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5. The Weighted Average Cost of Capital (WACC)

5.1 Introduction and main goals of the section

A specific deep focus on WACC in Regulatory Accounting reports starts from Chapter 5 of the 2017 RA report BoR (17) 169[1], which surveyed legacy WACC values, benchmarking final rates and methodologies for single parameters estimation within the WACC formula computed by NRAs specifically in market 3a and, more in general, in fixed markets.[2] It also provided information about the evolution of the WACC value over time.

The 2018 RA report (BoR (18) 215) provided an update of the information reported in BoR (17) 169 both for parameter values and methodologies with a cut-off date of 1st April 2018. The current 2019 report presents an up to date version of the WACC benchmark with a cut-off date of 1st April 2019.

Theoretical and practical issues concerning WACC were also covered in the opinion BoR (18) 167[3] issued by BEREC in response to the public Consultation launched by the European Commission.

During 2019 BEREC also provided further input to the Commission's considerations for the non-binding WACC Notice which was published on 7 Nov. 2019. In 2020 BEREC will start calculating certain WACC parameters according to the methodologies foreseen in the non-binding WACC Notice.

In line with the before mentioned BEREC input to the Commission consultation on the non-binding WACC Notice, (BoR (18) 167) it is important to point out that, whilst the importance of consistent application of the methodology foreseen in the Notice is acknowledged, NRAs must retain flexibility within the multidimensional details of their WACC estimation depending on national economic conditions, availability of data, the degree of wholesale and retail competition (which influences the beta), regulatory goals/strategy, judicial reviews, etc. NRAs must, of course, be able to substantiate individual approaches to the Commission, the regulated entity, competitors and other market participants, not least to provide legal certainty of their decisions.

The following analysis is based on an updated questionnaire targeted to collect information on:

- parameter values to evaluate the WACC;
- main methodologies currently used to estimate each parameter (based on predefined options) and adjustments that NRAs may apply to their standard approach in order to take into account country specificity
- evolution over time of methodologies and parameter values used by NRAs.

The questionnaire asked NRAs to provide updated information on pre-tax WACC both for fixed and mobile markets and the following main parameters of the WACC formula based on CAPM methodology – in force as at April 2019 -: i) Risk Free Rate (RFR); ii) Cost of Debt (CoD); iii) Beta; iv) Equity Risk Premium (ERP); v) Gearing; vi) Tax.

In Figure 1 the year of information available on WACC calculation in the RA-EWG database for fixed and mobile market respectively is reported for each country as well as their general frequency of updating (the RA-EWG started to collect information on historical information about the WACC calculation in 2016).

[1] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/7316-berec-report-regulatory-accounting-in-practice-2017.
[2] The information collected and presented in the report refers to market 3a. In some cases, due to country specificity issues, data provided can refer to the fixed market (i.e. market 1, market 3b, market 4). Where different data sets have been provided by NRAs this will be highlighted in the text.
[3] https://berec.europa.eu/eng/document_register/subject_matter/berec/opinions/8257-berec-position-paper-input-to-the-commission8217s-wacc-consultation-2018.

Figure 1 shows the information collected for each country (for 2019 the cut-off date is 1st April). The cells marked with "X" indicate that in that year single values of each WACC parameter are collected in the RA EWG data base. Colours provide information on the years where NRAs have taken a decision for the fixed market WACC since 2008: green marks decisions, orange public consultations in 2019[4], grey decisions in force in 2019 but taken after the cut-off date of the 1st April 2019.

For the mobile market information on those NRAs that calculate a specific mobile WACC is provided. Column "2018" reports the values collected in the RA EWG database in charge for 2018 independent from the year of the adoption, while the "2019" column reports only the cases where updated values are in force.

Questionnaires provide information on WACC methodologies and values applied to the fixed market for 32 NRAs[5]. Most of the NRAs (20) update WACC in line with their market analysis or when pricing decision are taken. In these cases, market-specific WACCs may be in force for 2 or more years. Some NRAs update yearly (10), but in some cases the update comes into force only when new pricing decisions are taken.

The dataset used for the following analysis takes into consideration 89 observations on all 6 parameters previously listed and 1 final value based on information collected and related to the period 2008-2019. The data collected refers to information provided by NRAs and is updated for the 2019 year report.

All values provided by NRAs are consistent with their final nominal pre-tax WACC calculation meaning that in some cases parameters also contain country specific adjustments applied to the cost of equity and attributed mainly to RFR, ERP or Beta according to the information provided in the questionnaires. Information on technical adjustments is also reported.

The 2019 report, in line with the 2018 version, will also provide statistics on WACC values and methodologies for the mobile market.

In order to present data and to compare with the previous years, a specific analysis on the dispersion of the values throughout the years is introduced by using box plot analysis. The main objective is to have a more detailed quantitative picture of the convergence path of the values. Taking into account the 25° percentile and 75° percentile of the values of each parameter distribution, a general reduction of the dispersion for all values may be observed: mainly for RFR and, to a lesser extent, ERP[6], CoD, beta and gearing.

Annex I of the current report contains information on a risk premium for NGA services.

Annex II of the current report contains a more detailed analysis of WACC parameters in terms of causal correlations as a follow-up from last year's report (see annex 2 of BoR(18) 215).

[4] In the following analysis the latest available information is displayed in line with each NRA's information on the appropriate value to be considered for the 2019 report. This approach allows the report to be updated with current information without effecting the consistency of the information on WACC estimation over time, taking into account the current status and time of adoption.

[5] For this year's report CH, LI, and IS, did not provide a reply, therefore these countries' data will be shown as in the last year's report BoR(18) 215. EE states that its final WACC value is obtained using a benchmark of other NRAs, rather than applying a formula.

[6] For ERP a reduction of "outlier" values is more evident in this year's report.

Figure 1 - WACC database and frequency of update/calculation[7]

	Fixed Market (Year of adoption)													Mobile Market		Frequency Update
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019		2018	2019	
AT		x			x			x						x		MA/RP
BE	x		x					x						x		MA/RP
BG						x			x					x		MA/RP
CH	x					x				x	x					YEARLY
CY				x				x		x	x	x		x	x	MA/RP
CZ									x			x		x	x	MA/RP
DE				x						x	x	x		x	x	YEARLY
DK								x	x	x	x	x		x	x	YEARLY
EL						x		x		x	x			x		MA/RP
EE																
ES		x				x			x	x	x			x	x	YEARLY
FI		x				x				x				x		MA/RP
FR				x		x		x		x				x		MA/RP
HR						x			x					x		MA/RP
HU								x	x	x	x			x		YEARLY
IE		x					x							x		MA/RP
IS											x					
IT			x					x				x		x	x	MA/RP
LI							x									MA/RP
LT								x			x					YEARLY
LU									x					x		MA/RP
LV																
MK		x												x		
MT					x									x		MA/RP
NL					x				x					x		MA/RP
NO						x				x	x			x		MA/RP
PL										x	x					YEARLY
PT								x	x	x				x		YEARLY
RO						x								x		MA/RP
RS							x	x	x	x	x			x		YEARLY
SE											x	x		x		MA/RP
SI							x					x				MA/RP
SK						x			x		x			x		YEARLY
UK			x					x			x	x		x		MA/RP
Number of observations Totals	2	5	3	3	3	10	4	12	11	13	15	8		26	6	

x	Available in the RA database
	Adopted decision
	Public consultation
	In force at the time of the annual report, but adopted after the cut off date of 1 April

Source: BEREC RA database 2019

[7] BNetzA WACC decisions are taken on the 30.06. of each year, therefore values stated are in use and valid for Q1/Q2 of the current year only.

5.2 WACC Nominal Pre-tax synthetic value

Figure 2 reports the main statistics related to nominal pre-tax WACC for all NRAs which provided information in 2019 (32 for fixed and 26 for mobile) and, separately, for the EU members states (26 and 23 respectively) which are subject to the same Regulatory framework (including EU notice on WACC).

Figure 2 - Main statistics nominal pre-tax WACC

	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
WACC fixed Nominal Pre-tax; 32 NRAs (2018)	**7.71% (7.96%)**	**7.28% (7.73%)**	**2.23% (2.34%)**	**28.87% (29.39%)**	**13.45% (14.30%)**	**4.04% (4.04%)**
WACC mobile Nominal Pre-tax; 26 NRAs (2018)	**8.59% (8.73%)**	**8.11% (8.11%)**	**2.17% (2.21%)**	**25.27% (25.37%)**	**14.29% (14.29%)**	**5.55% (5.66%)**
WACC fixed Nominal Pre-tax; 26 EU NRAs (2018)[8]	**7.60% (7.86%)**	**7.28% (7.73%)**	**1.87% (1.96%)**	**24.60% (25.00%)**	**13.45% (14.30%)**	**4.62% (14.30%)**
Wacc mobile Nominal Pre-tax; 23 EU NRAs (2018)	**8.22% (8.34%)**	**7.63% (7.89%)**	**1.89% (1.92%)**	**23.03% (22.97%)**	**14.29% (14.29%)**	**5.55% (5.66%)**

Source: BEREC RA database 2019

The average WACC value currently in force for fixed and mobile markets slightly decreased with respect to the previous year's report (values in brackets).[9] Also the relative standard deviation is decreasing mainly due to less outliers as reported in the box-plot in Figure 4 below.[10]

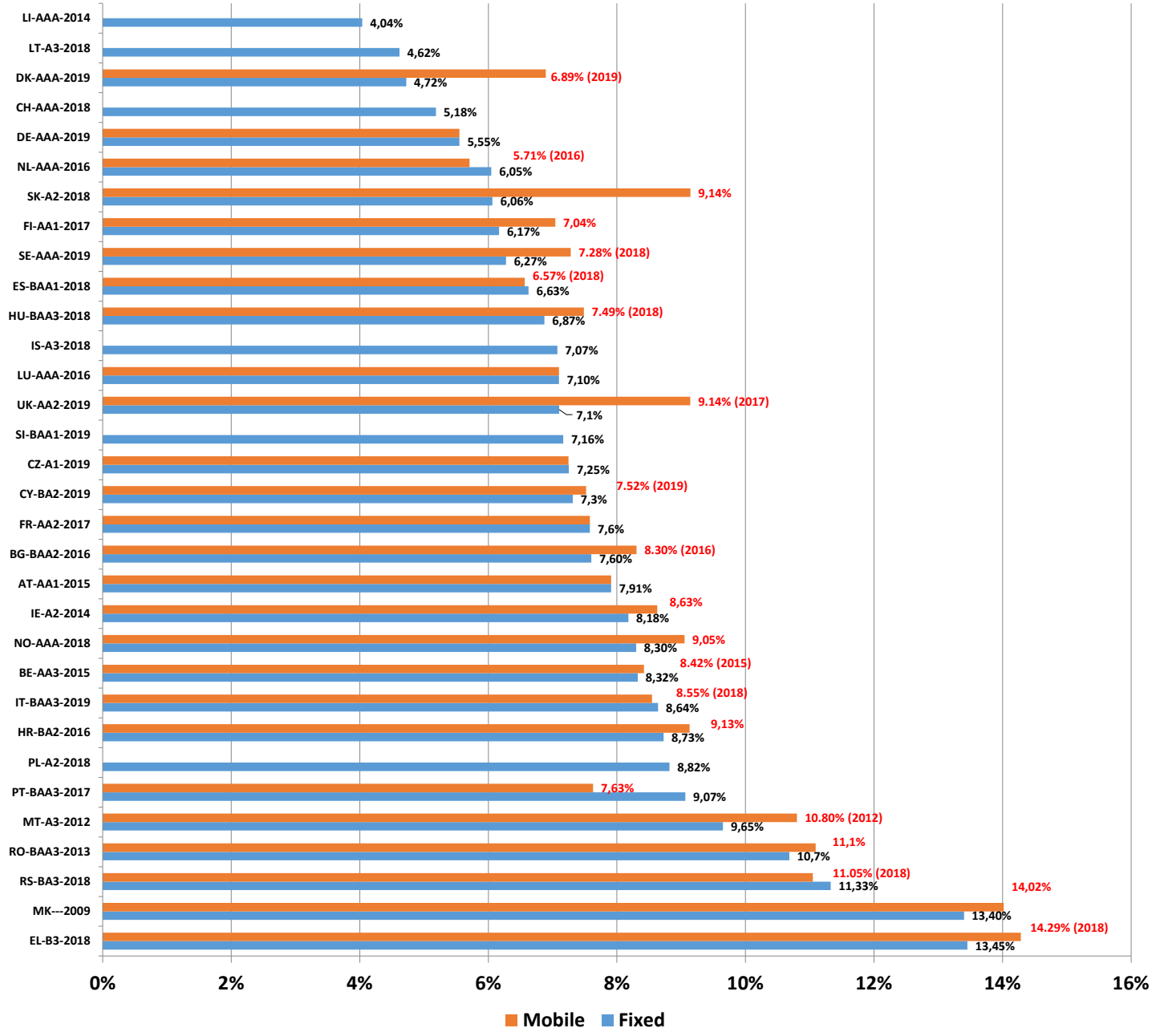
In Figure 3 WACC values for fixed and mobile markets have been sorted (from lowest to highest including the year of the adoption) and current country credit rating information is also provided. With respect to the overall 32 NRAs that gave details on WACC for the fixed market, 26 also provided information with reference to the mobile market. Among the 26 NRAs that evaluate a mobile market WACC, 4 NRAs estimate a single WACC for fixed and mobile markets; 16 NRAs estimate a higher WACC for the mobile market (on average +0.96%); and 6 NRAs estimate a lower mobile market WACC with respect to fixed services (on average -0.37%). As a whole, the differences between fixed and mobile estimation on average are decreasing.

[8] The information related to European Union Countries refer to the following countries: AT,BE,BG,CY,CZ,DE,DK,EL,ES,FI,FR,HR,HU,IE,IT,LT,LU,MT,NL,PL,PT,RO,SE,SI,SK,UK. Estonia and Latvia did not provide information.

[9] Slight differences with the values published in BoR (18) 215 are due to revision of historical series of the values provided by NRAs in the 2019 survey.

[10] In descriptive statistics a box plot is a method for graphically depicting groups of numerical data through their quartiles. It represents the median (bold black line) the 25th and 75th percentiles of the distribution (upper and lower part of the red square) and the dotted lines indicates variability outside the upper and lower quartiles. Values are plotted as individual points (yellow dots), showing outliers.

Figure 3 - Nominal pre-tax WACC - fixed and mobile markets



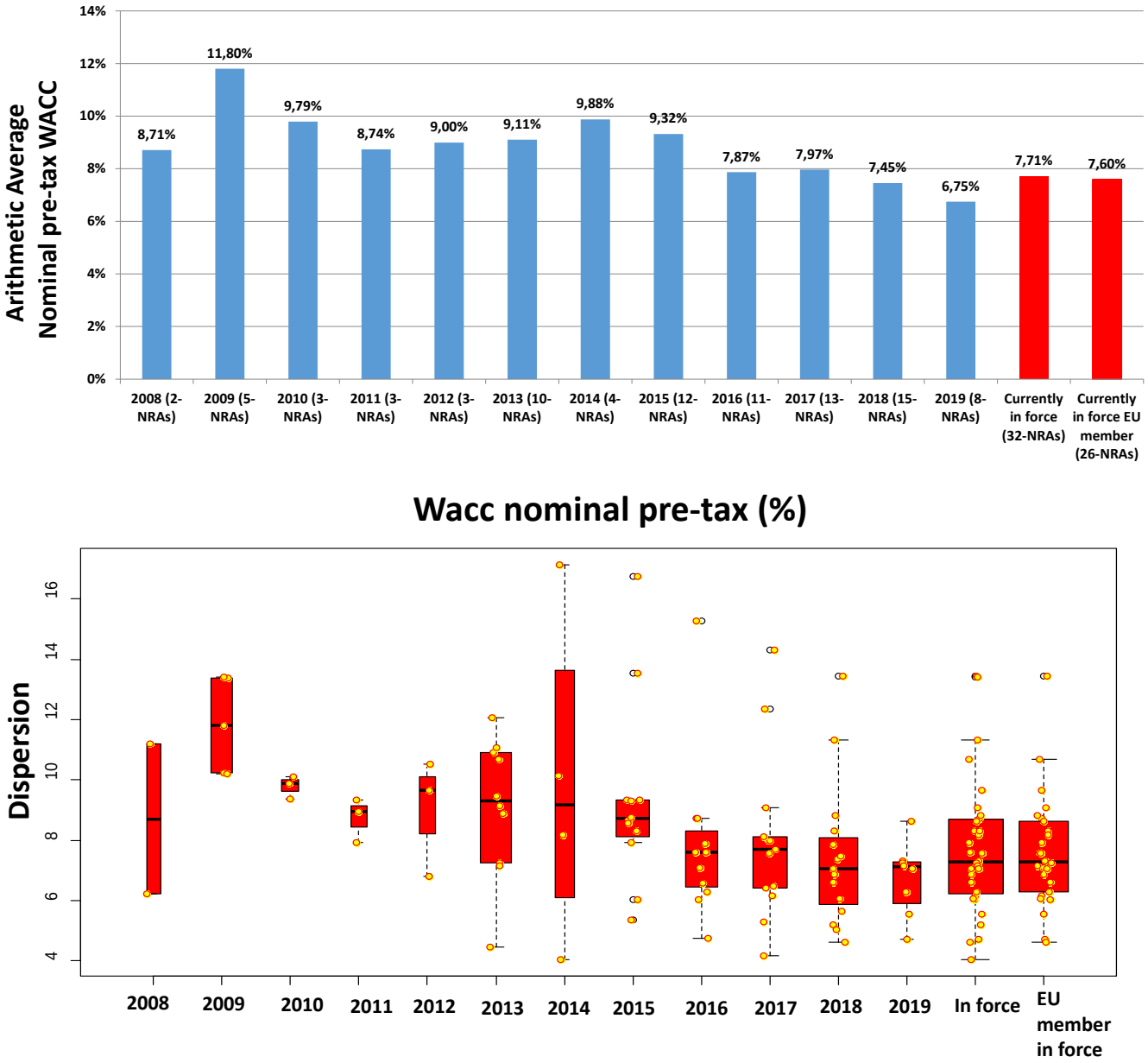
Source: BEREC RA database 2019

In Figure 4 the average year-by-year values and the corresponding box plot of the nominal pre-tax WACC for fixed market adopted are reported. The box plot reported in this figure provides only information about the dispersion between values where the average value is reported in the first graph. The objective is to inform the reader about how the average value is build up.

The average value currently in force is derived by averaging values that are in use at the date of the questionnaire's replies (independent of the year of the decision).[11]

[11] For DE the real pre-tax WACC in force after 1st July 2019 (after exponential smoothing) equals 4.87% for fixed and 4.91% for mobile. In Denmark (DK) a real pre-tax WACC of 4.9% is used in the LRAIC mobile model. For BE there exists (due to tax reform in 2006) a system of tax deduction for risk capital: deduction of fictitious interest (notional interest) calculated on the basis of a company's equity and which may be deducted up to a certain maximum the tax base of this company. The main aim of this measure was to reduce tax discrimination between loan financing and equity financing. Taking this into account the nominal pre-tax WACC for BE is 8,13% (both for fixed and mobile).

Figure 4 - Nominal pre-tax WACC (fixed market 2008-2019)



Source: BEREC RA database 2019

In order to explore the WACC parameters' weight with respect to the final WACC values according to the dataset collected by NRAs, we updated the regression exercise presented in BoR (17) 169 and in BoR (18) 215 see (Annex II). Updating the regression exercise can provide a quantitative approach useful to understanding the level of harmonisation of the parameters in light of the published Commission Notice on WACC, taking into account that the harmonisation process relates both to the methodology and values of some parameters. Data show – in line with the 2018 exercise – that the main differences in the final WACC values are mainly explained by parameters in the WACC calculation that are more "country specific" than "sector specific" such as the RFR, ERP and Tax, with a less relevant role for parameters such as beta, gearing and debt premium. This is consistent with survey results on "methodologies used" that confirm that beta, gearing and debt premium are estimated mainly on a "notional" basis.

The regression analysis (Annex II) in combination with descriptive statistics of the dispersion of the distribution of each parameter shows that the ERP is increasing in relevance (in relation to the variation of other parameters) when trying to explain variations in the final WACC value; at the same time a decrease

of the dispersion of the distribution of absolute values of the parameter is observed for all parameters. That means that even if the dispersion among values adopted by NRAs is decreasing for all parameters, this decrease in the dispersion is lower for ERP in comparison, for instance, to RFR. This highlights that the ERP is still the main element of differentiation among NRAs in a general scenario of harmonisation. Analysing the dataset for EU-only member states the last conclusion is still more relevant. A somewhat smaller contribution is provided by beta and debt premium.

5.2.1 Risk Free Rate

see BoR (17) 169[12] and BoR (18) 167[13] for definition and general financial theory

Main output from the survey.

Based on the replies provided for the 2019 survey the following statistics were derived for the overall responding NRAs and for EU NRAs separately (2018 values in brackets).[14]

Figure 5 – Nominal Risk Free Rate

2019	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Nominal RFR-fixed market: 32 NRAs (2018)	2.70% (3.00%)	2.50% (2.59%)	1.90% (2.11%)	70.18% (70.54%)	10.04% (10.04%)	0.31 (-0.17%)
Nominal RFR-mobile market: 26 NRAs (2018)	3.11% (3.18%)	2.58% (2.72%)	1,92% (2.02%)	61.94% (63.43%)	10.04% (10.04%)	0.91% (0.48%)
Nominal RFR-fixed market EU: 26 NRAs (2018)	2.34% (2.70%)	2.34% (2.59%)	1.32% (1.71%)	56.18% (63.30%)	6.39% (7.21%)	0.31% (-0.17%)
Nominal RFR mobile market EU: 23 NRAs (2018)	2.68% (2.74%)	2.54% (2.54%)	1.24% (1.37%)	46.25% (49.85%)	6.39% (6.39%)	0.91% (0.48%)

Source: BEREC RA database 2019

The average value of the nominal RFR currently in force is moderately decreasing in comparison to the 2018 survey, following the international trend of interest rates, even if the differences among countries remains relatively stable. It should be noted that differences are more relevant when non EU members are included in the sample.

