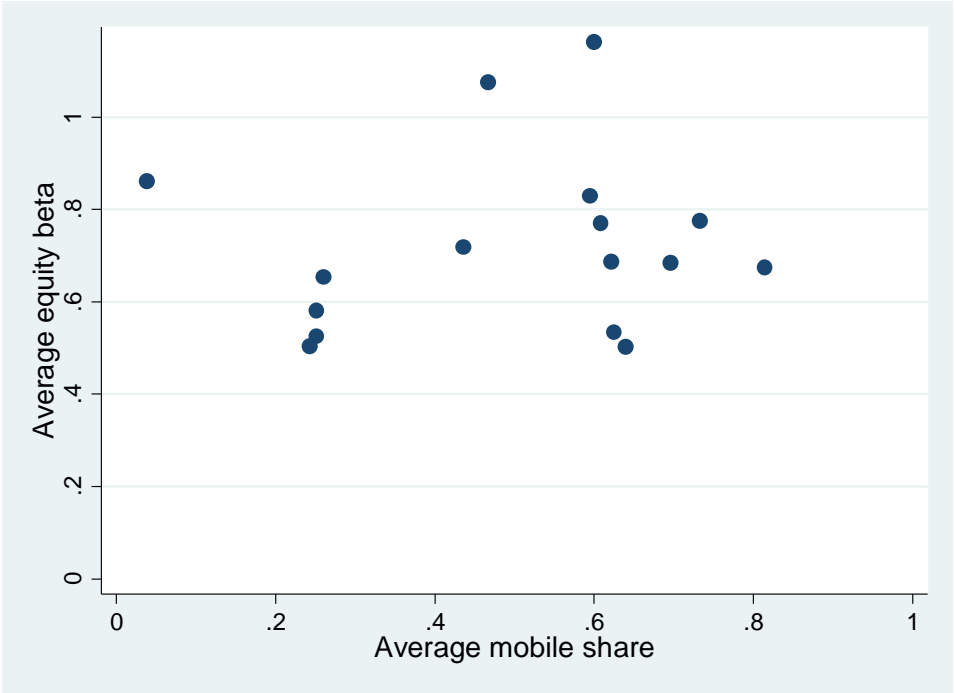


Figure 2: Average equity betas vs. mobile shares



5.3 Robustness

The results of the robustness checks confirm our main findings according to which we are not able to detect any empirical evidence for a significant difference in the risk parameters of fixed line and mobile operators.

In Table 6 statistical outliers according to the Cook's distance test are eliminated from the sample and the same regressions for the asset beta (1) and equity beta (2) are again estimated, now excluding three outliers in the former and four outliers in the latter specification. In both cases the mobile share coefficient is strongly insignificant; moreover, in specification (1) it is slightly positive and in specification (2) the opposite is true.

Table 6: Cook's distance robustness check

	(1) Asset beta <i>Fixed Effects</i>	(2) Equity beta <i>Fixed Effects</i>
Mobile share	0.07 (0.22)	-0.06 (-0.21)
Year dummy _2011	0.02 (0.60)	0.06* (1.89)
Year dummy _2012	0.01 (0.16)	0.04 (0.85)
Year dummy _2013	0.08 (1.67)	0.15** (2.40)
Year dummy _2014	0.12** (2.18)	0.20*** (3.09)
Year dummy _2015	0.14** (2.45)	0.20*** (3.34)
Year dummy _2016	0.12*** (3.00)	0.17*** (4.25)
Constant	0.43*** (3.03)	0.63*** (4.36)
F-Test	4.70	3.99
R ² -within	0.26	0.30
Number of observations	99	98
Number of eliminated outliers	3	4

Robust t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01

Table 7 reports the findings for the other robustness checks for which the value of the asset beta is derived using different values for the determining parameters than for the regression in Section 5.2. For specification (3), total debt, and for specification (4), book values of equity, is used in the transformation of the equity beta to the asset beta. In both specifications the mobile share coefficient is again highly insignificant.

Table 7: Further robustness checks

	(3) Asset beta <i>Fixed Effects</i> Total debt	(4) Asset beta <i>Fixed Effects</i> <i>Book value of equity</i>
Mobile share	0.04 (0.10)	-0.07 (-0.29)
Year dummy _2011	-0.02 (-0.83)	-0.03 (-0.95)
Year dummy _2012	-0.05 (-1.62)	-0.04 (-1.21)
Year dummy _2013	0.02 (0.38)	0.00 (0.01)
Year dummy _2014	0.05 (0.93)	0.025 (0.54)
Year dummy _2015	0.08 (1.41)	0.03 (0.65)
Year dummy _2016	0.04 (0.97)	0.00 (0.06)
Constant	0.39** (2.37)	0.323** (2.86)
F-Test	3.90	1.88
R ² -within	0.20	0.13
Number of observations	102	101

Robust t statistics in parentheses; * p<0.10, ** p<0.05, *** p<0.01

6 Conclusion

In the regulation of the prices of regulated services of telecommunications operators with significant market power, the determination of the cost of capital is of major importance. Capital costs depend to a great extent on the underlying interest rate, which is typically derived as the weighted average of the return on equity and the interest on debt and is therefore referred to as the weighted cost of capital (WACC). Due to the fact that operations in the telecoms sector are associated with entrepreneurial risk, both the return on equity and the interest rate on debt are assumed to be higher than the risk-free interest rate. The factor incorporating the risk is the beta factor. It is a highly controversial topic, both in the regulatory as well as the scientific research environment, whether the beta factor for fixed line and that for mobile operations has actually the same value. Since most telecommunications operators are today integrated, offering both types of services, It is difficult to address this empirical question directly.

This paper contributes to the discussion by providing new empirical evidence with an approach that is a bit more sophisticated than is typically the case. Using an especially derived panel data set for 16 European telecommunications operators, covering the period 2010 through 2016, we tested the main hypothesis regarding the impact of mobile operations on risk, as well as carried out a preliminary test regarding the validity of the Modigliani/Miller formula needed for the main hypothesis. We do not find any empir-

ical evidence that the risk parameters of fixed line and mobile network operators are different. Instead, they seem to be rather similar or within in the same range. Second, as a byproduct, we are not able to empirically confirm the Modigliani/Miller formula according to which the transformation of the equity betas into asset betas depends essentially on the debt/equity ratio assuming in the process a debt beta equal to zero. Our results rather confirm the findings of other studies suggesting that the debt beta is strictly positive.

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