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Dublin Airport Cost of Capital for 2019 Determination

Draft Report

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A report for the Commission for Aviation Regulation

12 March 2019

ISSN 2235-1868

Title: Dublin Airport Cost of Capital for 2019 Determination

Status: Draft Report

Date: 12.03.2019

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Executive Summary

Swiss Economics conducted a study on Dublin Airport's efficient cost of capital in connection with the 2019 Determination on the maximum level of airport charges. Based on this assessment, we advise to set a real pre-tax rate on the cost of capital of 3.99 percent for the next regulatory period from 2020.

Our advice is based on the sum of our best estimate of Dublin Airport's efficient cost of capital, 3.49 percent, and an uplift of 50 basis points to mitigate asymmetric risks from over- and underestimating the true cost of capital.

Our analysis of market evidence and regulatory precedent suggests that the true cost of capital ranges from 2.80 percent to 4.20 percent with a point estimate of 3.49 percent. We use a weighted average cost of capital (WACC) framework which takes into account the difference in cost levels for equity and debt. The weighting is based on a notional capital structure that minimizes overall cost.

The cost of equity ranges from 4.75 percent to 5.94 percent with a point estimate of 5.38 percent. This results from a capital asset pricing model (CAPM) approach, which relates Dublin Airport's systematic risk (measured by the Equity Beta) to the current equity risk premium (ERP) and returns on risk-free assets.

The real risk-free rate (RFR) ranges between -0.72 percent to 0.45 percent with a point estimate of -0.14 percent. This range is indicated by current yields on Irish and German government bonds taking into account market expectations on future government bond yields and changes in monetary policy.

The Equity Beta ranges from 0.81 to 0.86 with a point estimate of 0.84. This is the result of our assessment of 12 comparator airports. We estimate Asset Betas for 9 exchange-listed airports using regression analysis of stock market data with varying time horizons and data frequencies. In addition, we use Asset Betas set by other regulators for 3 non-listed comparator airports. Comparator airports' Asset Betas are weighted according to their relevance for Dublin Airport in terms of similarity of regulatory environments, demand structure, and business structure. The weighted Asset Beta estimates are converted to Equity Betas using Dublin Airport's notional gearing and the effective Irish corporate tax rate.

The ERP ranges between 6.19 percent and 6.94 percent with a point estimate of 6.56 percent. This range is based on the delta between total market returns (TMR) and the RFR. We combine backward-looking evidence from long-term averages of equity market returns with forward-looking estimates from a dividend discount model to estimate the TMR.

The cost of debt ranges from 0.65 percent to 1.04 percent with a point estimate of 0.85 percent. We distinguish between cost of embedded debt and cost of new debt. Our estimate of cost of embedded debt is based on Dublin Airport's current interest payments adjusted for expected changes in future payments for floating debt. The cost of new debt is based on yields for comparator airport bonds taking into account the existence of a small country-specific risk premium. We weight rates for embedded and new debt according to the debt structure expected over the next regulatory period and add further uplifts to reflect transaction costs and a notional "BBB"-credit rating.

Table 1 summarises our advice and reports the findings of our analyses on the individual WACC components.

Table 1: Overview advice and findings on individual WACC components

	Range	Point estimate
Gearing	45% - 55%	50%
Tax rate		12.50%
RFR	-0.72% - 0.45%	-0.14%
TMR	6.05% - 6.80%	6.43%
ERP	6.19% - 6.94%	6.56%
Asset Beta	0.43 - 0.46	0.45
Equity Beta	0.81 - 0.86	0.84
Cost of equity	4.75% - 5.94%	5.38%
Cost of debt	0.65% - 1.04%	0.85%
True pre-tax WACC	**2.80% - 4.20%**	**3.49%**
Aiming up		0.50%
Advice on regulatory pre-tax WACC		**3.99%**

Source: Swiss Economics.