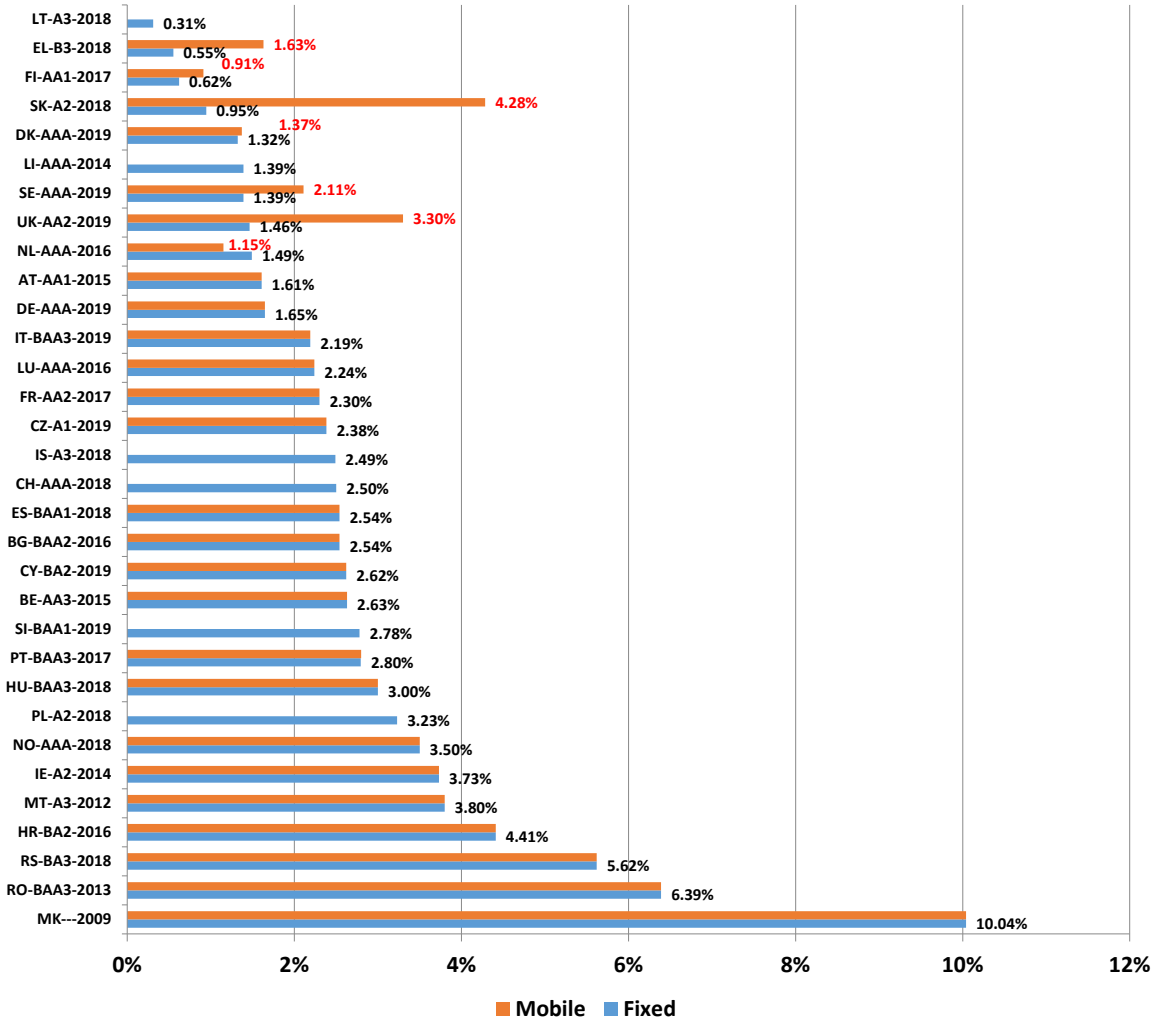
[12] https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/7316-berec-report-regulatory-accounting-in-practice-2017.

[13] https://berec.europa.eu/eng/document_register/subject_matter/berec/opinions/8257-berec-position-paper-input-to-the-commission8217s-wacc-consultation-2018.

[14] Data includes adjustments that can be attributed to RFR, as declared by NRAs, consistent with the final WACC estimation.

In Figure 6 the nominal risk free rate is reported for fixed and mobile markets (where available). Only 5 NRAs that estimate both fixed and mobile WACC have a different value for the RFR and this is due mainly to different years of estimation[15] rather than a different methodology or application of the methodology.

Figure 6 – Nominal Risk Free Rate (fixed and mobile markets)[16]



Source: BEREC RA database 2019

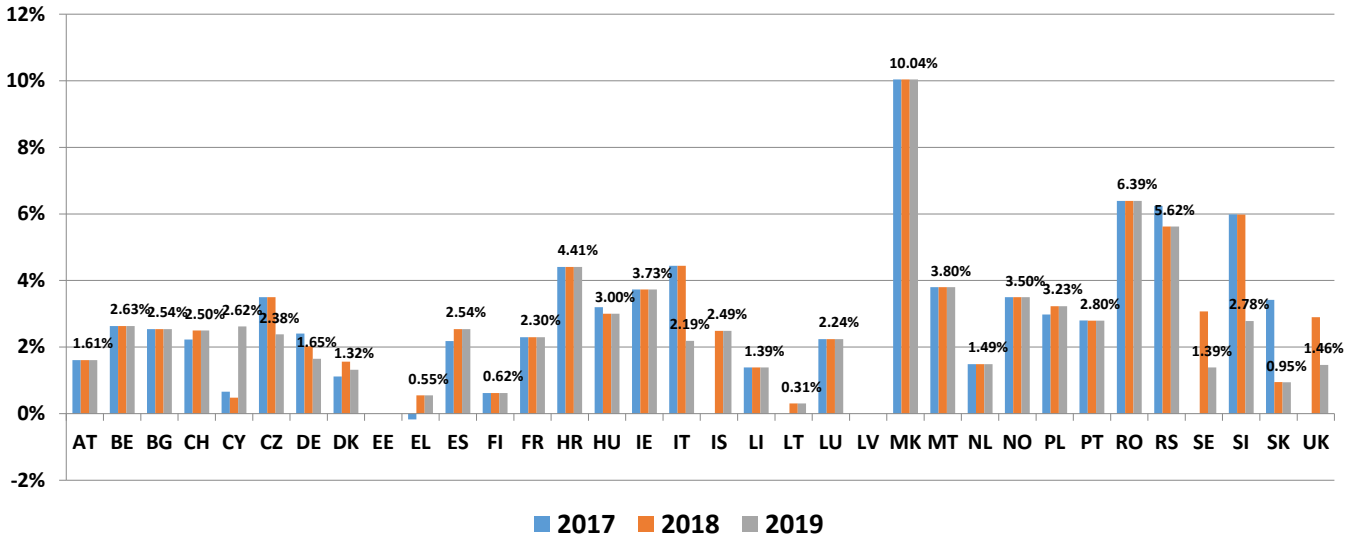
In Figure 7 the box plots of the distribution for 2017-2018-2019 data are also reported for the fixed market taking into account information on the RFR in force according to the data reported in Figure 1.[17]

[15] On the y-axis the date of the estimation for the fixed market is reported in line with the data provided in the RA EWG database as reported in Figure 1.

[16] Specifically for CZ the 2017 value reported in BoR (17) 169 includes a country risk premium, not included in the RFR data of the 2018 report. The country risk premium for CZ in 2018 is highlighted separately as an adjustment to the cost of equity as reported in the next section.

[17] In Figure 4 missing data for the specific year means that the value is not available in the RA database as it is shown in Figure 1 (notwithstanding to the value applied by NRAs for that year).

Figure 7 - Nominal Risk Free Rate (fixed market 2017-2019)



Source: BEREC RA database 2019

The following figures compares the main methodologies/approaches used by NRAs to estimate RFR (the answers were based on a set of pre-defined alternatives as reported in the figure).

Figure 8 - Main methodology in use to estimate RFR

Main methodology	
Domestic bond	Refers to the use of own country bond
Country-specific bond	Refers to the use of a specific bond from a different country
Other	A mix of methodologies and judgement is used to derive an estimate taking into account a mix of domestic and other country bond
Benchmarking	the RFR is estimated by referenced to RFR values used by other NRAs

Source: BEREC RA database 2019

In Figure 9 and Figure 10 the complete summary of the methodologies currently in use by NRAs for estimating the RFR for the fixed and mobile market is reported. Red figures report the most frequent approach (in comparison, 2018 data in brackets).

Figure 9 - Methodology used to estimate RFR (fixed market)

	Do you evaluate the Real Risk Free Rate in order to compute the Nominal Risk free Rate?		Methodology/Country bond		Bond length		Sampling period used		Averaging window		Average methodology		Quantitative Easing	
Nominal Risk Free Rate	Yes	7 (7)	domestic bond	21 (21)	1 year	0	Daily	15 (14)	Spot rate	1 (1)	Arithmetic average	24 (23)	Yes	2 (2)
	No	23 (23)	country specific bond	4 (4)	3 years	0	Weekly	1 (1)	3 months	1 (2)	Geometric Average	0	No	20 (21)
			other	7 (7)	5 years	0	Montly	10 (10)	6 months	1 (2)	Moving Average	1(2)	Comment	3 (2)
			benchmarking	0	10 years	26 (26)	Other	4 (3)	1 Year	7 (7)	Median	1 (1)		
					20 years	1			2 Years	3 (3)	Other	2 (2)		
					Other	4 (5)			3 Years	5 (5)				
									5 Years	9 (7)				
									10 Years	3 (3)				
									Others	0 (1)				

Source: BEREC RA database 2019

Figure 10 - Methodology used to estimate RFR (mobile market)

	Do you evaluate the Real Risk Free Rate in order to compute the Nominal Risk free Rate?		Methodology/Country bond		Bond length		Sampling period used		Averaging window		Average methodology		Quantitative Easing	
Nominal Risk Free Rate	Yes	(5)	domestic bond	16 (16)	1 year	(0)	Daily	11 (11)	Spot rate	1 (1)	Arithmetic average	18 (18)	Yes	2 (2)
	No	18 (18)	country specific bond	2 (2)	3 years	(0)	Weekly	1 (1)	3 months	1 (1)	Geometric Average	(0)	No	17 (17)
			other	7 (7)	5 years	(0)	Montly	8 (7)	6 months	1 (2)	Moving Average	2 (2)	Comment	2 (2)
			benchmarking	(0)	10 years	20 (21)	Other	2 (2)	1 Year	3 (3)	Median	1 (1)		
					20 years	1 (0)			2 Years	3 (3)	Other	1 (1)		
					Other	3 (3)			3 Years	5 (5)				
									5 Years	5 (4)				
									10 Years	3 (3)				
									Others	0 (2)				

Source: BEREC RA database 2019

With reference to the most frequent methodologies in use, the situation is stable in comparison to the previous year (few NRAs have changed methodology, i.e. CY, RS, SI, UK)[18].

[18] CY adopted a 20 year German bond (a 10 year bond used last year); RS, due to low liquidity of their own country bonds and low values compared to previous estimations, decided to use the ECB European bond estimation based on AAA countries, adjusted for country risk premium. UK placed more emphasis on short term averaging periods in comparison with the previous year, taking into account a long term effect of QE also on the cost of debt, and arguing that "*while the principle of stability referred to in the framework could support the use of longer averaging periods, we consider that placing greater weight on more recent yields would help ensure that our estimates of the cost of equity provide efficient price and investment signals, i.e. they would more closely reflect the current financial market conditions facing investors*". Due to this UK reduced the RFR by 1,3 percentage points from their 2018 estimation in line with an averaging window of 5 years from an estimation that was based on a longer average time window (see https://www.ofcom.org.uk/__data/assets/pdf_file/0021/149340/pimr-bcmr-llcc-draft-statement-annexes-1-25.pdf (pag. 326).

In line with the 2018 report, most NRAs use a nominal estimation of the RFR without first evaluating a real risk-free rate. A real risk-free rate is estimated in the fixed market by 7 NRAs (CH, IE, IS, MT, NO, PL, UK).

A quite consistent approach among NRAs in terms of the main methodologies used for estimating the RFR is evident, apart from the averaging window for which there is a less clear "most frequent" choice by NRAs. With respect to previous years an increase in the number of NRAs that use a "5 years" time-windows as averaging period can be shown.[19] At the same time RFR estimation can be influenced also by country specific issues such as exchange rates and expected inflation.[20]

Combining the approaches in terms of general methodology (geographical scope: domestic or country-specific) and time windows (the more differentiated parameters to estimate the RFR), the following statistics emerge (Figure 11).[21]

Figure 11 - Main methodology and time windows (frequency, number of NRAs, arithmetic averages, average time estimation in each subgroup, fixed market) [22]

RFR		Geographical scope			
		Domestic bond	Country specific	Other	Total
Time windows	<=1	8	1	1	10
	<=3	2	1	5	8
	>=5	10	1	1	12
	Total	20	3	7	30

RFR		Geographical scope			
		Domestic bond	Country specific	Other	Total
Time windows	<=1	BG,CH,ES,FI, HU,LT,PL,SK	EL	MK	11
	<=3	MT,PT	IE	AT,BE,HR, NL,RO	8
	>=5	CZ,DE,DK,FR,I S,IT,LU,SE,SI, UK	LI	RS	11
	Total	20	3	7	30

Source: BEREC RA database 2019

Two main groups (8 and 10 NRAs respectively) use domestic bonds and time windows that are: i) less than 1 year (BG, CH, ES, FI, HU, LT, PL, SK) or ii) greater than or equal to 5 years (CZ, DE, DK, FR, IS, IT, LU, SE, SI, UK).

Note that when "country specific" is chosen as the main category for RFR, a "country risk premium" is generally included in the cost of equity, e. g. in ERP; time windows are less relevant in this case.

[19] In Figure 2, replies of "7 years" (SE) and "6 years" (DK) were included in the category "5 years" for statistical reasons.
[20] When regressing categorical variables collected in the survey in the last years with the final value of the RFR no statistical significance can be detected between different methodologies used and the RFR final value (see Annex 2). On the other hand it is observed that RFR can be influenced by exchange rate issues between Eurozone and non-Eurozone countries.
[21] NRAs that have provided a different approach in comparison to previous year's report are shown in red.
[22] In the matrix figures (e. g. Figure 9), the first figure indicates the frequency of the methodological mix, the second mentions NRAs. NRAs listed in red have declared a different category in comparison to the previous year.

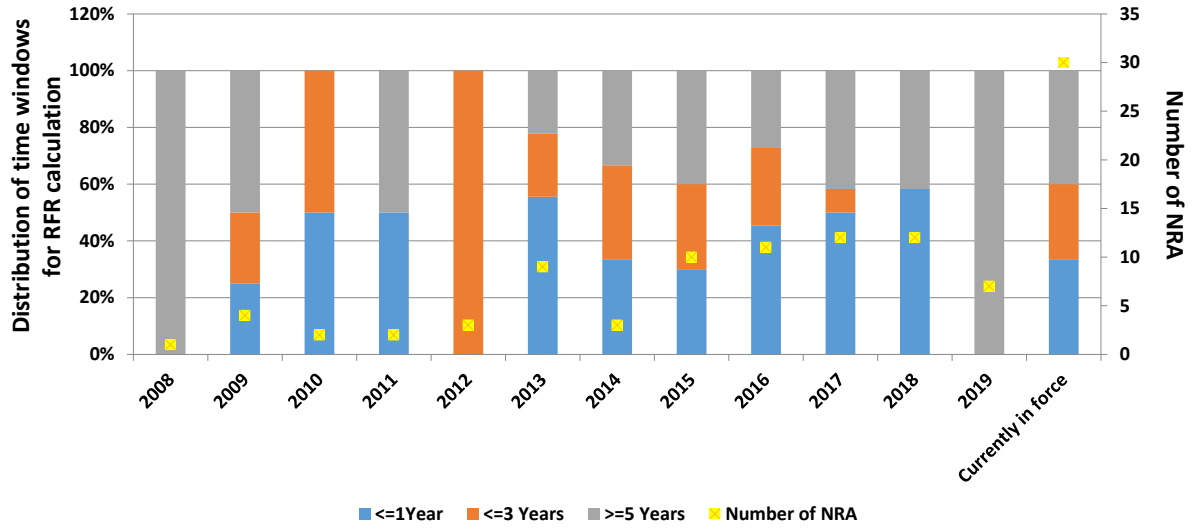
When “Other” is chosen as the main methodology combined with a short time window (<=1 year), the RFR generally includes some country specific risk premium (MK, RS) which is more relevant for the final value of the RFR; also in this case, the relevance of time windows is lower.

In any case values currently in force are also influenced by the time of estimation as shown by the corresponding figure.

Most NRAs that use an average window greater than 1 and less than 3 years do this in combination with “other” as the main methodology. In case of a heavy impact of the financial crisis, some countries state that they use German government bonds as a benchmark: these bonds are in fact less affected by fluctuations in short-term interest rates which may influence price control for 3 to 5 years.

Looking at the distribution of the “time windows” used by NRAs in 2013-2019, a period where many NRAs have updated WACC, an increase in the number of NRAs that choose time windows >=5 years is recorded especially in the case of the NRAs that update the WACC for 2019.

Figure 12 - Distribution of time windows RFR (fixed market)



Source: BEREC RA database 2019

Some countries apply adjustments to the estimation of the RFR as reported in the following figure. The year of update is also provided.

Since last year’s report SI eliminated any adjustment to the applied RFR methodology[23].

[23] SI have applied a country risk premium and a size premium to the RFR estimation since 2014.

Figure 13 - Adjustments applied to RFR (fixed market)

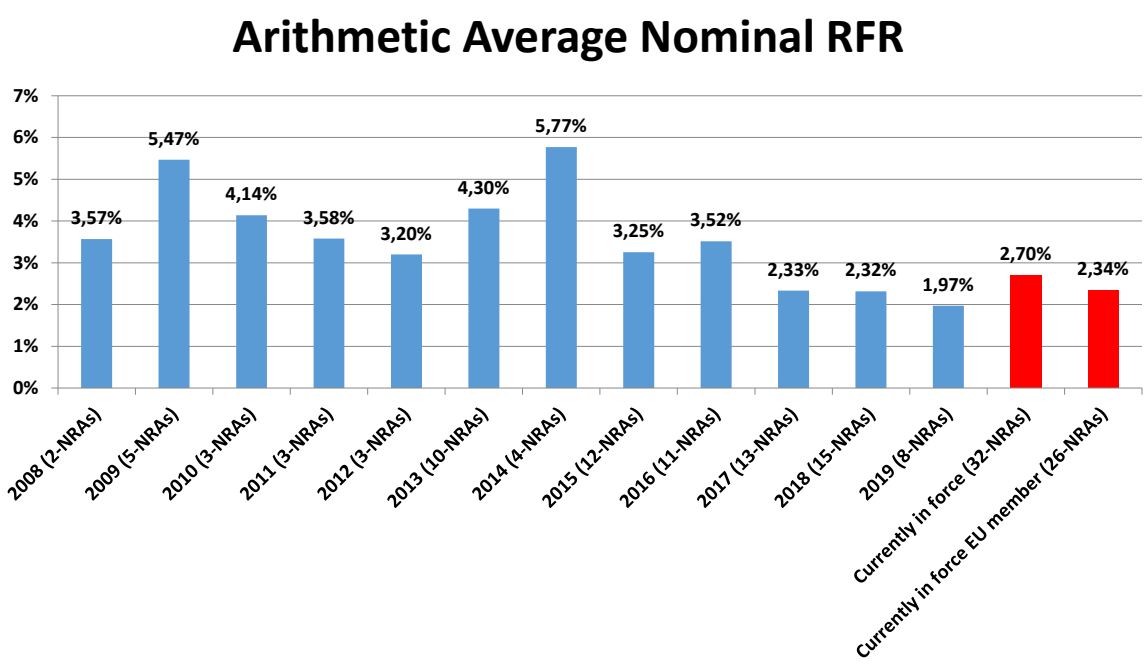
	Nominal RFR	Nominal risk free rate without adjustment	Country risk premium (%)	Size premium value (%)	Consistency with ERP estimation (hystorical data on ERP on different bond length)	Other adjustment: Size of adjustment (%)	Description of adjustment and how the adjustment was made
DK-2019 (previous report)	1.32% (1.56%)	0.84% (1.10%)			0.40% (0.4%)	0.076% (0.076%)	QE
ES-2018 (previous report)	2.54% (2.18%)	1.54% (1.18%)				1% (1%)	QE
IE-2014	3.73%	3.63%				0.10%	Aiming up
RO-2013	6.39%	3.19%	3.20%				Damodaran
MK-2009	10.04%	4.49%	4.19%	1.36%			

Source: BEREC RA database 2019

In Figure 14 the average year-by-year nominal Risk Free Rate adopted is reported including only NRAs that indicated in the survey an update for the WACC value in the corresponding year. The average value currently in force comes from averaging values in line with the information provided in Figure 1..

The RFR is slightly decreasing over the years in line with the experience of lower yields of own country bonds, also due to quantitative easing (QE) purchase programs. Looking at QE, two NRAs that have updated their WACC last year have taken this explicitly into account (DK, ES). In two other cases (FR and UK) quantitative easing has been indirectly taken into account without an explicit adjustment. One NRA (UK), even without making an explicit adjustment to time windows for this effect, explains that QE is one reason for preferring longer term average yields rather than spot rates. One NRA (IE) explains that using long time periods and taking account of the relationship with GDP growth implicitly adjusts for QE effects.

Figure 14 - RFR evolution over time (fixed market)



Source: BEREC RA database 2019

In conclusion:

- NRAs that use domestic bonds as a methodology for estimating the RFR together with a less than one-year time window explain their approach by aspiring to achieve consistency with a forward looking approach with respect to the financial situation. In this case, the deviation from the spot rate is a way to overcome short term volatility. It should be considered that the frequency of updating the WACC can have an influence on the approach used: among the 8 NRAs that use short time windows, 5 update the WACC yearly (ES, HU, LT, PL, SK)[24].

- NRAs that use domestic bonds and a time window average greater than 5 years explained their approach with the pursuing of "regulatory objectives" - thus granting predictability, consistency and transparency - and overcoming the effects of quantitative easing.[25] The choice of longer averaging bond windows seems to reflect the aim of estimating a "country risk premium" when this cannot be included in any other way. That is to say, within the current period of very low yields, the emphasis on longer data series aims at mitigating the risk of underestimating the WACC.

As to the main motivations behind the choice of the averaging windows, they are: i) to maintain regulatory predictability (e. g. a consistent approach over time or taking long term averages to limit variations between market reviews); ii) to avoid putting too much weight on factors which may distort current yields (e. g. QE); iii) consistency with the country-specific regulatory period; iv) consistency with the investment life cycle.

[24] On the other hand, out of the 8 NRAs that use a longer time window only one NRA updates the WACC yearly (DK).

[25] One NRA (DE) declared that a high fluctuation of the regulatory WACC over time is not in line with the requirements of the law. Therefore an exponential smoothing procedure has been used since 2009. The procedure's goal is to achieve fairness in the long run without having instability and unpredictability while, in the short run, it allows the regulator to stick to the chosen estimation procedures for the WACC even in years when the procedure leads to unexpected results. This exponential smoothing consists in weighting of the current estimation by 30%, while 70% is the weight attributed to the WACC estimated in the previous period.

5.2.2 Equity Risk Premium (ERP)

see BoR (17) 169 and BoR (18) 167 for definition and general financial theory

Main output from the survey.

Based on the replies provided for the 2019 survey the following statistics were derived for the overall responding NRAs and for EU NRAs separately (2018 values in brackets).

Figure 15 - ERP values (fixed and mobile markets)

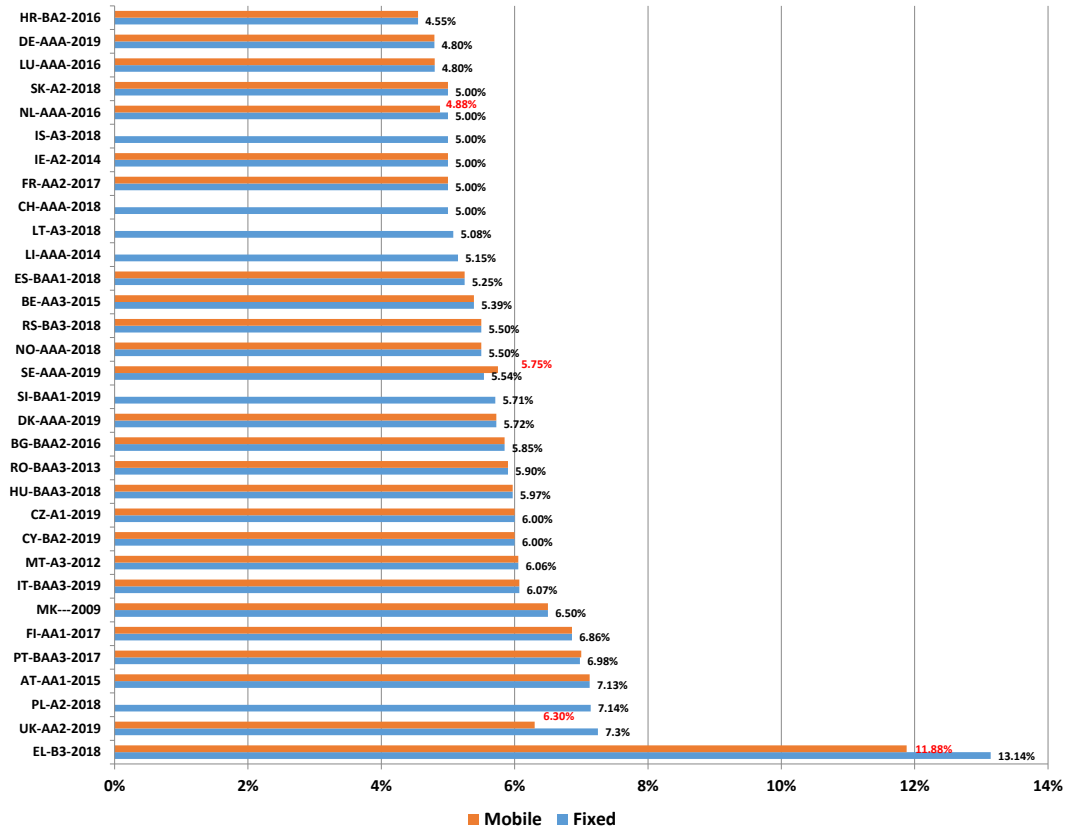
2019 currently in charge	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Equity risk premium ERP: fixed market - 32 NRAs (2018)	5.93% (5.90%)	5.63% (5.45%)	1.52% (1.90%)	25.57% (32.14%)	13.14% (14.46%)	4.55% (3.10%)
Equity Risk Premium mobile market- 26 NRAs (2018)	5.95% (5.90%)	5.80% (5.60%)	1.40% (1.69%)	23.47% (28.55%)	11.88% (11.88%)	4.55% (3.10%)
Equity risk premium ERP: fixed market - 26 EU NRAs (2018)	6.05% (6.03%)	5.79% (5.60%)	1.65% (2.07%)	27.27% (34.42%)	13.14% (14.46%)	4.55% (3.10%)
Equity Risk Premium mobile market - 23 EU NRAs (2018)	5.96% (5.93%)	5.85% (5.70%)	1.48% (1.78%)	24.77% (29.99%)	11.88% (11.88%)	4.55% (3.10%)

Source: BEREC RA database 2019

The average and median values for ERP in the fixed market are comparatively stable in relation to the past year, while the deviation decreased consistently.

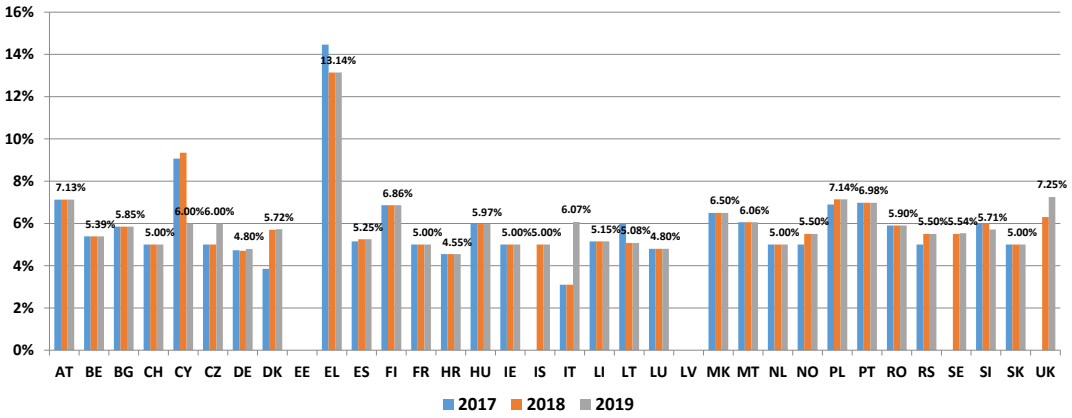
Figure 16 reports ERP ranking with the indication of Country rating.

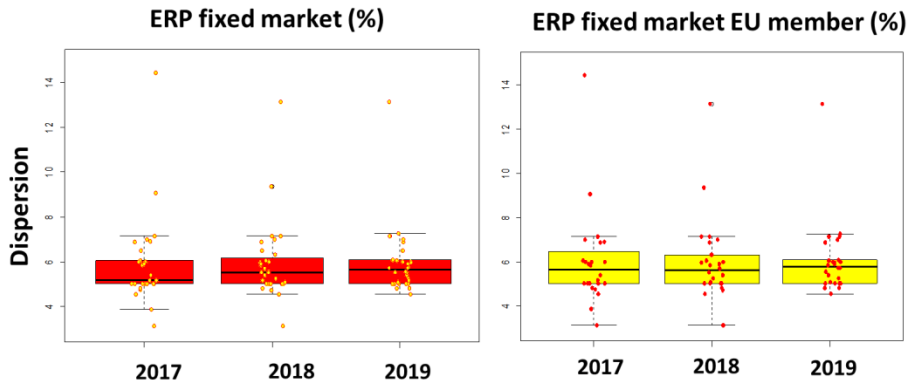
Figure 16 - ERP (fixed and mobile markets)



Source: BEREC RA database 2019

Figure 17 - ERP currently in force (fixed market 2017-2019)





Source: BEREC RA database 2019

Figure 17 shows that when the mobile WACC is estimated separately from the fixed market, the ERP is equal for the two markets; only 3 NRAs have provided different values. The dispersion of the distribution of ERP is decreasing over the years both in terms of outliers and the quantile of the distribution.

Figure 18 and Figure 19 compare the main approaches used by NRAs to estimate the ERP (the answers were based on a set of pre-defined alternatives as reported in the figure) for fixed and mobile markets.

Figure 18 – Methodologies for estimating ERP (fixed market)

	Methodology (General)		Specific Methodology		-If historical data Average methodology	
Equity risk premium	Notional value	13 (10)	Historical data	14 (13)	Arithmetic average	13 (12)
	country specific	9 (11)	Dividend grow model	0	Geometric Average	0 (1)
	other	8 (9)	Historical+DGM	3 (2)	Moving Average	0
	benchmarking	(1)	Historical+DGM+Suvey	2 (3)	Median	0
			Survey	2 (3)	Other	2(7)
			Historical+Survey	6 (6)	Arithmetic and Geometric	6

Source: BEREC RA database 2019

Figure 19 - Methodologies for estimating ERP (mobile market)

	Methodology (General)		Specific Methodology		-If historical data Average methodology	
Equity risk premium	Notional value	11 (9)	Historical data	11 (11)	Arithmetic average	11 (10)
	country specific	6 (7)	Dividend grow model	0 (0)	Geometric Average	0 (1)
	other	6 (7)	Historical+DGM	2 (2)	Moving Average	0(0)
	benchmarking	1 (1)	Historical+DGM+Suvey	3 (1)	Median	0 (0)
			Survey	2 (4)	Other	3 (5)
			Historical+Survey	6 (6)	Arithmetic and Geometric	3

Source: BEREC RA database 2019

In terms of the geographical scope of the methodology, the notional approach is the most frequent, even if no clear-cut preference emerges. In 2019, roughly one third of NRAs adopted a notional approach mixing

evidence from different countries, one third of NRAs choose a country-specific ERP (own country ERP) and one third opted for a methodological mix of own and foreign evidence (i.e. "other").[26]

According to some NRAs, a notional approach is generally preferred due to unreliable/missing own country-specific data and also because it may be able to provide more stable results.

In terms of the weight given to historical data, the ERP estimation by NRAs generally derives from a combination of data and judgement. Even in cases where NRAs use a clear cut methodology for ERP estimation, this is generally compared with other sources of evidence as a safeguard/sanity check (even if these further sources are not directly used for the estimation of the final value).

Most NRAs use historical data alone (14); the second largest group use historical data together with a survey and/or a DGM-Survey approach (11 NRAs); 2 NRAs estimate ERP only through surveys.[27]

In Figure 20 the main indicators on the "geographical scope" (notional vs. country specific) and the kind of information used in terms of weight given to the past is compared.[28] Countries in red are the ones which declared to have changed methodology in comparison to the previous year.

NRAs that use only historical data generally take into account long-time series.[29]
Where a mixed approach is chosen for the geographical scope ("other"), the estimation generally takes into account many sources, also from different European countries.

[26] One NRA uses a benchmarking approach based on ERP values in accordance with the risk premium used by other European NRAs (BG).
[27] In the 2018 questionnaire predefined options on the specific methodologies used have been included: i) Historical data (HD); ii) Dividend Growth Model (DGM); iii) HD+DGM; iv) HD+DGM+Survey; v) HD+Survey; vi) Survey.
[28] Note that not all NRAs have provided specific information on each methodological category.
[29] More than 100 years, taking as source DMS time series, Damoradan, Duff & Phelps, Pictet, as well as national bank sources. In some cases more than one source is used.

Figure 20 - Methodologies used to determine ERP (fixed and mobile markets)[30]

Fixed

	Historical data	Historical data + DGM/Survey	Survey	Total
Notional	5 (3)	6 (5)	1 (1)	12 (9)
Country specific	5 (6)	2 (3)	1 (1)	8 (10)
Other	4 (3)	3 (4)	0 (1)	7 (6)
Total	14 (12)	11 (11)	2 (3)	27(26)

	Historical data	Historical data + DGM/Survey	Survey
Notional	CZ,FR,HR, RO,SI	CY,DK,LU, MT,NL,PT	RS
Country specific	AT,CH,IE, IT,LI	ES,UK	FI
Other	DE,MK,NO, SK	BE,HU,SE	

Mobile

	Historical data	Historical data + (DGM/Survey)	Survey	Total
Notional	4	6	1	11
Country specific	3	2	1	6
Other	4	3	0	7
Total	11	11	2	24

	Historical data	Historical data + DGM/Survey	Survey
Notional	CZ,FR,HR, RO	CY,DK,LU, MT,NL, PT	RS
Country specific	AT,IE,IT	ES,UK	FI
Other	DE,MK,NO, SK	BE,HU,SE	

Source: BEREC RA database 2019

Relatively weak correlations, in terms of the main motivations behind NRAs methodological choices in defining ERP, may be observed from the data collected[31].

Predictability and transparency objectives are the main motivations behind a stronger emphasis on historical data. According to some NRAs, a notional approach is generally preferred in case of unreliable/missing own country-specific data. Where a notional approach is used in combination with historical data and other methodologies (DGM/Survey) this is generally motivated by the desire to combine predictability with a forward-looking perspective in the ERP estimation. The use of a pure forward-looking approach to estimate ERP is generally motivated by trying to include more country specificity in terms of macroeconomic conditions.

Figure 21 reports and compares the motivations behind the choice of parameters that contribute to the cost of equity (ERP and RFR) for the last two years.

[30] In parentheses the information from the 2018 report are provided for the fixed market. For the fixed market countries that have changed methodology in comparison to last year's report are shown in red. For the mobile market only those NRAs that apply a different methodology for fixed and mobile markets are shown in red.

[31] Main motivations behind NRAs methodological choices in defining ERP set in the questionnaire were: i) Regulatory predictability; ii) Consistency with RFR estimation and overall Total Market Return (TMR); iii) Reflect country specific conditions; iv) Consistency with market index used to estimate beta; v) Availability of evidence; vi) Other regulatory decisions.

Figure 21- Methodologies used to determine ERP and RFR (fixed and mobile markets)

Fixed

		ERP				
		Notional	Country specific	Other	Benchm arking	Total
RFR	Domesic bond	8 (7)	6 (8)	5 (4)	1 (1)	19 (20)
	Country specific	1 (0)	2 (2)	1 (2)	0 (0)	4 (4)
	Other	4 (3)	1 (1)	2 (2)	0 (0)	8 (6)
	Total	13 (10)	9 (11)	8 (8)	1 (1)	31 (30)

		ERP			
		Notional	country specific	Other	Benchm arking
RFR	Domesic bond	CZ,DK,FR,LT, LU,MT,PT,SI	CH,ES,FI,IT,IS, UK	DE,HU, NO,SE,SK	BG
	Country specific	CY	IE,LI	EL	
	Other	HR,NL,RO, RS	AT	BE,MK	

Mobile

		ERP				
		Notional	Country specific	Other	Benchma rking	Total
RFR	Domesic bond	6	4	4	1	15
	Country specific	1	1	0	0	2
	Other	4	1	2	0	6
	Total	10	6	6	1	23

		ERP			
		Notional	country specific	Other	Benchma rking
RFR	Domesic bond	CZ,DK,FR, LU,MT,PT	ES,FI,IT,UK	DE,HU, NO,SK	BG
	Country specific	CY	IE		
	Other	HR,NL,RO,RS	AT	BE,MK	

Source: BEREC RA database 2019

The comparison shows that some NRAs that use their own country specific ERP also estimate RFR with domestic bonds, providing the same geographical scope for the equity component (RFR and ERP) (6 NRAs), 8 NRAs use domestic bonds and a notional approach for the ERP (most frequent case).
One country, due to the heavy impact of the financial crisis, considers to include a country risk premium (EL).

Another relevant point is the relation between the "time windows" considered for estimating the RFR and the "data source" (historical vs forward-looking approach) for ERP estimation (Figure 20). This may be relevant in order to understand if a clear picture emerges showing the preference of NRAs for a forward-looking approach on RFR estimation (i.e. shorter time windows) rather than on ERP.

Figure 22 - Time windows used for ERP/RFR (fixed and mobile markets)[32]

Fixed Market

		ERP			
		Historical data	Historical data + other	Survey	Total
RFR	<= 1 year	3 (2)	2 (3)	1 (2)	7 (7)
	<= 3 year	4 (4)	5 (4)	(0)	8 (8)
	>= 5 years	5 (5)	4 (5)	1 (0)	10 (10)
	Total	12 (12)	11 (11)	2 (2)	25 (25)

		ERP		
		Historical data	Historical data + other	Survey
RFR	<= 1 year	CH,MK,SK	ES,HU	FI
	<= 3 year	AT,HR,IE,RO	BE,MT,NL,PT	
	>= 5 years	CZ,DE,FR,IT,LI,SI	DK,LU,SE,UK	RS

Mobile Market

		ERP			
		Historical data	Historical data + other	Survey	Total
RFR	<= 1 year	2	2	1	5
	<= 3 year	4	3	1	7
	>= 5 years	4	4	1	9
	Total	10	8	3	21

		ERP		
		Historical data	Historical data + other	Survey
RFR	<= 1 year	MK,SK	ES,HU	FI
	<= 3 year	AT,HR,IE,RO	BE,MT,NL	PT
	>= 5 years	CZ,DE,FR,IT	DK,LU,SE,UK	RS

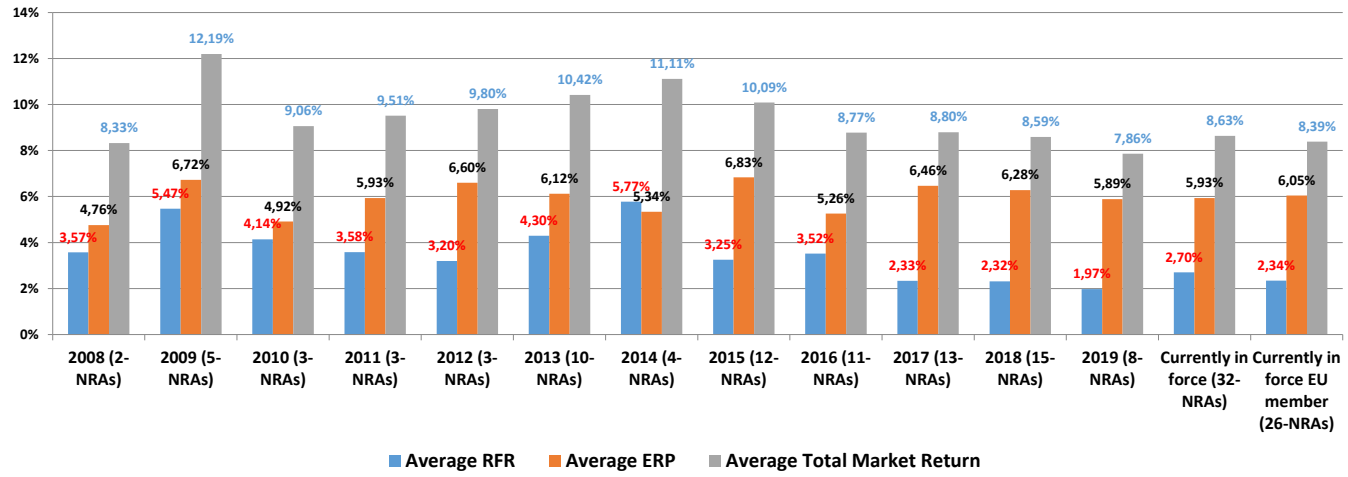
Source: BEREC RA database 2019

[32] The first figure indicates the frequency of the methodological mix, the second mentions NRAs, the third gives the arithmetic average values for main methodology combinations.

From Figure 22 we can derive that there is no clear common approach. The most frequent approach, which represents just one-fifth of the sample, is to estimate the RFR on the basis of a 3 or 5 year time window and the ERP based on historical time series. NRAs that choose this approach aim to be consistent with past WACC decisions. Deviations from pure historical time series are mainly due to the choice of adding more data sources ("sanity check") in order to estimate the parameter. In 2019 we note that the use of pure historical data seems to be the preferred approach for the final value estimation.

Figure 23 considers the average evolution over time of ERP, RFR[33] and TMR (ERP+RFR). In the period 2008-2019 ERP has a lower relative standard deviation over time with respect to RFR. The overall effect is a more stable result for the total cost of equity.

Figure 23 – Evolution ERP/RFR/TMR over time (2008-2019 fixed market)



Source: BEREC RA database 2019

Another element analysed in the questionnaire is the type of averaging method used when historical data are applied.

Most NRAs use an arithmetic average (12 NRAs for the fixed market), while a second group of NRAs using a mix of arithmetic and geometric average (7 NRAs for the fixed market).

A basic exercise of sensitivity analysis indicates that the choice of the "average" significantly affects the ERP value. The figure below shows the comparison of ERP actual values and values obtained "if" other types of averages were applied (e.g. data from the publicly available DMS database 1900-2017[34] were applied to some European countries).[35]

The data in Figure 24 cannot be directly compared to the data provided by NRAs in the questionnaire. When geometric and arithmetic average is presented, data refer to the available DMS database updated until 2018, whereas the actual value is the one provided by the NRAs for the RA EWG survey 2019. The

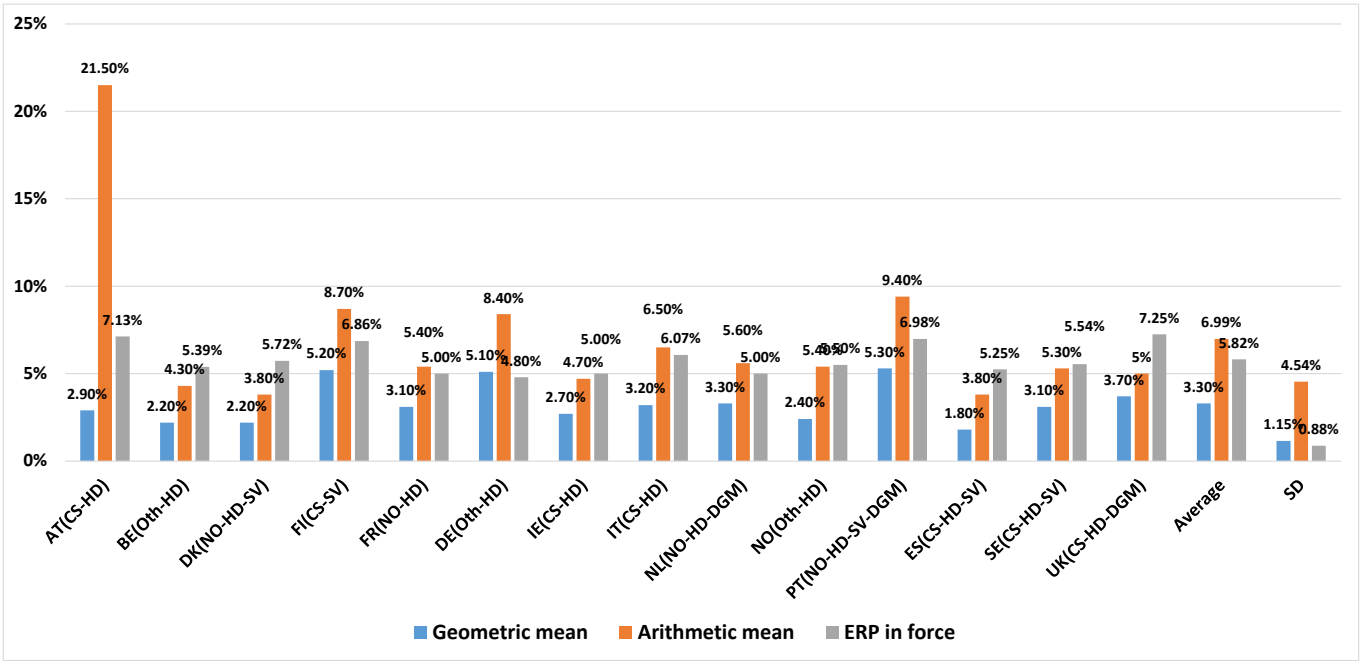
[33] This analysis is independent to the fact that NRAs take into account TMR estimation in their ERP/RFR calculation. Therefore values of TMR shown are obtained from RFR+ERP provided by NRAs for the WACC calculation. One NRA explicitly takes into account the calculation of TMR = ERP+RTR in their RFR and ERP estimation.