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Abbreviations

AEEGSI	Italian Regulatory Authority for Electricity and Water
bn	billion
bps	basis points
CAA	Civil Aviation Authority
Capex	capital expenditure
CAPM	Capital asset pricing model
CAR	Commission for Aviation Regulation
CER	Commission for Energy Regulation
CIP 2020+	Capital Investment Plan 2020+
Comreg	Commission for Communications Regulation
daa	Dublin Airport Authority
DDM	Dividend Discount Model
DMS	Dimson, Marsh, and Staunton
e.g.	for example
ECB	European Central Bank
EDF	Electricité de France
EIB	European Investment Bank
ENAC	Ente Nazionale per l'Aviazione Civile
ERP	Equity Risk Premium
ESBN	Electricity Supply Board Networks
GARCH	Generalized autoregressive conditional heteroskedasticity
GDP	Gross Domestic Product
GER	Germany
GLS	Generalized Least Squares
GNI	Gas Networks Ireland
IATA	International Air Transport Association
i.e.	in other words
IRE	Ireland
ISIN	International Securities Identification Number
m	million
mppa	million passenger per annum
Ofgem	Office of Gas and Electricity Markets
OLS	Ordinary Least Squares
Opex	operating expenditure
Q	quarter

QE	Quantitative Easing
RAB	Regulatory Asset Base
RFR	Risk-free Rate
S&P	Standard & Poor
SE	Swiss Economics
TMR	Total Market Return
Totex	Total Expenditure
UK	United Kingdom
UKRN	United Kingdom Regulatory Network
WACC	Weighted Average Cost of Capital

1 Introduction

1.1 Background

1 The Commission for Aviation Regulation (CAR) commissioned Swiss Economics SE AG (Swiss Economics) to conduct a study on Dublin Airport's efficient pre-tax cost of capital in connection with its 2019 Determination on the maximum level of airport charges (2019 Determination).

2 Dublin Airport is Ireland's busiest airport with passenger numbers in excess of 30 million per annum. It represents the country's main gateway for incoming and outgoing travellers. Price regulation ensures that charges to airlines for using the facilities at Dublin Airport are not higher than necessary. Dublin Airport is operated and owned by daa plc (daa).

3 The 2019 Determination will apply from 1 January 2020 for a period of at least four years and will replace the current 2014 Determination. CAR aims to set maximum allowable airport charges per passenger such that Dublin Airport's revenues cover the total efficient economic costs for its operations. These include a rate of return on the Regulatory Asset Base (RAB) that reimburses investors and lenders for accepting risk and foregoing alternative opportunities when providing Dublin Airport with the necessary funds to efficiently operate the regulated entity.

1.2 Methodology

4 In line with Irish regulatory precedent, we determine the appropriate rate of return using the Weighted Average Cost of Capital (WACC) approach. We estimate the WACC on a real, pre-tax basis in order to be consistent with other building blocks of CAR's regulatory scheme.

5 The pre-tax WACC is defined by the following formula:

$$WACC = R_E \times (1 - g) \times \frac{1}{1-T} + R_D \times g \tag{1}$$

where

- g is the gearing ratio;
- R_E is the real and efficient post-tax cost of equity;
- T is the Irish corporate tax rate (currently at 12.5 percent); and
- R_D is the real and efficient cost of debt.

6 We estimate the cost of equity using the capital asset pricing model (CAPM):

$$R_E = RFR + \beta \times (TMR - RFR) \tag{2}$$

where

- RFR is the risk-free rate;
- β measures the sensitivity of Dublin Airport equity returns with reference to changes in returns of the market portfolio; and
- TMR are expected total market returns.

7 We estimate the cost of debt R_D based on weighted estimates for the cost of embedded debt and the cost of new debt.

8 Each component of the WACC is assessed based on quantitative and qualitative evidence, keeping economic theory and regulatory practice in mind. Specifically, we have considered the following sources of evidence:

- relevant theory from financial economics and corporate finance;
- empirical results from academic studies;
- actual market data of government and corporate bond yields, stock returns, and central bank interest rates; and
- regulatory precedent in Ireland and Europe.

9 We have laid a strong focus on stakeholder engagement during the process and held multiple meetings and calls with daa as well as airlines. Opinions and views from stakeholders that were considered include the following:

- various stakeholders' views expressed in responses to CAR's Issues Paper;
- various stakeholders' views expressed during calls and meetings between November to December 2018;
- a report prepared by Nera Economic Consulting (Nera) on Dublin Airport's cost of capital dated December 2018, which was commissioned by daa;
- a note from the International Air Transport Association (IATA) dated 10 January 2019;
- a letter from Ryanair to Swiss Economics dated 16 January 2019; and
- a slide pack from Nera dated 22 January 2019.