[34] Equity Risk Premium(ERP): Determinants, Estimation and Implications –The 2018 Edition https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3140837

[35] HD refers to use of "Historical data"; NO refers to notional approach; AA refers to Arithmetic Average; GA refers to geometric average; CS refers to Country Specific.

figures compare the actual values of ERP with ERP values using pure geometric or arithmetic averages, computed using public reference data.

Figure 24 - ERP values sub-set of countries (fixed market)



Source: BEREC RA database 2019 and Dimson, Marsh, Staunton 1900-2017 in Damodaran 2018

It becomes apparent that ERP values are very sensitive to the choice of average type, especially when historical data are considered.

5.2.3 Beta

see BoR (17) 169 and BoR (18) 167 for definition and general financial theory

Main results of the survey

Based on the replies provided for the 2019 survey the following statistics were derived for the overall responding NRAs and for EU NRAs separately (2018 values in brackets).[36]

[36] Asset betas/Equity betas are calculated with reference to different market indexes, thus comparison should be considered in the light of this fact.

Figure 25 - Equity and Asset Beta values (fixed and mobile markets)

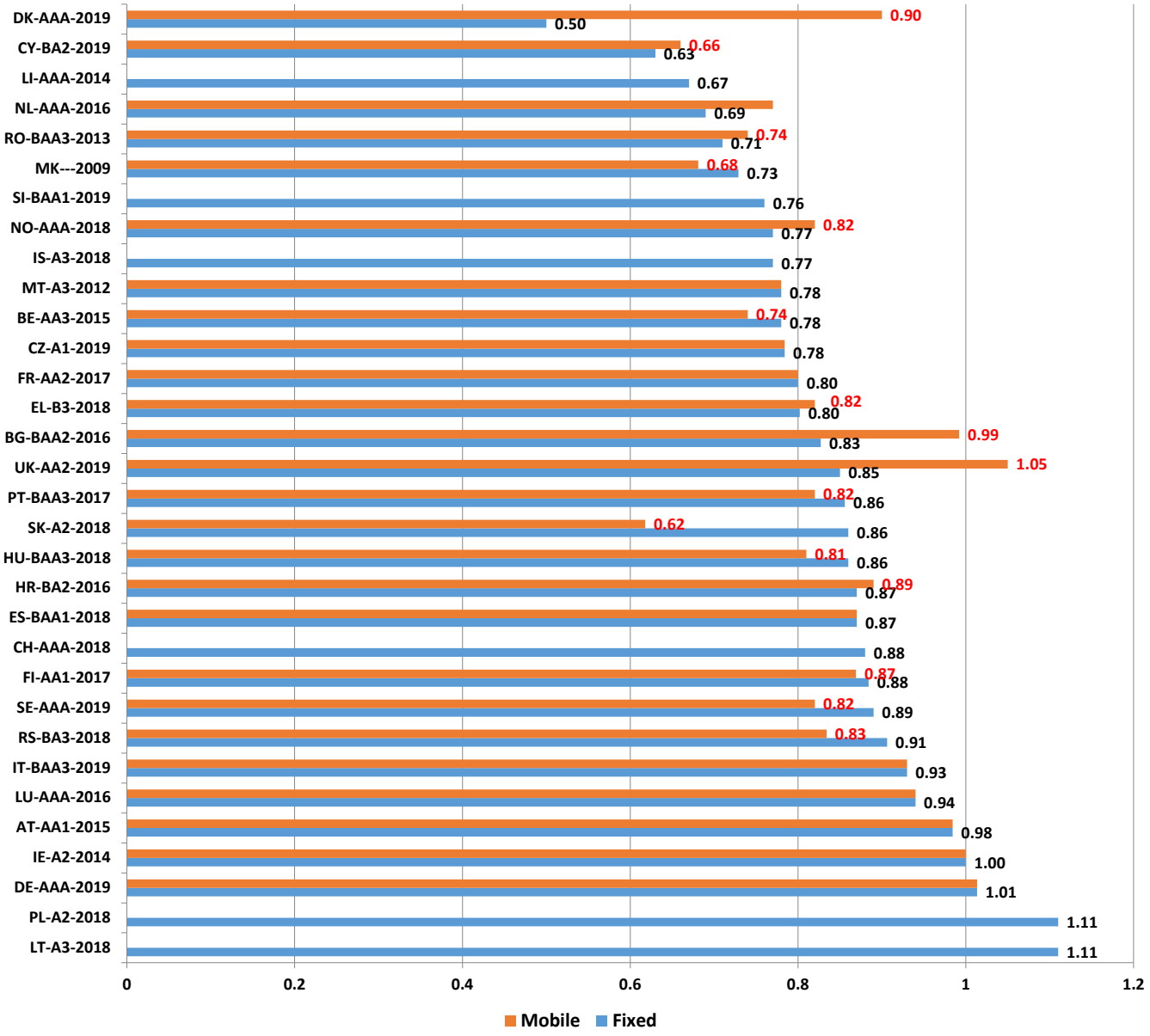
2019 Data		Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Fixed Market	Equity beta - 32 Nras (2018)	0.84 (0.83)	0.85 (0.82)	0.13 (0.14)	15.51% (15.53%)	1.11 (1.11)	0.5 (0.5)
	Asset beta - 18 NRAs (2018)	0.54 (0.53)	0.55 (0.54)	0.04 (0.06)	7.55% (12.06%)	0.62 (0.64)	0.43 (0.43)
	Beta debt - 3 NRAs (2018)	0.14 (0.14)	0.1 (0.1)	0.07 (0.07)	49.49% (49.49%)	0.22 (0.22)	0.1 (0.1)
Mobile market	Equity beta - 26 NRAs (2018)	0.84 (0.86)	0.82 (0.82)	0.11 (0.13)	13.24% (15.33%)	1.05 (1.21)	0.62 (0.62)
	Asset beta - 14 NRAs (2018)	0.57 (0.58)	0.60 (0.61)	0.1 (0.09)	16.98% (15.82%)	0.69 (0.69)	0.33 (0.33)
	Beta debt – 3 NRAs (2018)	0.16 (0.16)	0.15 (0.15)	0.06 (0.06)	38.47% (38.47%)	0.22 (0.22)	0.1 (0.1)
Fixed Market EU NRAs	Equity beta -26 NRAs (2018)	0.85 (0.84)	0.86 (0.84)	0.14 (0.13)	16.04% (16.02%)	1.11 (1.11)	0.50 (0.50)
	Asset beta – 14 NRAs (2018)	0.55 (0.54)	0.55 (0.55)	0.06 (0.07)	10.28% (13.40%)	0.64 (0.64)	0.45 (0.43)
	Beta debt -2 NRAs (2018)	0.16 (0.16)	0.16 (0.16)	0.08 (0.08)	53.03% (53.03%)	0.22 (0.22)	0.1 (0.1)
Mobile Market EU NRAs	Equity beta - 23 NRAs (2018)	0.85 (0.87)	0.82 (0.82)	0.11 (0.13)	13.32% (15.51%)	1.05 (1.21)	0.62 (0.62)
	Asset beta - 13 NRAs (2018)	0.57 (0.58)	0.60 (0.61)	0.10 (0.09)	17.37% (15.82%)	0.69 (0.69)	0.33 (0.33)
	Beta debt – 2 NRAs (2018)	0.16 (0.16)	0.16 (0.16)	0.08 (0.08)	53.03% (53.03%)	0.22 (0.22)	0.10 (0.10)

Source: BEREC RA database 2019

Average values for 2019 are stable with respect to 2018 data. Considering fixed and mobile markets, no major differences are reported.

Figure 26 reports Equity Beta values estimated by each NRA sorted from lower to higher values, as for the others parameters the information on the year of estimation and the credit rating of the country is reported.

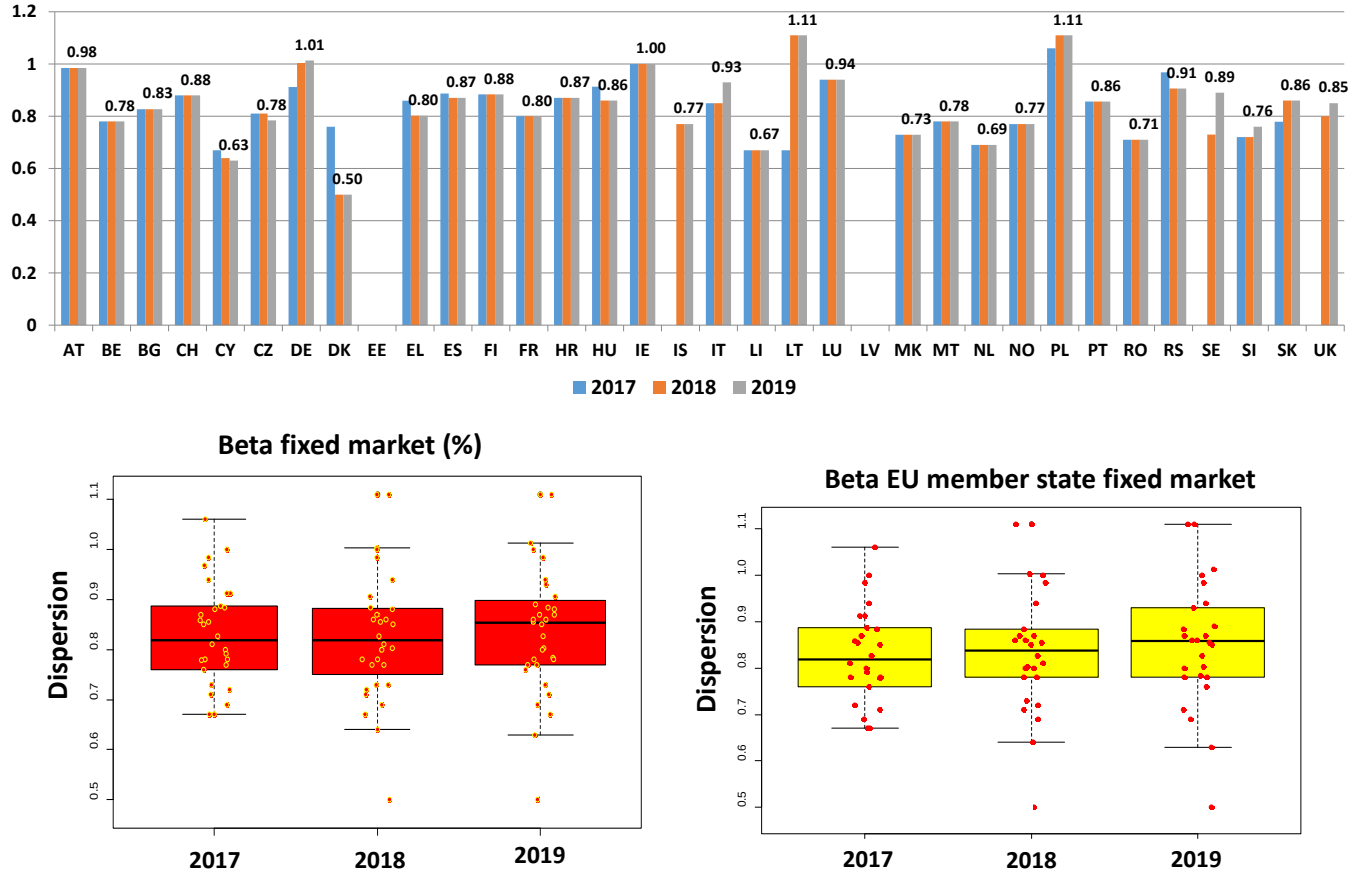
Figure 26 – Equity Beta values and distribution (fixed and mobile markets)[37]



Source: BEREC RA database 2019

[37] For UK the mobile beta is the midpoint of a high low range.

Figure 27 – Equity Beta values in fixed markets (2017-2019)



Source: BEREC RA database 2019

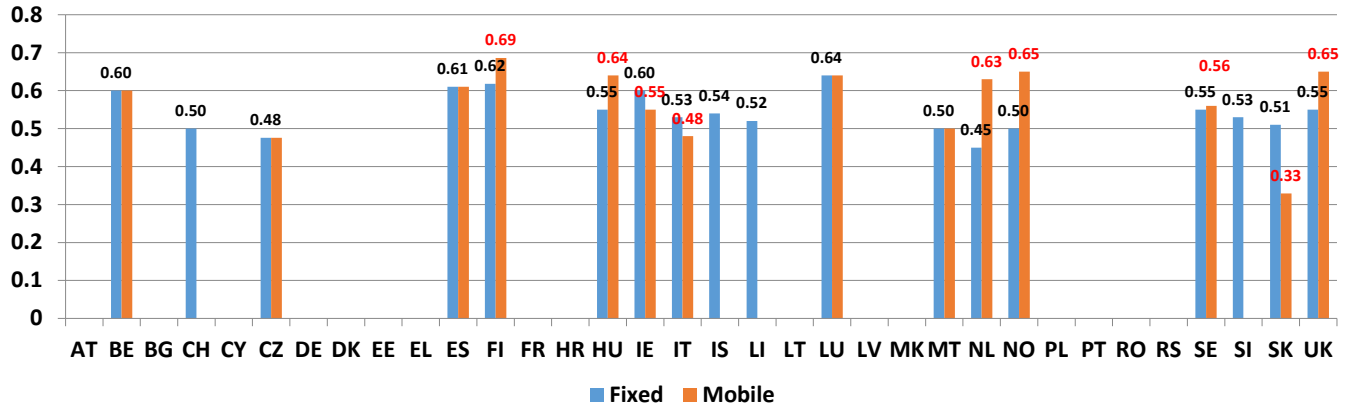
Among the 26 NRAs that evaluate WACC also for the mobile market, 9 NRAs estimate the same beta for the fixed and mobile market; 9 NRAs estimate a mobile beta higher than the one for the fixed market (on average +0.11 (+0.15))[38]; 8 NRAs estimate a lower mobile beta in comparison to fixed services (on average -0.072 (-0.14)).[39] In comparison to the previous year differences between fixed and mobile estimation are decreasing also for the beta factor in line with empirical evidence that the risk parameters of fixed and mobile operators are not differing since most operators are generally integrated in fixed and mobile markets.[40]

[38] "+" or "-" is referred with respect to fixed beta.

[39] Information collected in 2018 reported in brackets.

[40] S. Stephan and N. Wernet (2017) "The beta in the WACC for regulated fixed and mobile telecommunications services: its role and robust estimation" Passau, Germany, International Telecommunications Society.

Figure 28 - Asset Beta (fixed and mobile markets)[41]



Source: BEREC RA database 2019

The following figures summarise the different approaches used by NRAs to estimate the beta (mobile and fixed markets); the 2018 data are reported in brackets.

Figure 29 – Methodologies for estimating Beta (fixed market)

	Methodology		-if notional/others (if applicable) please indicate the average used (average to get the asset/equity beta from the comparable)		Sampling period		Time window		Adjustment Used		Market reference index used		Do you unlever your beta?		- if yes which formula do you apply?		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Beta (equity)	notional (generic operator)	21 (20)	Arithmetic average	6 (6)	daily	8 (8)	1 week	0	Dimson	0	Own Country	4 (3)	yes	22 (20)	Modigliani-Miller	13 (12)	Arithmetic average	(0)
	SMP Operator	6 (6)	Geometric Average	0	weekly	8 (8)	1 month	0	Bayesian	5 (5)	European	14 (14)	no	5 (6)	Miles & Ezzell	0	Geometric Average	(0)
	Other	3 (4)	Moving Average	0	montly	5 (4)	3 month	0	Blume	4 (4)	Word	6 (7)			Hamada	3 (3)	Moving Average	(0)
	benchmarking	2 (2)	Median	5 (4)	other	1 (1)	6 months	0	Vasicek	1 (1)					Other	5 (4)	Median	2 (2)
			Other	6 (5)			12 months	1 (1)	Others	2 (2)							Other	(0)
							2 years	3 (5)	No Adjustment	9 (8)								
							3 years	7 (7)										
							5 years	12 (8)										
							10 years	0										
							others	2 (2)										

Source: BEREC RA database 2019

[41] UK mobile asset beta is the midpoint of a high low range

Figure 30 - Methodologies for estimating Beta (mobile market)

	Methodology		-if notional/others (if applicable) please indicate the average used (average to get the asset/equity beta from the comparable)		Sampling period		Time window		Adjustment Used		Market reference index used		Do you unlever your beta?		- if yes which formula do you apply?		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Beta (equity)	notional (generic operator)	19 (17)	Arithmetic average	6 (5)	daily	8 (7)	1 week	0 (0)	Dimson	(0)	Own Country	3 (3)	yes	17 (16)	Modigliani-Miller	11 (11)	Arithmetic average	(0)
	SMP Operator	1 (2)	Geometric Average	0 (0)	weekly	6 (6)	1 month	0 (0)	Bayesian	5 (5)	European	11 (10)	no	4 (4)	Miles & Ezzell	0 (0)	Geometric Average	(0)
	Other	4 (5)	Moving Average	0 (0)	montly	3 (3)	3 month	0 (0)	Blume	3 (2)	Word	4 (5)			Hamada	1 (2)	Moving Average	(0)
	benchmarking	1 (1)	Median	3 (3)	other	1 (1)	6 months	0 (0)	Vasicek	0 (0)					Other	5 (4)	Median	1 (1)
			Other	5 (5)			12 months	1 (1)	Others	2 (2)							Other	(0)
							2 years	1 (2)	No Adjustment	6 (6)								
							3 years	7 (7)										
							5 years	8 (6)										
							10 years	0 (0)										
							others	0 (1)										

Source: BEREC RA database 2019

The most frequent methodology used by NRAs to estimate a notional beta is based on a peer group of telecom comparators (21 NRAs for fixed market). When “Other” is declared (3 NRAs) it generally refers to a hybrid approach that takes into account different sources of estimation; it can be either closer to a notional approach or to an estimation of an SMP beta. In comparison to last year’s report an increase of NRAs that use a time windows based on longer time period (5 years is now the more frequent approach with respect to the previous year) can be observed.

Figure 31 - Main Beta estimation methodologies and values (fixed and mobile markets 2019)[42]

	2019 Fixed Market			2019 Mobile Market		
	Equity beta	Asset Beta	Countries	Equity beta	Asset Beta	Countries
SMP Operator	0.83 (0.84)	0.53 (0.50)	BE,BG,EL,LT,NL,SI	0.74 (0.68)	0.55 (0.46)	BE
notional (generic operator)	0.85 (0.82)	0.55 (0.54)	AT,CH,CY,CZ,DK,ES, FI,FR,HR,HU,IE,IT,IS, LU,MK,PL,PT,RO,RS, SE,SK	0.82 (0.82)	0.50 (0.65)	BG,CY,CZ,DK,FI,FR ,HR,HU,IE,MK,NL, PT,RO,RS,SE,SK
Other	0.88 (0.83)	0.53 (0.51)	DE,NO,UK	0.93 (0.98)	0.59 (0.61)	IT,NO,UK
benchmarking	0.73 (0.73)	0.51 (0.51)	LI,MT	0.78	0.50	MT

Source: BEREC RA database 2019

Where a notional approach is chosen the number of comparable operators varies between 10 and 34, mainly European. Some NRAs choose the peer group in line with their main business: fixed, mobile or broadcasting.

One NRA, in order to differentiate the Beta for fixed and mobile, applies a regression directly to the equity beta of each comparable of the peer group considering as weight the percentage of revenues in each sector (fixed and mobile and other revenues) (DK).

Another NRA (LU) proved that no difference between fixed and mobile beta were found by applying a regression on asset beta finding no statistical significance between the estimated beta and the weights of revenues failing the corresponding beta decomposition.[43]

The way the average beta is estimated from the peer group may differ according to the different kind of averaging method chosen. The median is more frequent in case of higher number of comparables.

[42] For example, different market indices are considered (BE); in one case the TMI Telecom Stoxx Index is regressed as dependent variable with the general TMI Stoxx Index being the independent variable (DE), the comparison between the SMP and own country operators are benchmarked with other groups of comparable operators (UK, NO).
[43] https://assets.ilr.lu/telecom/Documents/ILRLU-1461723625-156.pdf

Figure 32 - Beta notional methodology (fixed market)

Country	Main Methodology	Peer Group	Kind of average
CH	notional (generic operator)	12, historical telco companies in UE	Arithmetic average
CZ	notional (generic operator)	19 telecom companies, criteria for selection: the shares of the firms are liquidly traded, the firms are active in telecom industry in European countries, market capitalization more that 1 billion EUR, and no acquisitions or mergers.	Median
DK	notional (generic operator)	14 operators	Arithmetic average
ES	notional (generic operator)	14 comparable operators, with similar business mix and listed in the stock exchange	Arithmetic average
FI	notional (generic operator)	15 telecom companies	Median
HR	notional (generic operator)	For peer group listed European telecom companies with headquateers in EU are selected. Beta coeficient peer group is consists of 20 companies.	
HU	notional (generic operator)	20, European operators listed on the stock exchanges	Median
IE	notional (generic operator)	7, European fixed-line incumbents	Other
IT	notional (generic operator)	10 main SMP access market Western Europe Operator	Arithmetic average
IS	notional (generic operator)	11 telecom companies in Western-Europe	Other
LU	notional (generic operator)	13 selected comparators as integrated operator	Arithmetic average
MK	notional (generic operator)	13 comparable fixed line operators in EU with following criteria: provides fixed line telephony services; generates majority of revenues from providing fixed line telephony services; operates and is based in Europe; has liquid common stock traded on a stock exchange in Europe; and has readily available financial data;	Median
PT	notional (generic operator)	16 comparator	Arithmetic average
RO	notional (generic operator)	17 countries peer group of operators based in Europe with shares traded on stock exchanges and consistent with previous WACC computation exercises	Other
RS	notional (generic operator)	12 comparable companies and main criteria for selection were: comparable industry, relatively similar products/services and geographical location.	
SE	notional (generic operator)	12 European operators (vertical integrated)	Arithmetic average
SK	notional (generic operator)	10, European telecom operators listed on the stock exchange.	Median

Source: BEREC RA database 2019

In Figure 33 it may be observed that if a different beta is evaluated for fixed and mobile, in case a notional approach is applied, mostly the number and the kind of comparables chosen reflect a specific mobile target. In other cases the difference in beta values is due just to different timing of the estimation.

Figure 33 - Beta notional methodology (mobile market)

	Fixed			Mobile		
Country	Methodology	Number of comparable	Average	Methodology	Number of operator	Average
AT	notional (generic operator)	-	-	notional (generic operator)	-	-
CY	notional (generic operator)	-	-	notional (generic operator)	-	-
CZ	notional (generic operator)	19 operators	Median	notional (generic operator)	19 operators	Median
DK	notional (generic operator)	14 operators	Arithmetic average	notional (generic operator)	14 operators	Arithmetic average
ES	notional (generic operator)	14 operators	Arithmetic average	notional (generic operator)	14 operators	Arithmetic average
FI	notional (generic operator)	15 operators	Median	notional (generic operator)	6 operators	Median
FR	notional (generic operator)	-	-	notional (generic operator)	-	-
HR	notional (generic operator)	20 operators	-	notional (generic operator)	20 operators	-
HU	notional (generic operator)	20 operators	Median	notional (generic operator)	9 operators	-
IE	notional (generic operator)	7 operators	Other	notional (generic operator)	-	-
LU	notional (generic operator)	13 operators	Arithmetic average	notional (generic operator)	13 operators	Arithmetic average
MK	notional (generic operator)		Median	notional (generic operator)	-	Median
PT	notional (generic operator)	16 operators	Arithmetic average	notional (generic operator)	5 operators	Arithmetic average
RO	notional (generic operator)	17 operators	Other	notional (generic operator)	23 operators	Other
RS	notional (generic operator)	12 operators	-	notional (generic operator)	8 operators	-
SE	notional (generic operator)	12 operators	Arithmetic average	notional (generic operator)	-	-
SK	notional (generic operator)	10 operators	Median	notional (generic operator)	11 operators	Median

Source: BEREC RA database 2019

Concerning the sampling period, daily and weekly sampling are the most frequent approaches used. In general, the choice of the sampling period doesn't seem to be correlated with the time window approach used as reported in Figure 34 (2018 figures in brackets).

Figure 34 - Beta methodology for sampling period and time windows (fixed and mobile markets)

Fixed							Mobile						
		Time windows						Time windows					
		<=2 Years	<=3 Years	>=5 Years	Others	Total		<=2 Years	<=3 Years	>=5 Years	Others	Total
Sampling period	daily	1 (2)	4 (3)	2 (2)	0	7	Sampling period	daily	0	4	1	0	5
	weekly	1 (3)	2 (1)	5 (3)	0	9		weekly	0	3	4	0	7
	montly	0 (0)	0 (0)	4 (4)	1	5		montly	1	0	2	0	3
	Others	0 (0)	1 (1)	0 (0)	0	1		Others	0	1	0	0	1
	Total	2 (5)	7 (5)	11 (9)	0	21		Total	1	8	7	0	16

	Fixed Market			Mobile Market		
	Methodology	Sampling period	Time windows	Methodology	Sampling period	Time windows
BE	SMP Operator	daily	3 years	SMP Operator	daily	3 years
CH	notional (generic operator)	weekly	2 years	-	-	-
CZ	notional (generic operator)	weekly	5 years	notional (generic operator)	weekly	5 years
DE	Other	daily	5 years	Other	daily	5 years
DK	notional (generic operator)	daily	3 years	notional (generic operator)	daily	3 years
ES	notional (generic operator)	weekly	5 years	notional (generic operator)	weekly	5 years
FI	notional (generic operator)	weekly	3 years	notional (generic operator)	weekly	3 years
HR	notional (generic operator)	other	3 years	notional (generic operator)	other	3 years
HU	notional (generic operator)	weekly	5 years	notional (generic operator)	weekly	5 years
IE	notional (generic operator)	daily	2 years	-	-	-
IT	notional (generic operator)	weekly	5 years	Other	daily	5 years
LT	SMP Operator	montly	5 years	-	-	-
LU	notional (generic operator)	daily	3 years	notional (generic operator)	daily	3 years
MK	notional (generic operator)	weekly	3 years	notional (generic operator)	weekly	3 years
NL	SMP Operator	daily	3 years	-	-	-
PT	notional (generic operator)	montly	5 years	notional (generic operator)	montly	12 months
RO	notional (generic operator)	daily, weekly	12 months, 3 years	notional (generic operator)	daily, weekly	12 months, 3 years
RS	notional (generic operator)	montly	5 years	notional (generic operator)	montly	5 years
SE	notional (generic operator)	weekly	5 years	notional (generic operator)	weekly	5 years
SK	notional (generic operator)	montly	5 years	notional (generic operator)	montly	5 years
SI	SMP Operator	montly	4 years	-	-	-
UK	Other	daily	5 years	Other	daily	2 years

Source: BEREC RA database 2019

With reference to the time windows chosen for the estimation of the beta, the approach among NRAs is more variable with three main clusters (two, three and five years).

The motivation behind these choices are related (i) to the importance given to a theoretical approach for providing a reliable estimation of the beta, (ii) to the need to be consistent with the estimation of other parameters such as the RFR, (iii) to the availability of data from referenced sources such as Bloomberg and (iv) a shorter time period is more relevant for the purpose of forming a forwards-looking view of beta.

The time windows used for estimating RFR and Beta are the same in 13 cases out of 22 for the fixed market, where information is available for all indicators (Figure 35). With respect to last year's report the tendency is to have a long time window both for the RFR and Beta estimation.

Figure 35 - Beta/RFR time windows (fixed and mobile markets)

Fixed Market

		Beta (Time windows)			
		<=2 Years	<=3 Years	>=5 Years	Total
RFR (time windows)	<=1 Year	3 (3)	2 (1)	4 (5)	9 (9)
	<=3 Years	1 (0)	3 (3)	1 (1)	5 (4)
	>=5 Years	0 (3)	2 (2)	7 (4)	9 (9)
	Total	4 (6)	7 (6)	12 (10)	23 (22)

		Beta (Time windows)			
		<=2 Years	<=3 Years	>=5 Years	Total
RFR (time windows)	<=1 Year	CH,PL,SI	FI,MK	ES,HU,LT,SK	9
	<=3 Years	IE	BE,HR,NL	PT	5
	>=5 Years		DK,LU	CZ,DE,IS ,IT,RS,SE,UK	9
	Total	4	7	12	23

Mobile Market

		Beta (Time windows)			
		<=2 Years	<=3 Years	>=5 Years	Total
RFR (time windows)	<=1 Year	0	2	3	5
	<=3 Years	1	3	0	4
	>=5 Years	1	2	5	8
	Total	2	6	8	16

		Beta (Time windows)			
		<=2 Years	<=3 Years	>=5 Years	Total
RFR (time windows)	<=1 Year		FI,MK	ES,HU,SK	5
	<=3 Years	PT	BE,HR,NL		4
	>=5 Years	UK	DK,LU	CZ,DE,IT,RS,SE	8
	Total	2	7	8	16

Source: BEREC RA database 2019

According to information provided by NRAs, a choice of time window for beta >=5 years and differing from the one for the RFR is mainly motivated by predictability and reliability and stability objectives reducing variability along the time, but also by theoretical reasons to have enough data to reduce the standard error in the estimation (i.e. in case when sampling period is longer than daily).

Concerning the adjustment used for estimating the equity beta of SMP or comparable companies (Figure 36), there is no clear view, in fact some NRAs do not make any adjustment (9 NRAs considering fixed market) some others (9 NRAs considering fixed market) instead use a Bayesian/Blume adjustment. Some NRAs apply the Blume/Bayesian adjustment explaining their choice (i) to report evidence from an academic study,[44] (ii) remarking that in case of "off the shelf" data provided by Bloomberg, the Blume adjustment is applied, (iii) stating that the Blume adjustment reflects future risk. Other NRAs (8 NRAs), do not make any adjustments considering that there is no reason for applying it. Generally, the application of an adjustment is done where a shorter time windows for beta estimation is in use; this is consistent with the idea that with less data available, the estimation of the equity beta can be less reliable.

Figure 36 - Time window adjustments to Equity Beta (fixed and mobile markets)

Fixed

	Time Windows			
	<=2 Years	<=3 Years	>=5 Years	Total
No Adjustment	2 (2)	1 (1)	5 (5)	8 (8)
Blume	1 (2)	1 (1)	2 (1)	4 (4)
Vasiecek	0 (0)	1 (1)	0 (0)	1 (1)
Bayesian	0 (0)	2 (2)	2 (2)	4 (4)
Others	0 (1)	1 (1)	1 (0)	2 (2)
Total	3 (5)	6 (6)	10 (8)	19 (19)

Mobile

	Time Windows			
	<=2 Years	<=3 Years	>=5 Years	Total
No Adjustment	1	2	3	6
Blume	0	1	2	3
Vasiecek	0	0	0	0
Bayesian	0	2	2	4
Others	1	1	0	2
Total	2	5	7	14

Source: BEREC RA database 2019

Most NRAs apply an unlevered beta before estimating the final equity beta (21 NRAs).

[44] Pablo Férnandez, Beta used by professors: A survey with 2500 answers, IESE CIIF, Business School, University of Navarra, Working Paper, WP-822, September, 2009.

Concerning the unlevering formula the most widely used is the Modigliani-Miller formula (Miller being the same formula without tax[45]).

Only four NRAs apply a beta debt in the levering/un-levering procedure. Generally, this is done when an "SMP" beta, rather than a notional one, is estimated.

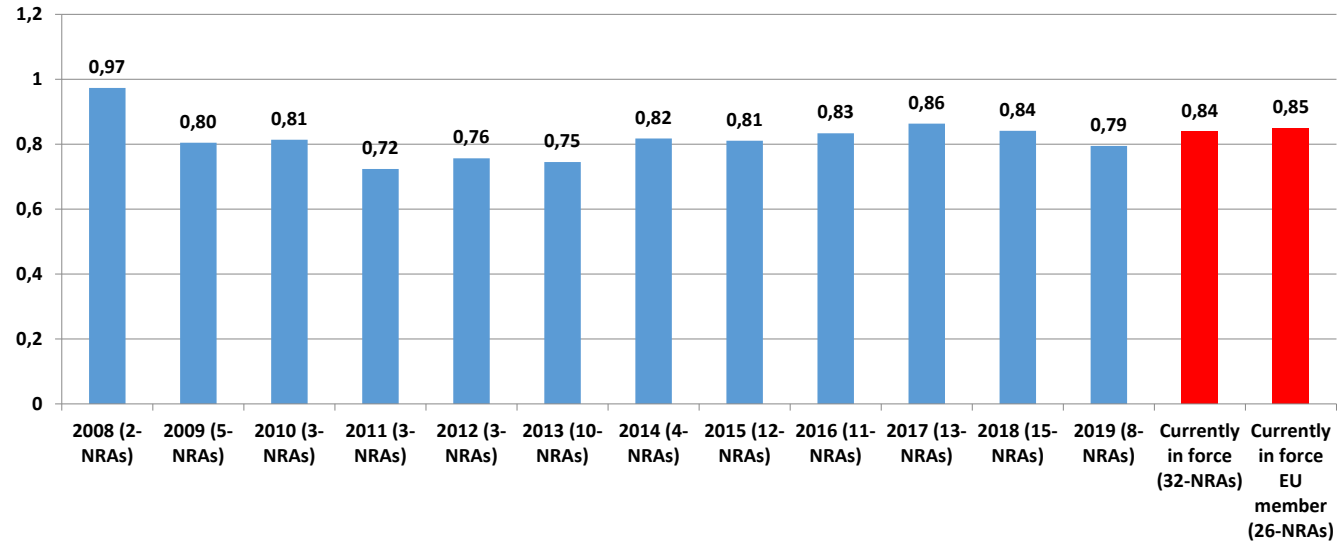
Concerning the market index, most NRAs (14 NRAs) use a European index (STOXX Europe TMI Telecommunications; STOXX Europe TMI, MSCI Europe Index). Some estimate the equity beta for each comparable on a specific country index (e. g. every comparable beta is estimated on its own country market index). In case of a World index, the MSCI is used by several NRAs (5 NRAs). A country specific index is typically used when the beta is evaluated by regards only to the SMP operator (4 NRAs).

The chosen approach is generally motivated by the fact that the specific index provides a reliable data source and is consistent with earlier decisions.

Sensitivity analysis on the time windows, adjustments and the choice of market index shows a relevant variability of the estimation (see **annex 1 of** BoR (17) 169). A notional approach can reduce a certain level of variability.

Overall, in the period 2008-2019, estimated beta values have remained relatively stable[46].

Figure 37 - Equity Beta evolution over time (fixed market)



Source: BEREC RA database 2019

Concerning the principle of "internal consistency", a sort of correlation can be found in the choice of the beta and gearing approach with respect to the price control methodology. Generally, in case a Bottom-up approach is in use as allocation method, a "notional beta" is applied (this relation is missing for the cost of debt).

[45] Sometimes the same formula is referred to as "Hamada formula".
[46] The variability may be explained by the number of observations (e. g. one NRA in 2011).

5.2.4 The cost of debt

see BoR (17) 169 and BoR (18) 167 for definition and general financial theory

Main output from the survey.

Based on the replies provided for the 2019 survey the following statistics were derived for the overall responding NRAs and for EU NRAs separately (2018 values in brackets).

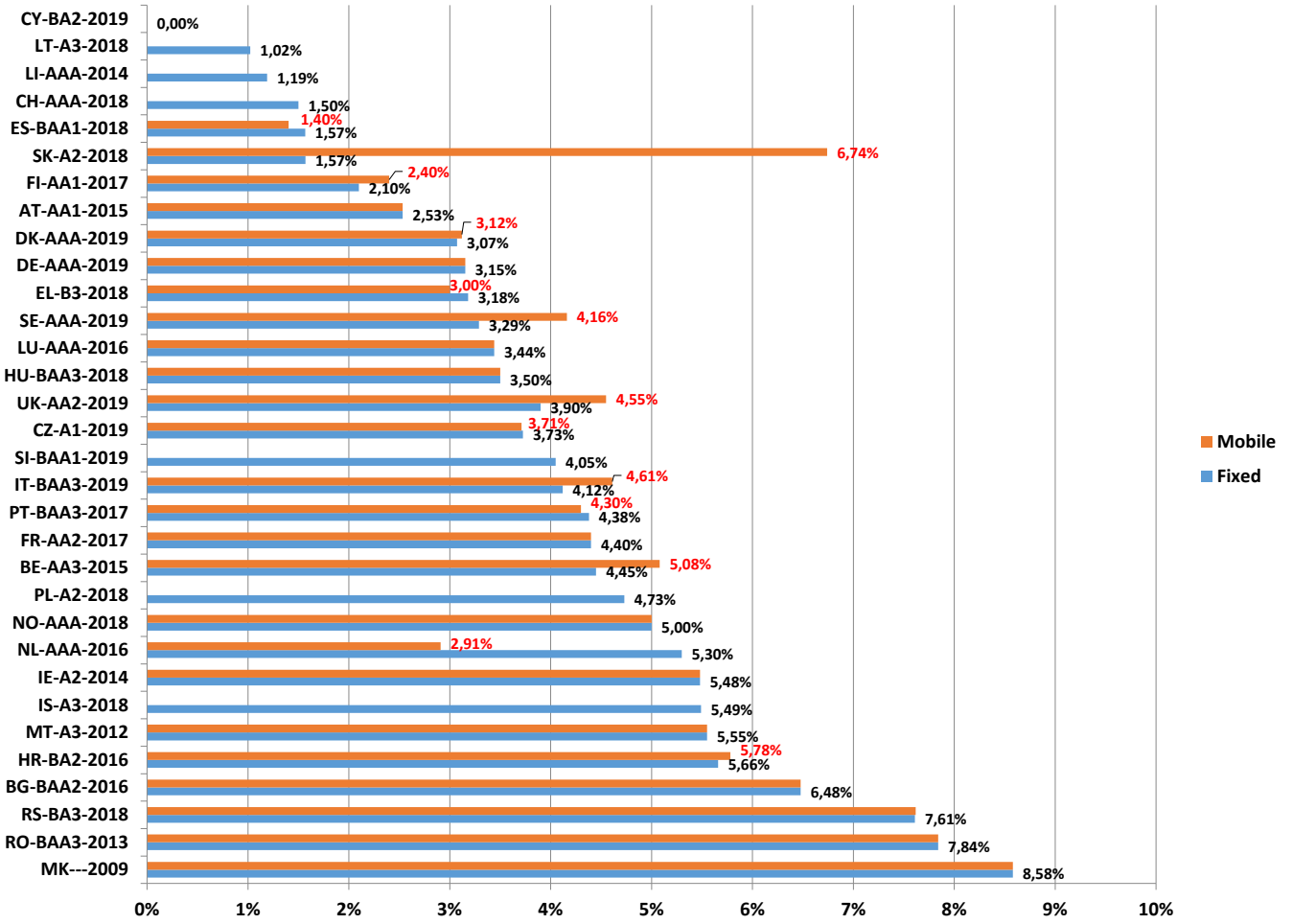
Figure 38 – Cost of debt values

	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Cost of debt fixed market 32 NRAs (2018)	**4.00% (4.30%)**	**3.98% (4.43%)**	**2.03% (2.08%)**	**50.89% (48.31%)**	**8.58% (8.77%)**	**0.00% (0.00%)**
Cost of debt mobile market 26 NRAs (2018)	**4.44% (4.60%)**	**4.35% (4.35%)**	**2.00% (2.06%)**	**45.12% (44.77%)**	**8.58% (8.58%)**	**0.00% (0.00%)**
Cost of debt fixed market 26 EU NRAs (2018)	**3.79% (4.12%)**	**3.81% (4.39%)**	**1.74% (1.74%)**	**45.92% (42.14%)**	**7.84% (7.84%)**	**0.00% (0.00%)**
Cost of debt mobile market 23 EU NRAs (2018)	**4.09% (4.25%)**	**4.16% (4.16%)**	**1.78% (1.82%)**	**43.54% (42.87%)**	**7.84% (7.84%)**	**0.00% (0.00%)**

Source: BEREC RA database 2019

In Figure 39 the cost of debt currently estimated for the fixed and mobile market is shown. As for the other parameters credit rating and its year of estimation is also reported.

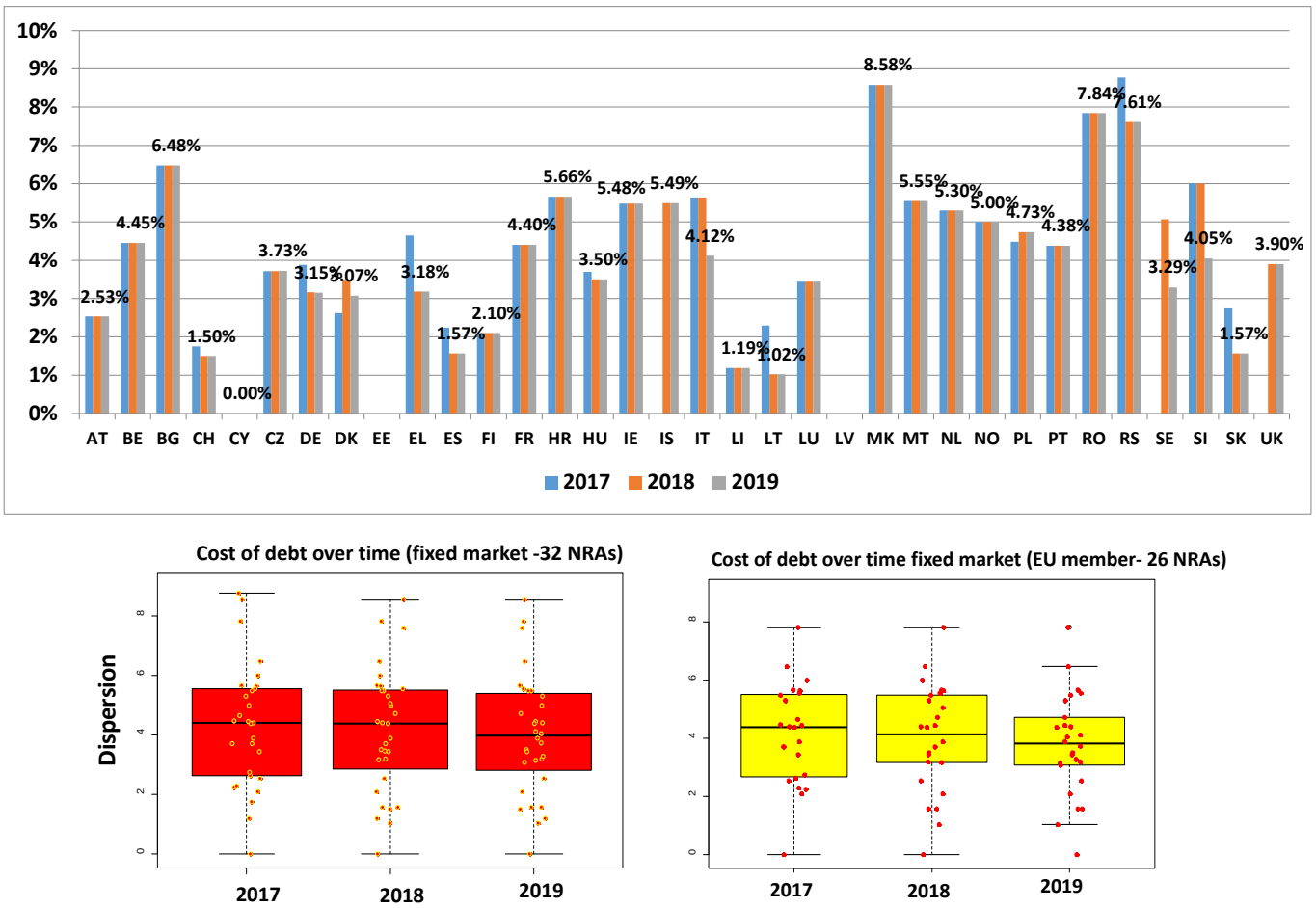
Figure 39 - Cost of debt value and distribution (fixed and mobile markets)[47]



Source: BEREC RA database 2019

[47] UK mobile number is midpoint of a range.

Figure 40 - Evolution of cost of debt over time (2017-2019)



Source: BEREC RA database 2019

The overall situation is quite stable from year to year.

The following figures summarise the different approaches used by NRAs to estimate the cost of debt component for fixed and mobile markets.