1.3 Structure

10 The remaining parts of the report are structured as follows:

- in Section 2, we analyse Dublin Airport's notional gearing;
- in Section 3, we quantify the appropriate level of the risk-free rate;
- in Section 4, we assess the risk premium for holding equity;
- in Section 5, we estimate Dublin Airport's Beta;
- in Section 6, we determine the cost of debt for Dublin Airport;
- in Section 7, we discuss arguments for aiming up the WACC; and
- Section 8 concludes.

2 Gearing

11 We base our advice regarding the gearing level on the following evidence and considerations:

- conceptual points on the purpose of the appropriate gearing level; and
- regulatory precedent from CAR and other airport regulators.

2.1 Considerations regarding the appropriate gearing level

12 Rather than reflecting Dublin Airport's actual gearing, the notional capital structure underlying the regulatory WACC should be based on a hypothetical gearing rate representing the capital structure that an efficient airport operator would choose in order to minimise cost of capital. The notional capital structure optimises the trade-off arising from increasing debt levels between greater tax benefits (as cost of debt is tax deductible) and increased risk (for which equity holders must be reimbursed). Independent of theoretical considerations, the notional gearing ratio should be set so that it can be achieved by Dublin Airport over the next regulatory period or otherwise financial viability is at risk.

13 daa's actual gearing level is currently below 50 percent. According to daa's 2017 financial statement, total assets amount to €2.7bn with gross debt of €1.1bn (i.e. 41 percent of total assets). However, daa raises debt on the group level without distinguishing between various business activities. Borrowings used to finance assets for ARI, daa's airport retailing business, or daa international, daa's management and advisory services, cannot be distinguished from borrowings used to finance Dublin Airport assets.

14 If all of daa's debt was allocated to Dublin Airport assets, the corresponding gearing ratio would be [✂] percent.[1] This value represents the maximum achievable gearing ratio for Dublin Airport in the short term and should not be exceeded substantially by the upper boundary of gearing ratio range.

15 **Table 2** summarises regulatory precedent of European airport regulators regarding the gearing ratio.

Table 2: Recent regulatory precedent on gearing ratios of airports

Regulator	Decision	Point estimate	Based on
HMWEVL (2017)	Fraport 2017 WACC Determination	52%	n/a
ENAC (2016)	Aeroporti di Roma WACC Determination for 2017-2021 Price Control Period	57%	n/a
CAA (2014)	Q6 (2015-2019) Price Control of Heathrow	60%	Gearing as debt to regulatory asset base
CAA (2014)	Q6 (2015-2019) Price Control of Gatwick	55%	Gearing as debt to regulatory asset base
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	50%	n/a

Source: Swiss Economics based on regulatory decisions.

16 We note that other airport regulators have typically chosen values for the notional gearing ratio between 50 percent to 60 percent.

[1] This is based on current total debt of approximately [✂] and a regulatory asset base (RAB) of €1.5bn (see Section 6).

17 CAR has used a gearing ratio of 50 percent in past decisions, mimicking a balanced capital structure that takes into account the trade-off between tax benefits and risk described above. There is merit in maintaining the current gearing ratio for the next regulatory period in the absence a compelling reason to deviate. Regulatory consistency is likely to increase investor and creditor confidence and have a hampering effect on the cost of capital.

18 Also, none of the stakeholders have raised any concerns in connection with our proposal to keep the gearing rate at a level of 50 percent.

2.2 Conclusion

19 There is no compelling reason to deviate from the notional capital structure used in past decisions. In the interest of regulatory consistency, we advise to continue using a gearing rate of 50 percent.

20 **Table 3** summarises our advice.

Table 3: Summary gearing rate

	Range (in %)	Point estimate (in %)
2019 SE advice	45 – 55	50
CAR 2014 Determination	40 – 60	50

Source: Swiss Economics.

3 The risk-free rate

21 The level of the RFR can be assessed using a benchmark security that proxies the characteristics of a risk-free asset. Theoretically, the benchmark security has the following properties:

- no variance, i.e. a guaranteed fixed return absent of any credit default risks;
- no liquidity or reinvestment risks;
- no currency risks; and
- no risks in connection with inflation.

22 We consider the following evidence to estimate the level of the RFR:

- current market evidence from Irish and German government bond yields;
- evidence from forward rates and effects of monetary policy; and
- regulatory precedent.