Figure 41 - Methodology used for estimating cost of debt (fixed market)

	Methodology		Cost of debt/debt-premium		Market/book value		-if "Market value"/"Other" (if applicable) Source data		-if "Market value"/"Other" (if applicable) bond window		-if "Market value"/"Other" (if applicable) Average window		-if "Market value"/"Other" (if applicable) Average methodology (with respect to the hystorical series included in the Average window)		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Cost of debt (RFR+ Debt premium)	notional (generic operator)	13 (12)	Debt premium	21 (20)	Book value	2 (3)	Secondary traded market	5 (5)	1 year	0 (0)	Spot rate	3 (3)	Arithmetic average	11 (11)	Arithmetic average	(0)
	SMP Operator	5 (5)	Cost of Debt	8 (9)	Market Value (Company bond)	19 (17)	Nominal bond yield	8 (9)	3 years	0 (0)	3 months	1 (0)	Geometric Average	0(0)	Geometric Average	(0)
	Other	11 (10)			Other	4 (5)	Other	5 (4)	5 years	2 (2)	6 months	1 (1)	Moving Average	0 (0)	Moving Average	(0)
	benchmarking	1 (1)							10 years	8 (7)	1 Year	1 (3)	Median	0 (0)	Median	(0)
									20 years	1 (0)	2 Years	1 (2)	Other	2 (1)	Other	1 (1)
									Hybrid	1 (1)	3 Years	2 (0)				
									Other	5 (6)	5 Years	1 (1)				
											10 Years	4 (4)				
											Others	3 (1)				

Source: BEREC RA database 2019

Figure 42 - Methodology used for estimating cost of debt (mobile market)

	Methodology		Cost of debt/debt-premium		Market/book value		-if "Market value"/"Other" (if applicable) Source data		-if "Market value"/"Other" (if applicable) bond window		-if "Market value"/"Other" (if applicable) Average window		-if "Market value"/"Other" (if applicable) Average methodology (with respect to the hystorical series included in the Average window)		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Cost of debt (RFR+ Debt premium)	notional (generic operator)	10 (9)	Debt premium	19 (17)	Book value	0 (0)	Secondary traded market	3 (3)	1 year	1 (1)	Spot rate	3 (3)	Arithmetic average	9 (8)	Arithmetic average	0 (0)
	SMP Operator	2 (2)	Cost of Debt	4 (6)	Market Value (Company bond)	16 (16)	Nominal bond yield	8 (8)	3 years	0 (0)	3 months	0 (1)	Geometric Average	1 (1)	Geometric Average	0 (0)
	Other	11 (12)			Other	4 (4)	Other	3 (4)	5 years	1 (1)	6 months	1 (1)	Moving Average	0 (0)	Moving Average	0 (0)
	benchmarking	1 (1)							10 years	7 (7)	1 Year	1 (2)	Median	0 (0)	Median	0 (0)
									20 years	0 (0)	2 Years	0 (0)	Other	0 (0)	Other	1 (1)
									Hybrid	0 (0)	3 Years	2 (1)				
									Other	5 (5)	5 Years	1 (1)				
											10 Years	3 (3)				
											Others	3 (2)				

Source: BEREC RA database 2019

For the fixed market, the most frequent approach used by NRAs is a notional approach (13 NRAs), the second category chosen by 11 NRAs is “Other” which reflects a mix of approaches (SMP and notional). This is followed by the estimation of the SMP cost of debt (5 NRAs).

Most NRAs estimate a debt premium instead of estimating the cost of debt directly, and this is done most frequently when a notional approach is used (see Figure 43). On the other hand, when the cost of debt refers to the SMP operator, a direct cost of debt is generally estimated. Within a notional approach, NRAs generally use peer groups according to credit rating (at least BBB-).[48]

One NRA (UK) modified its approach to the evaluation in comparison to the previous year, by basing the cost of debt on a weighted average of new debt (based on a debt premium + RFR approach) and the incumbent’s existing debt. This approach recognises that an efficiently financed firm may not have anticipated the scale of the Bank of England’s quantitative easing (QE) programme and the extent of the current low interest rate environment, and that a cost of debt based primarily on current market rates may not be consistent with providing the regulated firm with a ‘fair bet’ on its financing costs.

In general there is a large consistency between fixed and mobile, and only a few NRAs have a marginally different approach to fixed and mobile markets.

[48] One NRA declared that the level of debt of the SMP operator is negligible and for this reason it is considered equal to 0.

Figure 43 - Cost of debt calculated through debt premium (fixed and mobile markets)

Fixed

	Cost of debt calculated through debt premium	Cost of Debt
Notional (generic operator)	12 (11)	1 (1)
SMP operator	1 (1)	4 (4)
Other	7 (7)	3 (4)
Benchmarking	1 (1)	0 (0)

	Cost of debt calculated through debt premium	Cost of Debt
Notional (generic operator)	CZ,DK,FI,FR,HR,HU, IS,LI,PT,RO,RS,SE	CH
SMP operator	AT	BG,IT,LT,NL
Other	BE,DE,IE,LU,NO,SK, SI	ES,PL,UK
Benchmarking	MT	

Mobile

	Cost of debt calculated through debt premium	Cost of Debt
Notional (generic operator)	10	0
SMP operator	1	1
Other	7	3
Benchmarking	1	0

	Cost of debt calculated through debt premium	Cost of Debt
Notional (generic operator)	CZ,DK,FI,FR,HR,HU, PT,RO,RS,SE	
SMP operator	AT	BG
Other	BE,DE,IE,LU,NO,SK, UK	ES,IT,NL
Benchmarking	MT	

Source: BEREC RA database 2019

With reference to the data source used, most NRAs use the market value of peer group companies' nominal bond yield. A book value approach is used generally in case of SMP cost of debt.

Concerning the bond windows, the most common approach is to use 10 year bonds, in line with the bond length used to estimate RFR, as shown in the next figure.

Figure 44 - Bond lengths used for estimating cost of debt/RFR (fixed and mobile markets)

Fixed

		Bond length						
		1 Year	3 Years	5 Years	10 Years	20 Years	Hybrid	Other
RFR	1 Year	0	0	0	0	0	0	0
	3 Years	0	0	0	0	0	0	0
	5 Years	0	0	0	0	0	0	0
	10 Years	0	0	2 (2)	8 (7)	1	0 (1)	5 (4)
	20 Years	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	1 (2)

Mobile

		Bond length						
		1 Year	3 Years	5 Years	10 Years	20 Years	Hybrid	Other
RFR	1 Year	0	0	0	0	0	0	0
	3 Years	0	0	0	0	0	0	0
	5 Years	0	0	0	0	0	0	0
	10 Years	0	0	1	7	0	0	4
	20 Years	0	0	0	0	0	0	0
	Other	0	0	0	0	0	0	1

Source: BEREC RA database 2019

NRAs generally choose time windows in accordance with their choice for the RFR. It can be noted that when "other" is chosen for the time windows, this happens only when the cost of debt is estimated based on the nominal bond yield and not when the secondary traded market is used as source. Moreover, when "other" is chosen, NRAs generally consider in their calculation all the bonds not yet expired that are emitted in a range of time that can be not strictly the same with the time windows used for the RFR estimation.

In every case the results of the methodological survey are in line with the general principle expressed in the BoR (18) 167 where BEREC understands the need for consistency in the time windows used for the cost of debt and RFR, but recognises a necessity for some NRAs to be flexible due to the issue of data availability.

Figure 45 - RFR/cost of debt time windows (fixed and mobile markets)

Fixed

		Cost of debts			
		<=1 Year	<=3 years	>= 5 Years	Total
RFR	<=1 Year	2 (4)	0 (1)	1 (1)	3 (6)
	<=3 Years	1 (1)	1 (1)	2 (2)	4 (4)
	>= 5 Years	2 (2)	2 (1)	4 (3)	8 (6)
	Total	5 (7)	3 (3)	7 (6)	15 (16)

		Cost of debts		
		<=1 Year	<=3 years	>= 5 Years
RFR	<=1 Year	ES,SK		PL
	<=3 Years	RO	PT	BE,HR
	>= 5 Years	CZ,RS	LU,SE	FR,UK,IT,SI

Mobile

		Cost of debts			
		<=1 Year	<=3 years	>= 5 Years	Total
RFR	<=1 Year	2	0	0	2
	<=3 Years	1	1	2	4
	>= 5 Years	2	1	3	6
	Total	5	2	5	11

		Cost of debts		
		<=1 Year	<=3 years	>= 5 Years
RFR	<=1 Year	ES,SK		
	<=3 Years	RO	NL	BE,HR
	>= 5 Years	CZ,RS	LU	FR,SE,UK

Source: BEREC RA database 2019

Concerning specific adjustments to the Cost of debt, two NRAs apply the following:

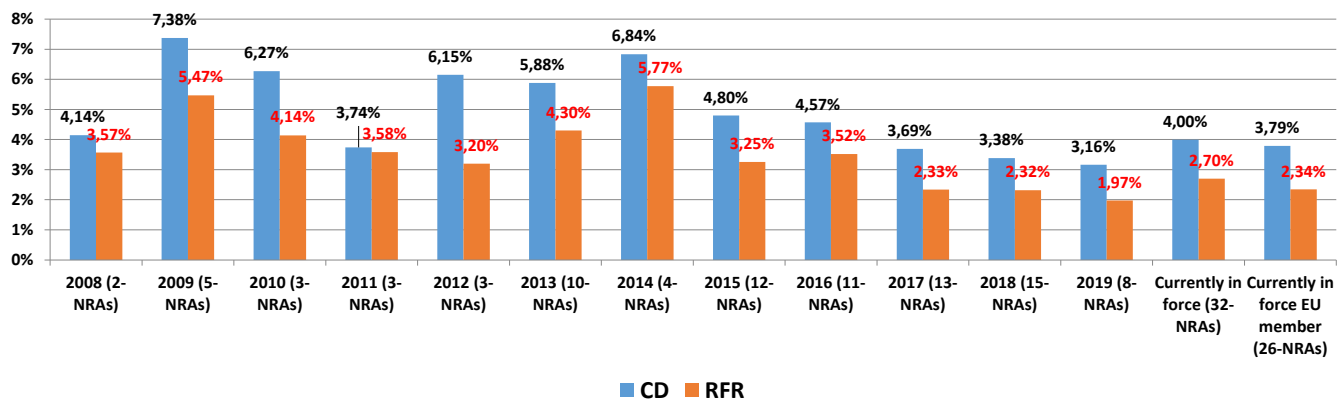
Figure 46 - Adjustments to cost of debt

Adjustment	Cost of debt	Cost of debt without adjustment	Adjustment	Motivation
IE -2014	5.48%	5.18%	0.30%	Aiming up
RS-2018 (previous report)	7.61% (8.77%)	6.48% (7.23%)	1.13% (1.54%)	Adjustment is made using the inflation rate for Serbia and Eurozone, since the initial value of cost debt is in EUR. Inflation adjustment was made using Fisher equation: "Pretax Cost of debt no adj"*(1+Projected Inflation Rate for RS)/(1+Projected Inflation Rate for Eurozone)

Source: BEREC RA database 2019

The next figure shows the evolution over time of the cost of debt and the RFR (fixed market).

Figure 47 - Evolution of cost of debt over time (fixed market)



Source: BEREC RA database 2019

5.2.5 Gearing Ratio

see BoR (17) 169 and BoR (18) 167 for definition and general financial theory

Main results of the survey.

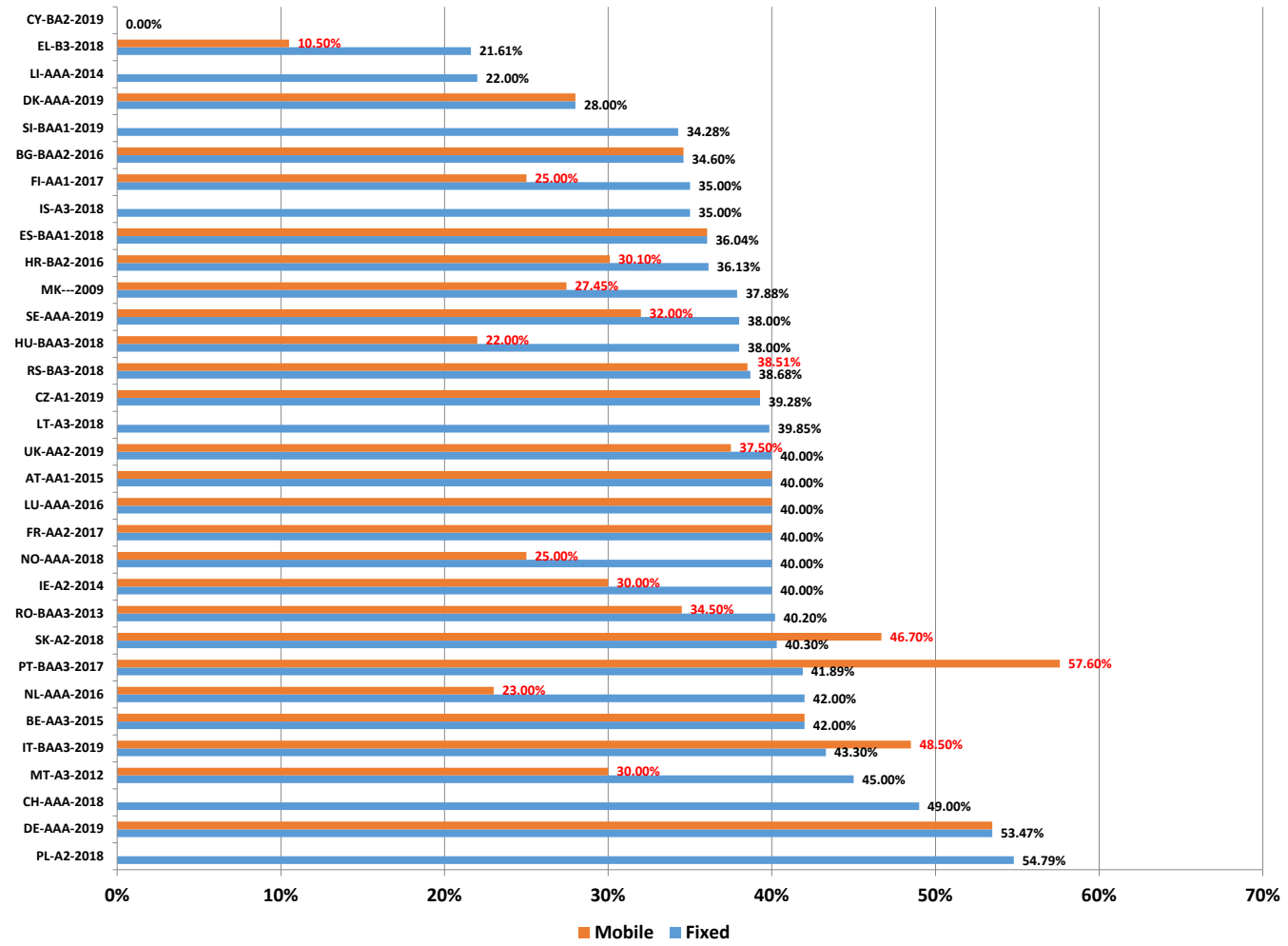
Based on the replies provided for the 2019 survey the following statistics were derived for the overall responding NRAs and for EU NRAs separately (2018 values in brackets).

Figure 48 - Gearing ratio (fixed and mobile markets)

	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Gearing fixed market – 32 NRAs (2018)	37.70% (37.28%)	39.93% (39.85%)	9.71% (10.04%)	26.76% (26.93%)	54.79% (55.62%)	0.00% (0.00%)
Gearing mobile market - 26 NRAs (2018)	33.53% (33.34%)	34.55% (33.25%)	12.34% (12.50%)	36.79% (37.50%)	57.60% (57.60%)	0.00% (0.00%)
Gearing fixed market EU member-26 NRAs (2018)	37.24% (37.27%)	40% (40%)	10.61% (10.65%)	28.48% (28.58%)	55.62% (55.62%)	0.00% (0.00%)
Gearing mobile market EU member - 23 NRAs (2018)	33.95% (33.85%)	34.60% (34.50%)	12.91% (13.13%)	38.02% (38.78%)	57.60% (57.60%)	0.00% (0.00%)

Source: BEREC RA database 2019

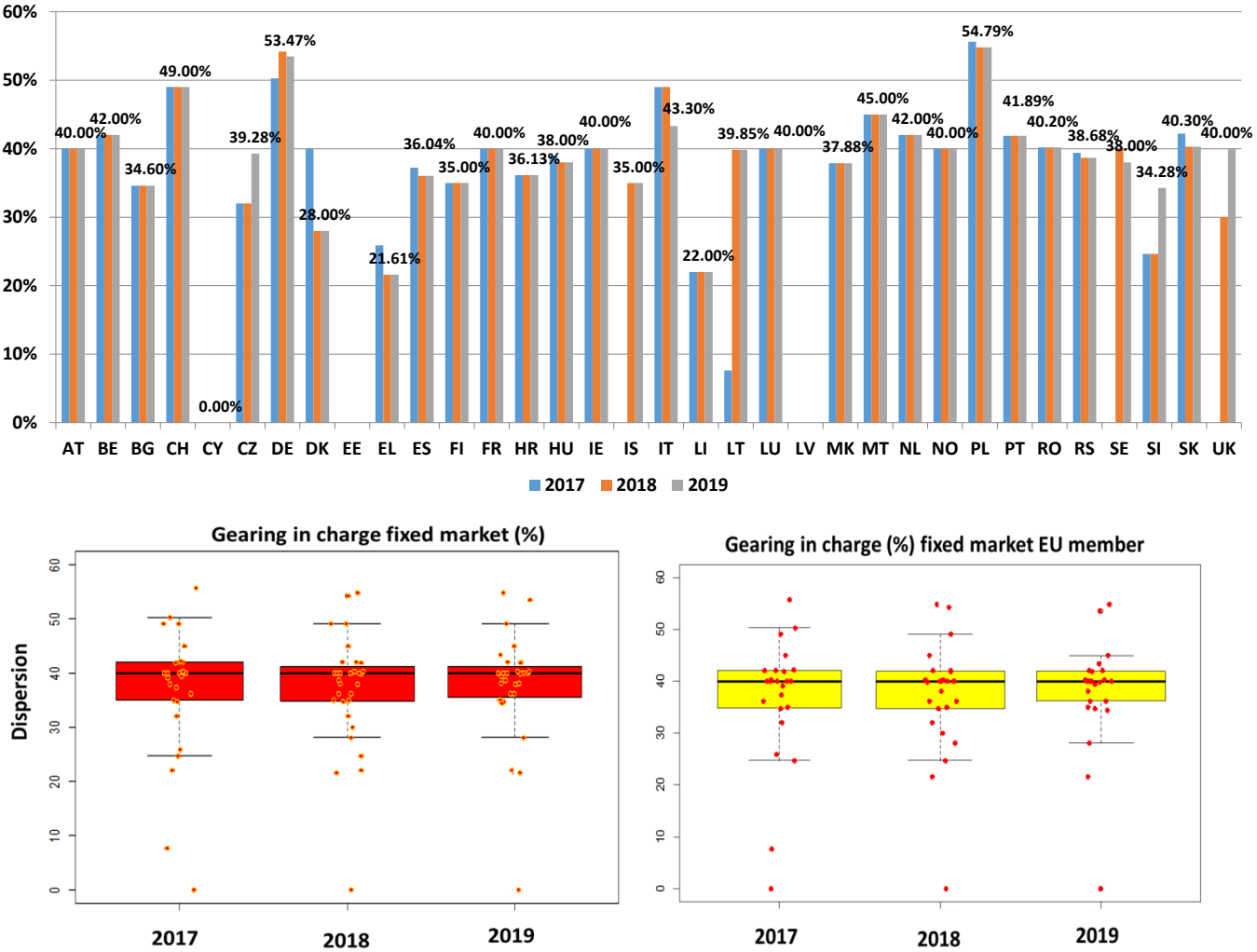
Figure 49 - Gearing values (fixed and mobile markets)[49]



Source: BEREC RA database 2019

[49] UK mobile number is midpoint of a range.

Figure 50 - Gearing values (fixed market 2017-2019)



Source: BEREC RA database 2019

The following figures summarise the different approaches used by NRAs to estimate the gearing parameters (fixed and mobile markets).

Figure 51 - Gearing methodology (fixed market)

	Methodology		Debt component (if applicable)		Equity component (if applicable)		-if notional value "Average methodology"		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Gearing	notional (generic operator)	18 (18)	Book value	9 (8)	Book value	1 (1)	Arithmetic average	7 (7)	Arithmetic average	0 (0)
	SMP Operator	7 (6)	Market Value	5 (5)	Market Value	13 (12)	Geometric Average	0 (0)	Geometric Average	0 (0)
	Other	4 (5)	Other	2 (2)	Other	2 (2)	Moving Average	0 (0)	Moving Average	0 (0)
	benchmarking	0 (0)					Median	4 (4)	Median	0 (0)
							Other	2 (2)	Other	0 (0)

Source: BEREC RA database 2019

Figure 52 - Gearing methodology (mobile market)

	Methodology		Debt component (if applicable)		Equity component (if applicable)		-if notional value "Average methodology"		-if benchmarking is indicated in the methodology section please indicate the average used from other countries	
Gearing	notional (generic operator)	17 (14)	Book value	7 (6)	Book value	(0)	Arithmetic average	8 (7)	Arithmetic average	0 (0)
	SMP Operator	2 (2)	Market Value	4 (4)	Market Value	11 (10)	Geometric Average	0 (0)	Geometric Average	0 (0)
	Other	4 (7)	Other	1 (1)	Other	1 (1)	Moving Average	0 (0)	Moving Average	0 (0)
	benchmarking	(0)					Median	4 (4)	Median	0 (0)
							Other	2 (2)	Other	0 (0)

Source: BEREC RA database 2019

The vast majority of NRAs use a "notional" approach, and, in general, do not adjust the gearing according to national circumstances; instead they use the value of the notional gearing used to unlever the beta. The gearing is generally evaluated taking into account the same time windows used for beta estimation. In line with last year's report, most NRAs use a notional approach, equal to their approach for estimating the beta.

Concerning their data source, most NRAs also use book value for the debt component and market value for the equity component. Where the SMP operator's gearing is considered, the estimation of the equity component is often computed using the book value (Figure 53).

When the debt component is estimated via the book value, generally long term and short term debt without netting off the cash is considered.[50]

[50] Cash is considered useful to operate the business (rather than being available to pay off debt).