3.1 Evidence from current government bond yields

3.1.1 Nominal yields of Irish and German government bonds

23 We use long-term Irish and German government bond yields as a benchmark for the RFR. Given their discretion to levy taxes, governments are frequently perceived as the most reliable debtors.

24 The use of Irish government bonds as benchmark is in line with the Thessaloniki Forum of Airport Charges Regulators (Thessaloniki Forum) recommendations, which suggest using bonds from the member state the airport is located in (Thessaloniki Forum Guidelines, 2016, p. 4). Although it is not explicitly mentioned by the Thessaloniki Forum, we consider that for airports in the Euro area, bonds from other Euro countries are relevant as well. This is illustrated by the fact that daa is not limited to raise funds in Ireland. For example, most of its existing debt was raised through the European Investment Bank. This is of relevance because bonds from other countries in the Euro area are perceived to be lower risk than Irish government bonds.

25 Within the Euro area, German government bonds are often considered to be the least risky assets by practitioners (van Riet, 2017). Even though Luxembourg and the Netherlands similarly achieve the highest possible credit ratings, German government bonds trade at higher volumes implying slightly lower liquidity risks.

26 We focus on liquid bonds with a relatively long investment horizon, i.e. 10 years to maturity, reflecting that physical assets at Dublin Airport are of long-term nature. In addition, investors seeking to invest in airport assets with limited business risk, such as pension funds, are likely to have a relatively long investment horizon.

27 The use of Irish and German 10-year government bonds is consistent with Irish regulatory precedent. The Commission for Energy Regulation (CER) and the Commission for Communications Regulation (Comreg) have both relied on consultant reports that considered 10-year government bond yields as evidence for the appropriate RFR. For example, CER's 2016 Decision Paper for the Second Revenue Control 2017 – 2018 for Irish Water cites a report by Europe Economics (2016) which refers, among other evidence, to yields of 10-year Euro area bond markets to inform the level of the RFR. Similarly, Comreg's 2014 decision on the WACC for mobile, fixed line, and broadcasting services in Ireland is based on a consultancy report referring to 10-year government bond yields in the Euro area.

28 **Table 4** recaps the methodology relied on by various Irish regulators during past decisions. From the widespread adoption of current government bond yields, we conclude that their relevance as evidence to inform the RFR is uncontroversial.

Table 4: Use of current government bond yields in regulatory precedent

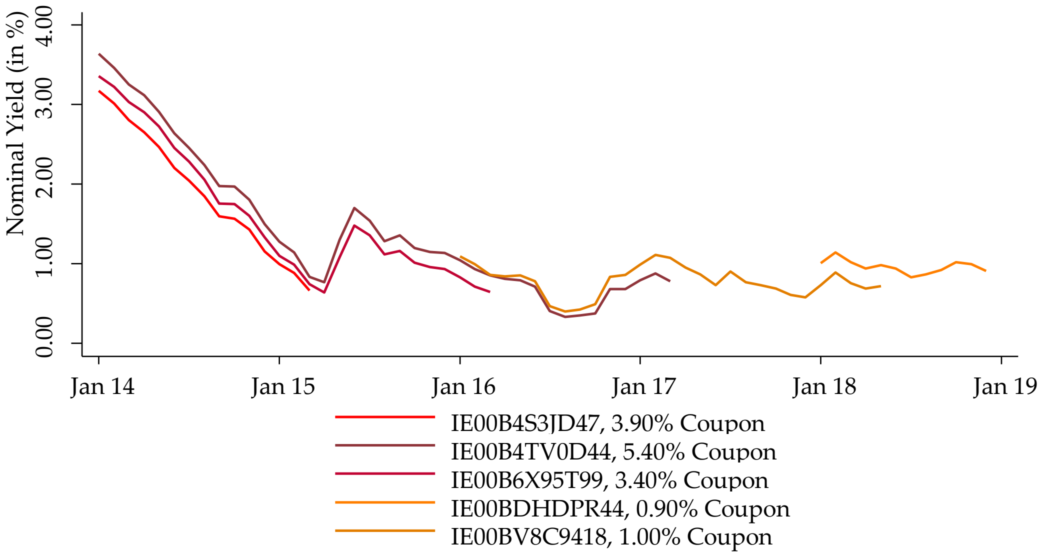
Regulator	Decision	Issuing government	Time horizon	Importance
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	Germany, UK, Ireland	10-year bonds	Did not consider current government bond yields. Relied on Irish utility regulatory precedent.
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	Euro area governments	10-year bonds	Pre-2008 yields considered.
CER (2016)	ESBN/EirGrid PR4	Germany	10-year bonds	Yields considered for lower bound of estimate.
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	Germany	10-year bonds	German government bonds from 2000-October 2014 considered.
CAR (2014)	Airport Charges 2014-Determination	Germany	10-year bonds	Yields considered for lower bound of estimate.