Figure 53 - Gearing methodology (fixed and mobile markets)

Fixed Market

	Debt component			Equity component		
	Book value	Market value	Other	Book value	Market value	Other
notional (generic operator)	5 (4)	3 (3)	2 (2)	0 (0)	8 (7)	2 (2)
SMP Operator	2 (2)	1 (0)	0 (0)	1 (1)	2 (1)	0 (0)
Other	2 (2)	1 (1)	0 (0)	0 (0)	3 (3)	0 (0)
benchmarking	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	9 (8)	5 (4)	2 (2)	1 (1)	13 (11)	2 (2)

	Debt Component			Equity component		
	Book value	Market value	Other	Book value	Market value	Other
notional (generic operator)	DK,HR,IT,LU, SE	ES,HU,SK	CH,IE		DK,ES,HR,HU,IT,LU, SE,SK	CH,IE
SMP Operator	LI,NL	SI		LI	NL,SI	
Other	DE,UK	MK			DE,MK,UK	
benchmarking						
Total	9	5	2	1	13	2

Mobile Market

	Debt component			Equity component		
	Book value	Market value	Other	Book value	Market value	Other
notional (generic operator)	5	3	1	0	8	1
SMP Operator	0	0	0	0	0	0
Other	2	1	0	0	3	0
benchmarking	0	0	0	0	0	0
Total	7	4	1	0	11	1

	Debt Component			Equity component		
	Book value	Market value	Other	Book value	Market value	Other
notional (generic operator)	DK,HR,IT,LU, SE	ES,HU, SK	IE		DK,ES,HR,HU, IT,LU,SE,SK	IE
SMP Operator						
Other	DE,UK	MK,			DE,MK,UK	
benchmarking						
Total	7	4	1	0	11	1

Source: BEREC RA database 2019

Figure 54 and Figure 55 indicate that the gearing methodology is influenced mainly by the main methodology in use for the beta estimation, while gearing also influences the debt premium estimation.

Considering the methodologies used by all NRAs for the cost of debt, gearing and beta (that are company/industry specific parameters) it becomes clear that the gearing estimation is important since

- it determines the weight placed on the cost of equity and cost of debt
- it is used to unlever and re-lever the beta
- it influences the size of the cost of debt.

Figure 54 - Methodology gearing and cost of debt estimation (fixed and mobile markets)

Fixed

		Cost of debt				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	12 (11)	2 (2)	4 (5)	0 (0)	18 (18)
	SMP Operator	1 (1)	3 (3)	3 (2)	0 (0)	7 (6)
	Other	0 (0)	0 (0)	2 (3)	1 (1)	3 (4)
	Benchmarking	0	0	0	0	0
	Total	14 (12)	5 (5)	9 (10)	1(1)	28 (28)

		Cost of debt				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	
Gearing	notional (generic operator)	CH,CZ,DK,FI,FR,HR,HU,IS,PT,RO,RS,SE	AT,IT	ES,IE,LU,SK		19
	SMP Operator	LI	BG,LT,NL	BE,PL,SI		6
	Other			DE,UK	MT	3
	Benchmarking					0
	Total	14	5	9	1	28

Mobile

		Cost of debt				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	10	1	6	0	17
	SMP Operator	0	1	1	0	2
	Other	0	0	2	1	3
	Benchmarking	0	0	0	0	0
	Total	10	2	9	1	22

		Cost of debt				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	CZ,DK,FI,FR,HR,HU,PT,RO,RS,SE	AT	ES,IE,IT,LU,NL,SK		17
	SMP Operator		BG	BE		2
	Other			DE,UK	MT	3
	Benchmarking					0
	Total	10	2	9	1	22

Source: BEREC RA database 2019

Figure 55 - Methodology gearing and beta estimation (fixed and mobile markets)

Fixed

		Beta				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	18 (17)	0 (0)	0 (1)	0 (0)	18
	SMP Operator	1 (1)	5 (4)	0 (0)	1 (1)	7
	Other	1 (0)	0 (1)	2 (2)	1 (1)	4
	Benchmarking	0 (0)	0 (0)	0 (0)	0 (0)	0
	Total	21 (18)	5 (5)	2 (3)	2	29

		Beta				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	AT,CH,CZ,DK,ES,FI,FR,HR,HU,IE,IT,IS,LU,PT,RO,RS,SE,SK				19
	SMP Operator	PL	BE,BG,LT,NL,SI		LI	6
	Other	MK		DE,UK	MT	4
	Benchmarking					0
	Total	21	4	2	2	29

Mobile

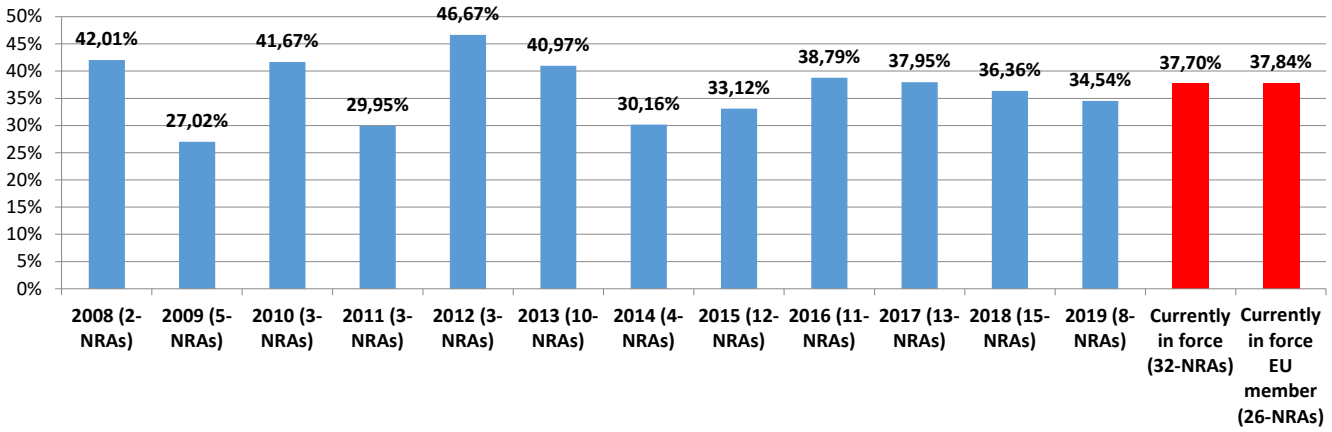
		Beta				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	16	0	1	0	17
	SMP Operator	1	1	0	0	2
	Other	1	0	2	1	4
	Benchmarking	0	0	0	0	0
	Total	18	1	3	1	23

		Beta				
		notional (generic operator)	SMP Opearator	Other	Benchmarking	Total
Gearing	notional (generic operator)	AT,CZ,DK,ES,FI,FR,HR,HU,IE,LU,NL,PT,RO,RS,SE,SK		IT		17
	SMP Operator	BG	BE			2
	Other	MK		DE,UK	MT	4
	Benchmarking					0
	Total	18	1	3	1	23

Source: BEREC RA database 2019

The evolution over time of the gearing estimation is reported in Figure 56.

Figure 56 – Evolution of gearing over time



Source: BEREC RA database 2019

5.2.6 Tax rate

Concerning the corporate tax rate in use the following statistics emerge (2018 figures in brackets):

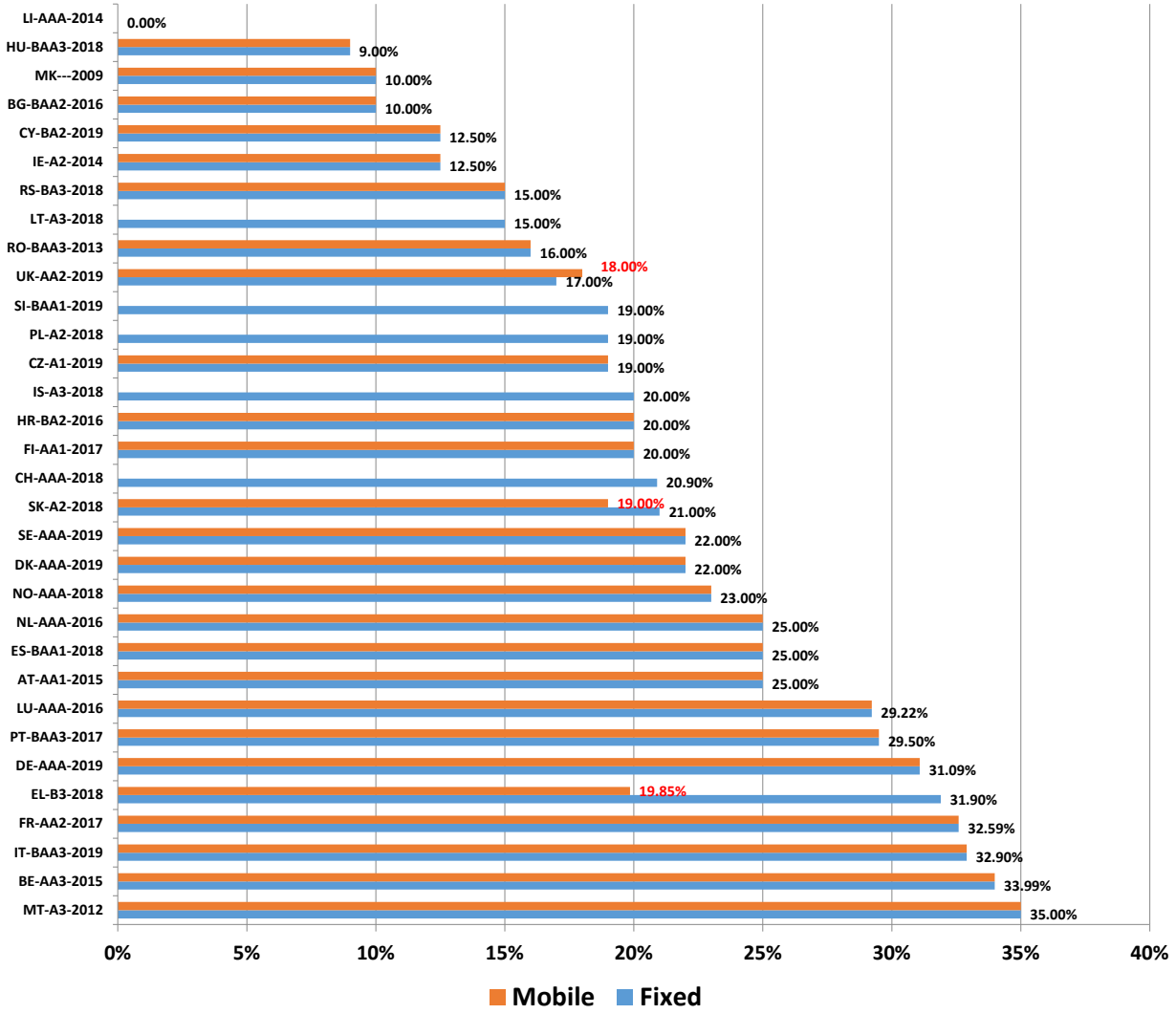
Figure 57 - Corporate tax rate (fixed and mobile markets)

	Average	Median	Standard Deviation	Relative Standard Deviation	Maximum	Minimum
Tax rate fixed market 32 NRAs (2018)	21.07% (21.09%)	20.45% (20.45%)	8.34% (8.48%)	39.57% (40.19%)	35.00% (36.00%)	0.00% (0.00%)
Tax rate mobile market 26 NRAs (2018)	21.81% (22.93%)	21.00% (21.00%)	7.83% (8.03%)	35.87% (36.60%)	35.00% (36.00%)	9.00% (9.00%)
Tax rate fixed market Eu 26 NRAs (2018)	22.51% (22.54%)	21.50% (22.00%)	7.73% (7.91%)	34.33% (35.08%)	35.00% (36.00%)	9.00% (9.00%)
Tax rate mobile market EU 23 NRAs (2018)	22.57% (22.70%)	22.00% (22.00%)	7.78% (7.99%)	34.45% (35.21%)	35.00% (36.00%)	9.00% (9.00%)

Source: BEREC RA database 2019

As already mentioned, taxation is also an important parameter to explain WACC variations between NRAs and it represents a typical country-specific parameter. Needless to say that it is not a parameter that NRAs have an influence over.

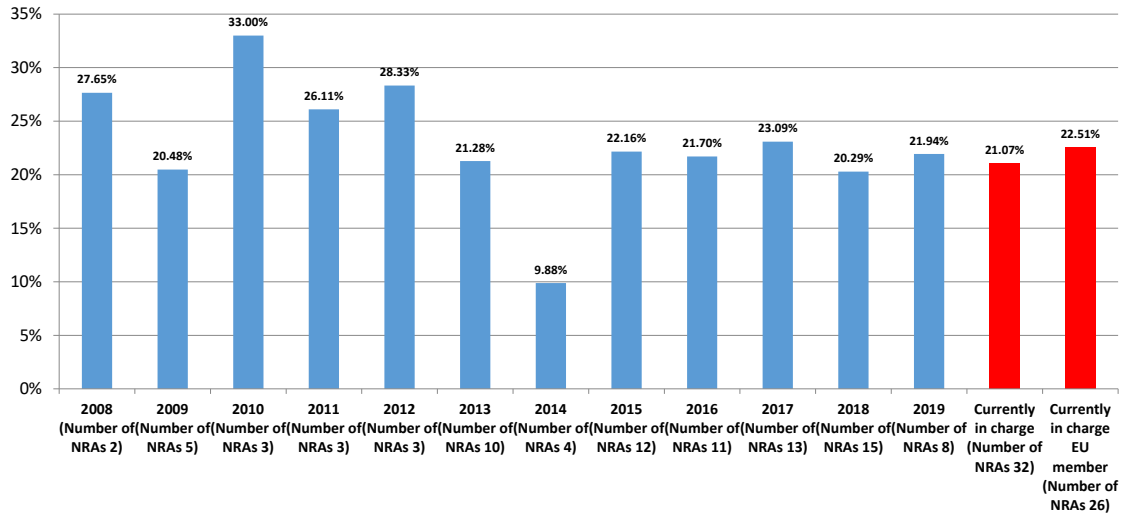
Figure 58 - Tax rate currently in use (fixed and mobile markets)



Source: BEREC RA database 2019

The time evolution of the tax rate adopted is reported in Figure 59.

Figure 59 - Evolution of tax rate over time (fixed market 2017-2019)



Source: BEREC RA database 2019

5.2.7 Other Adjustments

The practice by some NRAs of adjusting the value of WACC parameters posed an issue in some cases of the Article 7/a evaluation processes by the European Commission.

In order to better understand the use of adjustments, specific questions have thus been addressed in the 2019 questionnaire on technical adjustments on single parameters estimation and, in general, on the cost of equity.

In Figure 60, NRAs that apply an adjustment to the cost of equity are listed (in bracket the adjustment applied in 2018).[51]

Technical adjustments to the cost of equity are evaluated as: Post tax cost of equity (RFR+ Equity Beta*ERP) + “Adjustment”. The following adjustments do not include other adjustments reported in previous sections.

In comparison to the previous year only SI completely eliminated their adjustment to the cost of equity.

[51] In Figure 60 only adjustment on fixed market are shown.

Figure 60 - Adjustments to the cost of equity

	Adjustmet for cost of equity	Motivation
BE	0.51% (0.51%)	Obtained to take into account additional country risk premium CPR*lambda (the Risk Free Rate in this case is obtained as the weighted average of the German and Euro bond)
CZ	0.64% (0.42%)	The country risk premium captures risks connected with investments in the local (Czech) market that are directly included neither into the risk free rate nor into the equity risk premium derived from the developed stock markets. The specific calculation method for estimating the country risk premium was based on a widely accepted approach developed by prof. Damodaran and represents the difference between the product of a country default risk and ratio of stock and bond markets volatility and a country default risk.
DE	-0.88% (-0.92%)	The adjustment is obtained considering a different equity ratio for the estimation of the weight of cost of Equity, including for the gearing calculation also the non-interest bearing debt
NO	0.35%	
RS	1.01% (1.38%)	Adjustments to the initial values of cost of debt and cost of equity (in EUR) were made using the inflation rate for Serbia and Eurozone in order to obtain values in local currency. Infation adjustments were made using Fisher equation.
SK	1.94% (1.94%)	Size premium

Source: BEREC RA database 2019

Technical adjustments are more frequent when “RFR” and/or “ERP” are estimated not using a pure country-specific approach.

5.3 Risk premium for NGA WACC (Annex I)

This year's RA report gives an overview about the adoption of NGA risk premium, as it is one instrument provided by the regulatory framework, specifically in case cost orientation is imposed at wholesale level, for incentivising investment in NGA infrastructure.
Investment incentive in NGA - and specifically in VHCN - is the most relevant connectivity objective on the agenda of the Commission and it is relevant to keep track on the consistent application at national level, since it is directly related to the WACC calculation.

In this section an overview on NGA WACC is provided without looking at the price control applied to the NGA wholesale regulated product by which the information is also available in the RA section of the report.

Based on the survey the following situation emerges: 12 NRA estimate a risk premium for NGA FTTH services, 5 NRAs apply this risk premium also to the FTTC network without differentiating the final value with respect to the one applied for NGA. Two NRAs apply a decomposition approach, three NRAs use a benchmarking approach and three NRAs use a methodology mainly based on the outcome of a DCF calculation as reported in next figure.[52]

Figure 61 - Risk premium

	2018	2019	Risk premium FTTC	Risk premium FTTB	Which methdologies do you use?	On which infrastructures do you apply?
CZ	3.31%	1.41%	No	Yes	other	
DK	2%	2%	Yes	Yes	Beta decomposition	Passive and Active
ES	4.81%	4.81%	No	No	DCF approach	Only Active
FI	Yes	Yes			other	Only Active
FR	Yes	Yes			DCF approach	
HR	3.30%	3.30%	No	Yes	Benchmark	Passive and Active
IT	3.20%	3.20%	No		Mainly based on DCF approach	Passive and Active
LU	2.50%	2.50%	Yes	Yes	Benchmark+ consideration on the evolution of the NGA demand	Passive and Active
NL	2%	2%	No	No	Partially qualitative approach	Only Passive
PL	Yes	1.25%	Yes	Yes	other	Only Active
SI	0.61%	2.50%	Yes	Yes	Benchmark	Passive and Active
UK	1.03%	0.90%	Yes		Beta decomposition	

Source: BEREC RA database 2019

[52] When "Yes" or "No" is missing means that the architecture is not relevant for the market condition. "Yes" means that risk premium is applied on the specific wholesale product provided through the corresponding architecture.

The information provided by NRAs on how the Risk premium is evaluated is described in more detail below:

Denmark

In Denmark DBA adds 2 % to the nominal WACC before tax for fibre services. The 2 % are not added nationally, as a certain area around the capital (Copenhagen) has a high deployment of fibre and therefore fibre services for this area are not added to the NGA-premium. DBA has undertaken a risk analysis of all infrastructure technologies i. e. fibre, copper, coax and mobile networks. DBA concluded that the deployment of new fiber infrastructure is exposed to asymmetrical risk primarily caused by the lack of usage of NGA from the operator and consumer sides. The assessment is based on the general criteria for setting the risk premium mentioned in EC Recommendation (2010/572/EU, Annex I, no. 6):

- uncertainty relating to retail and wholesale demand;
- uncertainty relating to the costs of deployment, civil engineering works and managerial execution;
- uncertainty relating to technological progress;
- uncertainty relating to market dynamics;
- and the evolving competitive situation, such as the degree of infrastructure-based; and/or cable competition; and
- macroeconomic uncertainty.

Based on the assessment of these criteria, DBA arrived at a 2 % NGA risk premium.

DBA has also assessed if the level of the 2 % seemed valid. This was done in co-operation with WIK consultants. The hypothesis was, that: WACC + NGA = 'WACC for a pure NGA operator' e.g. 5 % + 2 % = 7 %. DBA then isolated the beta for a WACC of 7 % (all else being equal) and found a high beta value which could represent a beta for a pure NGA-operator.

Italy

Agcom also included a different risk premium for FTTH and FTTC network and has applied this premium since 2015 to all cost-oriented products over NGA services (in the last decision on market analysis the FTTC premium will be removed from 2019). In line with the objective of the NGA Recommendation the risk premium evaluated by AGCOM has been seen as an instrument to promote efficient investment by providing the right make or buy signal to the market taking into account the risks incurred by all investing undertakings. The level of the risk addressed is generally systematic and is related to speed up the investment in NGA network in a context where there is uncertainty about demand for new services and no first mover advantage apparent due to the cost oriented obligation over all NGA products.

Agcom evaluated through an option pricing model (mainly based on a DCF approach) the level of risk premium in a way to include two main risk factors:

a) the “wait and see” option to postpone the investment when new information about demand/cost will be available
b) the risk to open the network to third parties without having any first mover advantage.

The two sources of risk are justified in Italy for FTTH, also for the next regulatory period 2019-2021, due to the specific conditions that show: i) already a national coverage with FTTC solution, achieved recently by the incumbent operator in combination with a very low coverage of FTTH; ii) the fact that the investments in FTTH will be done at a national level by an alternative operator with a wholesale only model. The investment in FTTH solution in this context is not an independent choice by the SMP operator, but a reply to the competitive context.

This means that the fast deployment of FTTH is a source of increased systematic risk not for the incumbent but also for a generic operator, due to the fact that every operator deploying VHCN networks face demand uncertainty at retail and wholesale level in combination with the need to find new sources for substantial capital (capital leverage) for asset investments.

Czech Republic

CTU calculates the NGA risk premium, which consists of a risk difference between the NGA and legacy networks, assessed separately for all relevant criteria. For this exercise a special model of complex box method for cost of equity estimation published by prof. Mařík was used. This method segments the total risk into partial risks which are then assessed separately. Individual risks associated with NGA networks are not estimated in their absolute values but relatively to risks of legacy networks, i. e. whether the risk is the same, higher or lower than for the legacy networks. Consistent risk factor is a value of 100 %, higher risk factor is more than 100 % and lower risk factor is lower than 100 %. Finally, CTU calculated the weighted average from percentage values of risks. This average value represents the risk ratio of NGA networks and other technologies. For detailed calculation see the table below:

Risk	Relevancy	Coefficient of relevancy	Weight	Weighted average of relevancy
Dynamics of industry, innovation and continuity of services	High	150,00 %	12,50 %	18,75 %
Dependence on economic cycle	Lower	125,00 %	6,25 %	7,81 %
The market size and possibility of expansion	High	110,00 %	6,25 %	6,88 %
Competition	High	125,00 %	12,50 %	15,63 %
Barriers to entry into industry	High	125,00 %	12,50 %	15,63 %
Position towards customers and suppliers	Lower	100,00 %	6,25 %	6,25 %
Competitiveness of the service	Lower	75,00 %	6,25 %	4,69 %
Prices	High	150,00 %	12,50 %	18,75 %
Regulatory risk	High	110,00 %	12,50 %	13,75 %
Financial risk	High	90,00 %	12,50 %	11,25 %
Coefficient of total risk				**119,38 %**

WACC $_{pre\text{-}tax}$ for legacy and mobile network	7,253 %
Coefficient of total risk	119,375 %
WACC NGA	**8,658 %**
NGA risk premium	1,405 %

France

When putting in place the regulation of FttH which is symmetrical in France, not SMP-driven, ARCEP has felt the need to have a long-term approach taking into account the development of the cash-flows over time and an analytical framework: ARCEP has thus developed and published such a framework which was subject to two public consultations in 2014, and finally published in 2015.