Note: The importance of the CER (2016) ESBN/EirGrid government bonds becomes clear only in the consultant's report prepared for CER by Europe Economics.

Source: Swiss Economics.

29 **Figure 1** displays nominal yields of Irish government bonds over time. All bonds pay a fixed annual coupon and are denominated in Euros. We focus on bonds with a remaining duration to maturity of between 8 to 12 years. Spreads between yields are small. They are the result of slightly different weights of short-term and long-term risks between bonds with 8 years to maturity and bonds with 12 years to maturity. Marginal changes in cash-flow profiles, due to differences in coupon payments, may play a role as well.

Figure 1: Nominal yields of Irish government bonds



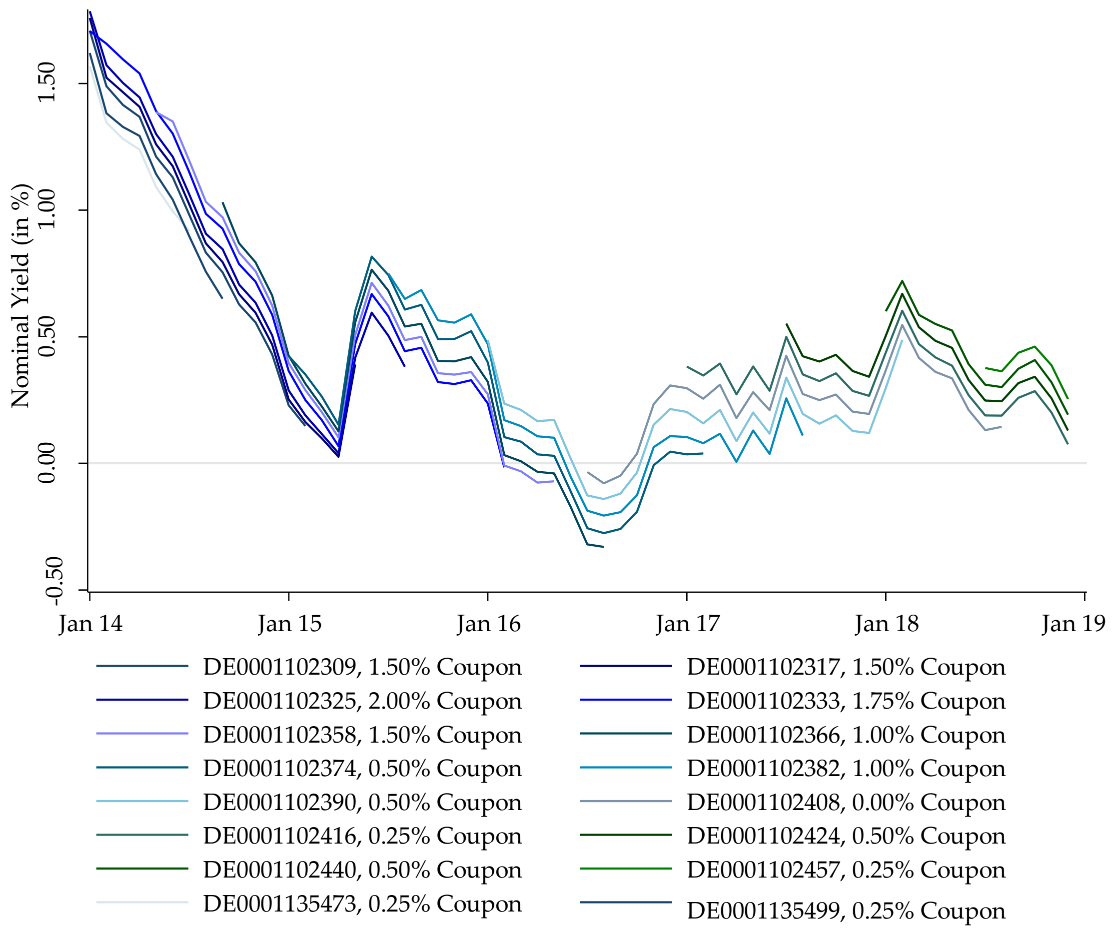
Note: Illustrated are nominal yields of Irish government bonds with a remaining time to maturity between 8 to 12 years. Only Euro-denominated fixed coupon bonds are considered.