This framework consists of a cash flow (DCF) model for fibre-based networks which can be used as a tool by operators to build and discuss tariffs. It is built to ensure reasonable profitability to investors in a fair and reasonable price context with access obligations. The model is built to find a net present value of incomes and expenses of zero with a discount rate equal to the WACC with a risk-premium. The lifetime of the network is not known in advance, so the net present value is a computed on a sufficiently long period. The illustrative life span used in the model published by ARCEP is 25 years. The ARCEP model presents indicative levels of risk premia as ARCEP considers it relevant to add such a NGA premium to the WACC due to the existence of specific risks when building a new network.

UK

In relation to the WACC for fibre-based services, Ofcom has adopt a beta disaggregation approach which separates the BT Group beta between lower risk ‘access’ products (e. g. duct and poles access and copper access lines) and higher risk ‘usage’ productions (including FTTC and leased lines). The latter (which is referred to as the Other UK telecoms WACC) is higher than the ‘access’ WACC (which is referred to as

the Openreach WACC). The pre-tax nominal WACC is applied to price-regulated fibre products in 2019 (the VULA 40/10 anchor product) and represents an increase of 0,9 % compared to the WACC for copper, duct and pole access products.

Annex II - WACC parameter quantitative analysis

Carried out since BoR(17)169, as new observations on WACC estimation become available, the time series on WACC estimation for causal inference analysis has been updated in order to identify parameters that may better explain WACC variations on a historical basis. In this case, the independent variables (parameters for estimating WACC) are considered as causes of the dependent variable (WACC values). Causality exploration aims to determine whether a particular independent variable influences the dependent variable, and to estimate the magnitude of the effect, if any.

We use the following regression model, which links the WACC values to six main parameters (data updated in 2019):[53]

$WACC\_i\_k = Constant + \beta_1 RFR\_i\_k + \beta_2 Equity\ Beta\_i\_k + \beta_3 ERP\_i\_k + \beta_4 gearing\_i\_k + \beta_5 Debt\ premium\_i\_k + \beta_6 Tax\_i\_k$ (where i is the year of the data and k identifies countries involved).

Regression analysis can provide a deep understanding and numerical information on the causality between the dependent variable and each independent variable, taking into account information provided by other independent variables.

This cannot be addressed by a simple correlation analysis between each independent and the dependent variable as this only considers a measure of the extent the two variables move together, independently with respect to the information on variation provided by all other independent variables (thus not being able to prove real causality).

Several checks are needed to validate the use of a linearized model in order to infer or predict[54]. In case of a panel data analysis using a linear regression model, it is necessary, *inter alia*, to address the following main elements: i) linearity of the relationship between dependent and independent variables; ii) multicollinearity between independent variables; iii) homoscedasticity (constant variance) of the errors; iv) normality of the error distribution.

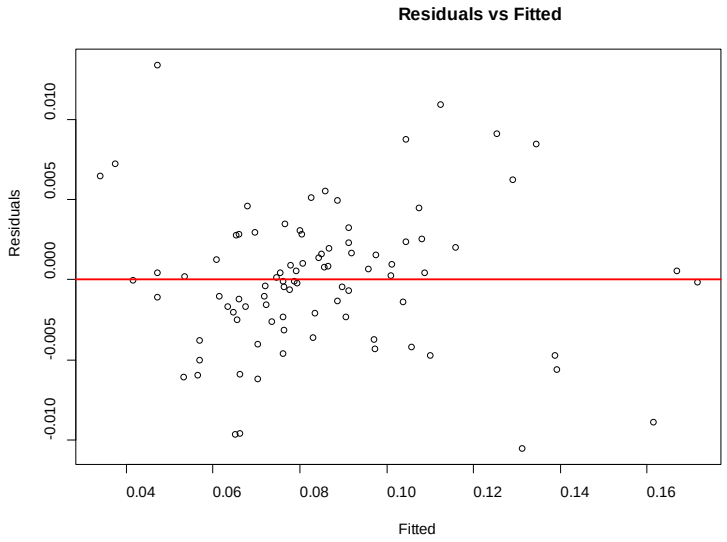
In the following, “sanity checks” of the proposed linear model have been addressed analysing the residual output of the model before addressing the relevance of variables that better explain observed WACC values.

Linearity

A first verification of the validity of the linear approximation is to detect if some path can be identi- fied in the residual plot (y-axis) with respect to the expected values (x-axis). Points should be distributed symmetrically, around a horizontal line in relation to an intercept equal to zero. Different trends indicate at first point the presence of some non-linearity in the model (Figure 62)[55]. The assumption that the average error E(ε) is everywhere zero implies that the regression surface accurately reflects the dependency of Y on the X’s.

[53] The parameter have been analysed not including adjustment not attributed to single parameter.
[54] “Statistics for business and economics” Heinz Kohler 1994.
[55] The residual of an observed value is the difference between the observed value and the estimated value of the quantity of interest.

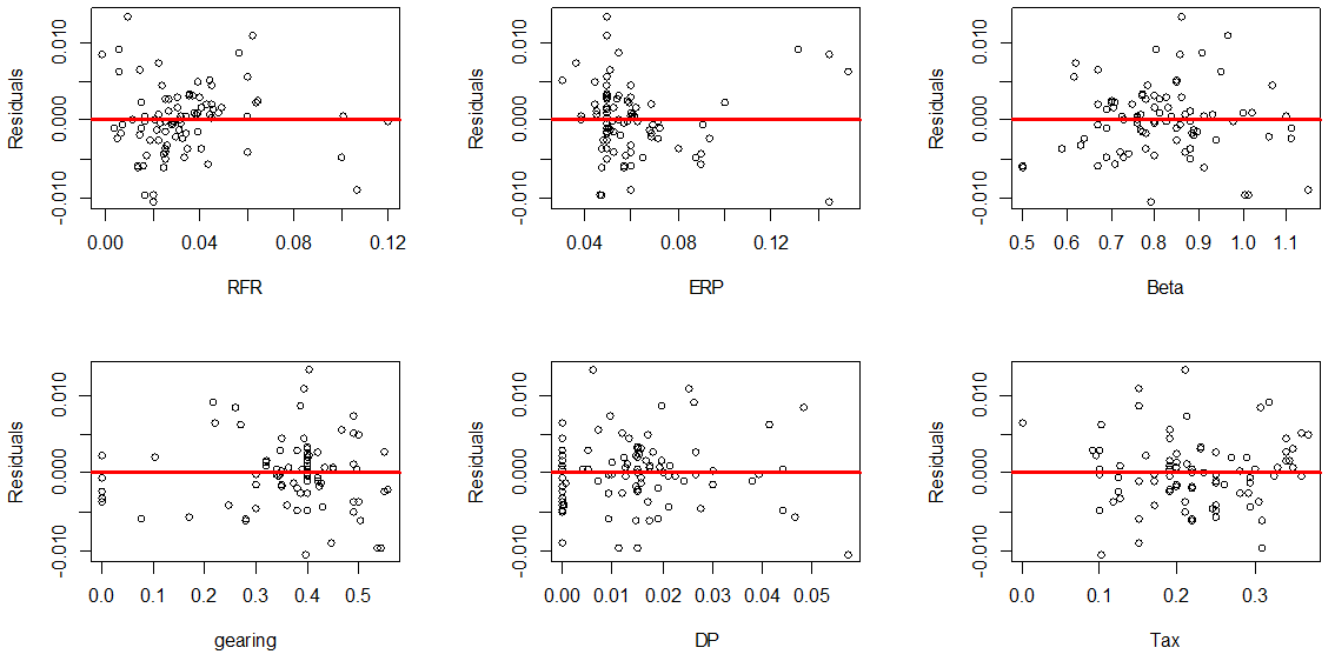
Figure 62 - Linear approximation



Source: BEREC RA database 2019

Moreover, a deeper analysis on each regressor should be considered plotting the residual previ- ously represented with each independent variable. Also in this case non-linear effects could be de- tected when paths deviate from the “random” shape (visible in the residual plots).

Figure 63 - Non-linear effects



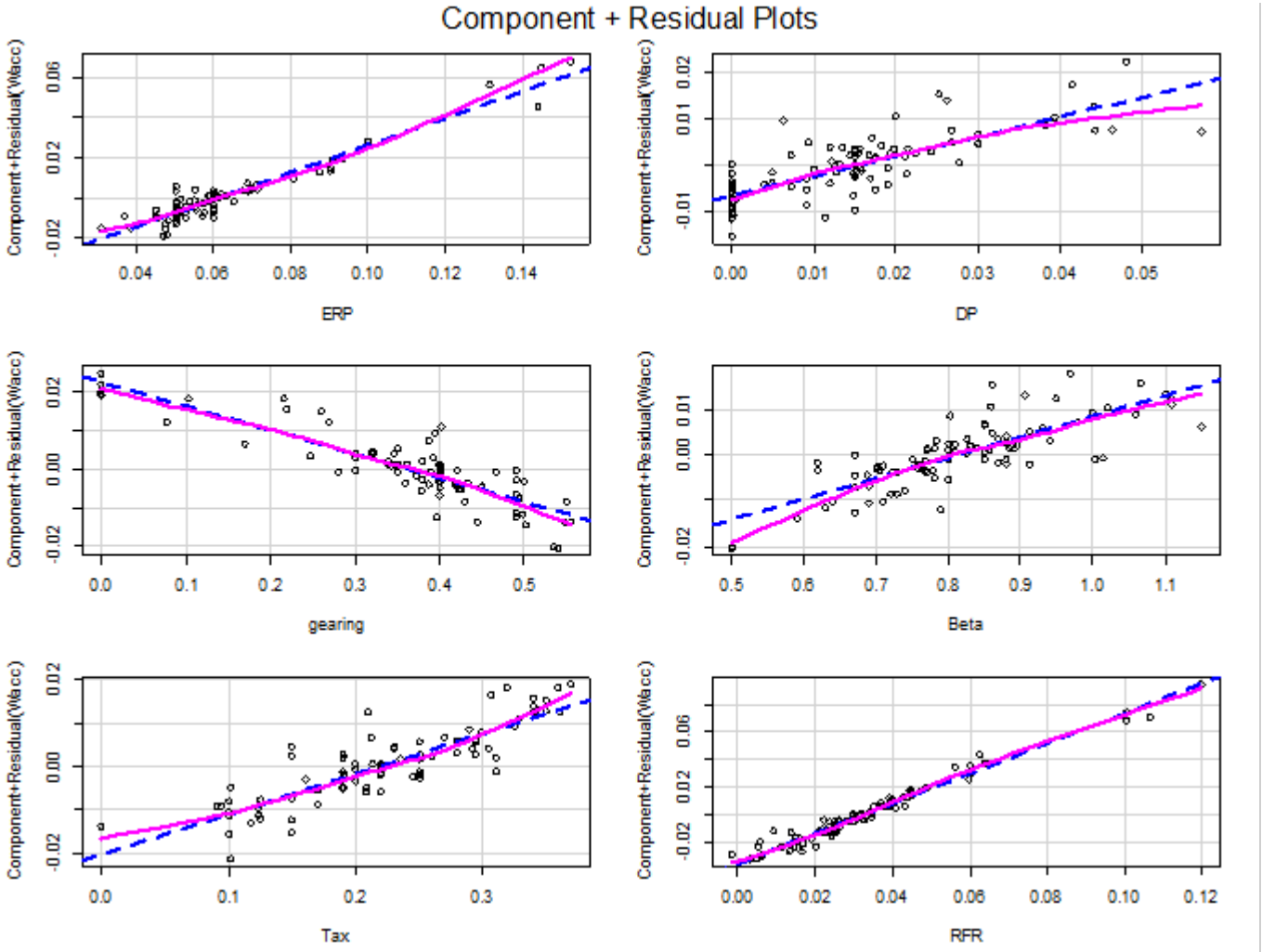
Source: BEREC RA database 2019

Another relevant measure to detect non-linearity in the model is provided through the use of the

partial residual plot[56] (Figure 64), which, in case of multiple regression, shows the relationship between a given independent variable and the response variable, given that other independent variables are also in the model. Since in our case the dependent variable depends on six main parameters, the use of a partial residual plot is therefore more correct than simple single-variables scatter plots[57] (correlation measure).

In Figure 64 a nonparametric fitting (pink line) helps to assess whether the linear trend adequately captures the partial relationship between Y and X. The partial residual plot (blue line) highlights that linear approximation is good for each parameter.

Figure 64 - Nonparametric fitting



Source: BEREC RA database 2019

Normality, multicollinearity, homoscedasticity

[56] Partial residual plot includes E_ij=(residual_i + beta_j*x_ij) vs x_ij. This simply adds the linear component of the partial regression between Y and x_i (which may be characterised by a nonlinear component) to the least squares residuals. The "partial residuals" E(j) are plotted versus Xj, meaning that beta_j is the slope of the simple regression of E(j) on X_j. Through this plot both monotone and non-monotone non linearity can be detected.

[57] Regressing each independent variable with the dependent variable like a bi-variate model.

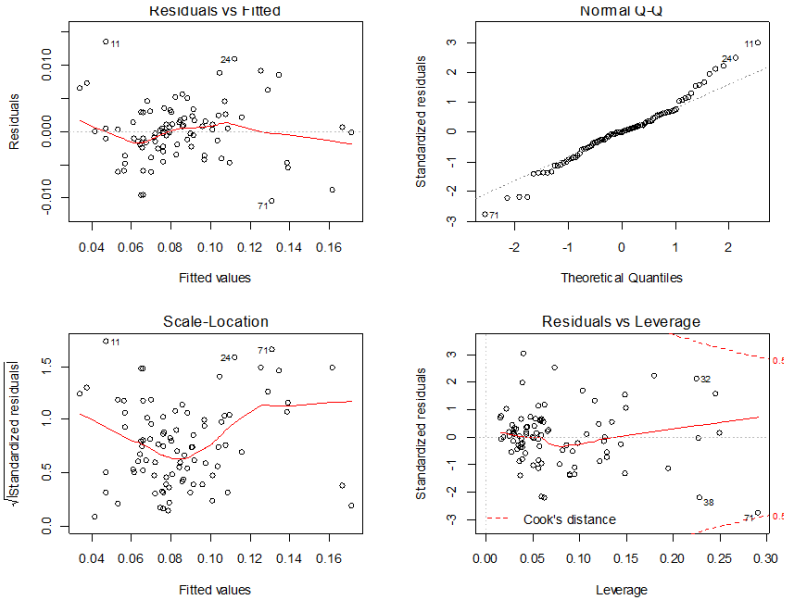
In Figure 65 summarised statistics are provided showing that all regressors are statistically significant with an adjusted R squared of 0.98. Moreover, the standard variance inflation factor (VIF) shows no multicollinearity among variables, thus further validating the model. We show hence (i) the residual graph against theoretical values, which looks completely casual, thus not revealing the existence of a residual systemic dependence among variables (already shown in Figure 62); (ii) the normal Q-Q plot of the standardised residues, which graphically verifies the assumption of normality of the erratic component of the linear model; (iii) the chart of square roots of standardised residues against theoretical values, and (iv) the graph of Cook distances, which let us identify three observations as possible outliers.

Figure 65 - Nominal panel data statistics

```
Call:
lm(formula = Wacc ~ ERP + DP + gearing + Beta + Tax + RFR, data = mydataselreg1)

Residuals:
      Min        1Q    Median        3Q       Max
-0.0105400 -0.0023418 -0.0000266  0.0022838  0.0134170

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.032405   0.003923  -8.260 2.13e-12 ***
ERP          0.676049   0.029799  22.687  < 2e-16 ***
DP           0.421467   0.045686   9.225 2.56e-14 ***
gearing     -0.061949   0.005682 -10.903  < 2e-16 ***
Beta         0.044899   0.004474  10.035 6.37e-16 ***
Tax          0.091883   0.006932  13.255  < 2e-16 ***
RFR          1.082744   0.023901  45.300  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.004538 on 82 degrees of freedom
Multiple R-squared:  0.9742,    Adjusted R-squared:  0.9723
F-statistic: 516.2 on 6 and 82 DF,  p-value: < 2.2e-16
```

VIF

```
     ERP       DP  gearing     Beta      Tax      RFR
1.829085 1.434718 2.152578 1.441395 1.311523 1.173805
```



Source: BEREC RA database 2019

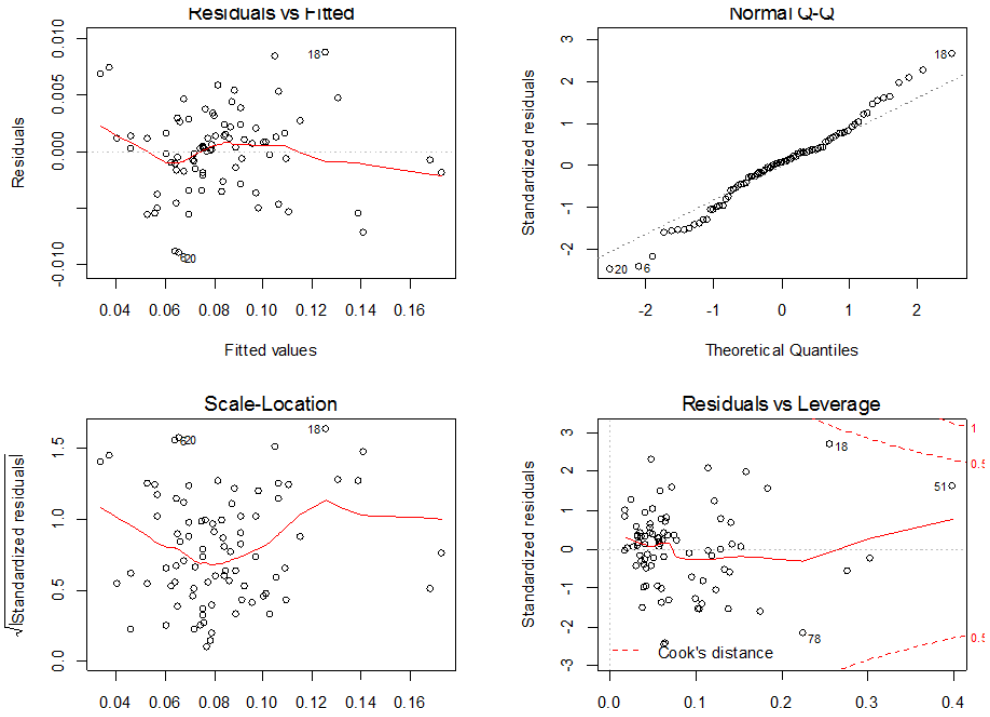
We hence show the same model without the five possible outlier observations, by still finding similar results, as shown in Figure 66.[58]

Figure 66 - Nominal panel data statistics without outliers

```
Call:
lm(formula = Wacc ~ ERP + DP + gearing + Beta + Tax + RFR, data = mydataselreg2)

Residuals:
       Min         1Q     Median         3Q        Max
-0.0089515 -0.0018482  0.0002416  0.0020249  0.0086926

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.034475   0.003513  -9.813 3.30e-15 ***
ERP          0.708114   0.028453  24.888  < 2e-16 ***
DP           0.407339   0.039681  10.265 4.52e-16 ***
gearing     -0.057650   0.004914 -11.732  < 2e-16 ***
Beta         0.043066   0.003906  11.026  < 2e-16 ***
Tax          0.088928   0.005965  14.909  < 2e-16 ***
RFR          1.107211   0.021524  51.441  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.003751 on 77 degrees of freedom
Multiple R-squared:  0.9799,    Adjusted R-squared:  0.9783
F-statistic: 625.2 on 6 and 77 DF,  p-value: < 2.2e-16
```

VIF

```
      ERP        DP  gearing      Beta       Tax       RFR
1.614131  1.216652 2.321099  1.453599  1.341127  1.122254
```



Source: BEREC RA database 2019

Figure 67 shows the contribution to the increase in R-squared that each parameter produces when it is added to a model that already contains all of the other variables. Specifically, we include all N-1 variables in the model and we evaluate how well they fit in the model, like in a Backward elimination selection rule in a stepwise regression, and comparing the results with the Model specified with the N independent variable.

Since the change in R-squared analysis considers each variable as the last one entered into the model,

[58] Global test and Breush-Pagan test have been carry on with a result to discard the null Hypothesis of Non linearity, Skewness, Kurtosis, Kind of Model (categorical/continuous), Heteroscedasticity.

the change represents the percentage of the variance one single variable explains that the other variables in the model cannot explain. In other words, this change in adjusted R-squared rep- resents the amount of *unique* variance that each variable explains above and beyond the other variables in the model. We further estimate the Akaike Information Criterion,[59] comparing the value obtained with a model with N independent variables and the values obtained with models composed by N-1 variables. This analysis confirms what the R-square analysis already highlighted, in terms of relevance of the parameters and provides that no model overfitting problem comes out. In figure 67 we report statistics from the three analysis done, when all the observations are taken into account (n=89) ,when possible 5 "outliers" have been deleted (n=84), when only EU members are included (n=71).

Figure 67 - WACC Nominal pre-tax R^2 adjusted variations / AIC variations

Number of obsevations 89	Total	RFR	ERP	Tax	gearing	beta	DP
R^2	97.23%	68.40%	17.13%	5.82%	3.90%	3.32%	2.80%
AIC	-953.64	-288.06	-174.64	-99.91	-77.75	-69.3	-61.36
Number of obsevations 84	Total	RFR	ERP	Tax	gearing	beta	DP
R^2	97.83%	73.52%	17.19%	6.15%	3.80%	3.35%	2.90%
AIC	-931.72	-297.52	-182.97	-112.03	-84.11	-77.57	-70.43
Number of observation 71 (only EU member)	Total	RFR	ERP	Tax	gearing	beta	DP
R^2	97.27%	62.25%	30.99%	9.68%	5.93%	5.50%	3.55%
AIC	-800.84	-224.17	-177.59	-106.61	-81.09	-77.49	-58.24

Source: BEREC RA database 2019

The main conclusion prevails that most of the variability is explained by the RFR estimation and, to a lesser extent, by the ERP estimation (with respect to last year's analysis the relevance of the RFR and ERP is increased, as can be shown for the percentage of R^2). Looking at only EU member state countries it is possible to observe that ERP become more relevant for understanding causality variation of the final WACC value. All other parameters provide a much lower statistically significant explanation to the variation of the final WACC value.

[59] The Akaike information criterion (AIC) is a measure of the relative quality of statistical models for a given set of data. Given a collection of models for the data, AIC estimates the quality of each model, relative to each of the other models. Hence, AIC provides a means for model selection. Given a set of candidate models for the data, the preferred model is the one with the minimum AIC value. AIC rewards goodness of fit (as assessed by the likelihood function), but it also includes a penalty that is an increasing function of the number of estimated parameters. The penalty discourages overfitting, because increasing the number of parameters in the model almost always improves the goodness of the fit.