Source: Swiss Economics based on Infront data.

30 After the European debt crisis had quietened down, nominal yields of Irish government bonds dropped significantly in 2014. Since 2015, yields have remained on a historically low level, at around 1.00 percent. Recently, Irish government bond yields have picked up again slightly.

31 A similar picture is revealed for German government bonds. Although they have always been traded at slightly higher prices (i.e. lower nominal yields), a substantial decrease in yields in 2014 can as well be observed for German government bonds. **Figure 2** displays nominal yields of Euro denominated German government bonds with a remaining 8 to 12 years to maturity.

Figure 2: Nominal yields of German government bonds

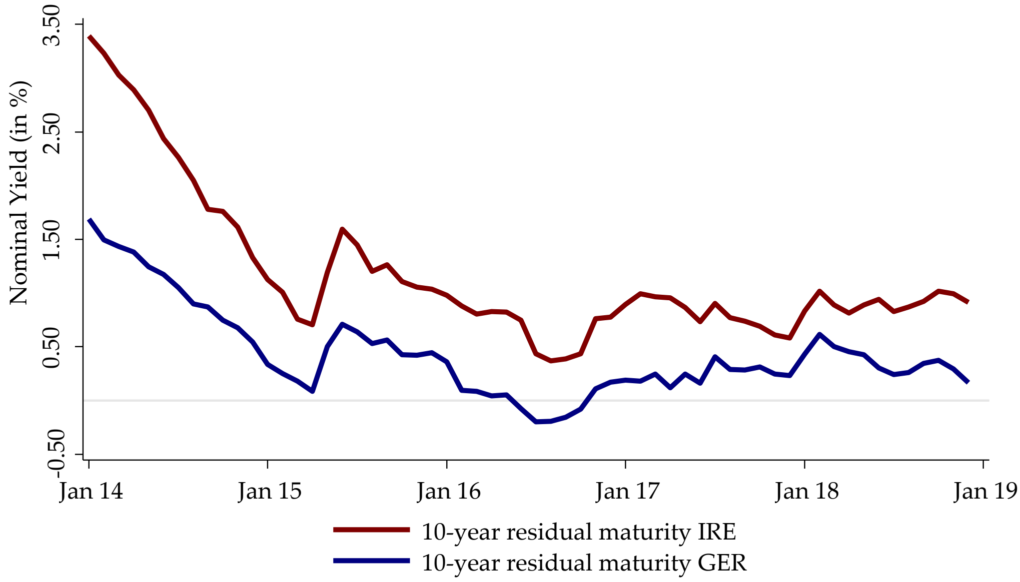


Note: Illustrated are nominal yields of German government bonds with a remaining time to maturity between 8 to 12 years. Only Euro-denominated fixed coupon bonds are considered.

Source: Swiss Economics based on Infront data.

32 **Figure 3** presents collated average series of Irish and German government bond yields using the data presented in Figure 1 and Figure 2. The series indicate the range of the RFR in nominal terms based on current market data.

Figure 3: Average nominal yields of Irish and German government bonds



Note: The series reflect arithmetic averages of the yields for all issued Irish and German government bonds with a residual time to maturity between 8 to 12 years.

Source: Swiss Economics based on Infront data.

3.1.2 Conversion from nominal to real yields

33 To be consistent with other building blocks, we express the level of the RFR and all other WACC components in real terms.

34 Nominal government bond yields must be converted to real yields in order to adequately serve as a benchmark of the relevant risk-free rate. We use the Fisher equation (Fisher, 1930) to transform nominal to real yields:

$$1 + i_t = (1 + n_t)/(1 + \pi_t^e) \tag{3}$$

where

- i_t is the real yield at time t;
- n_t is the nominal yield at time t; and
- π_t^e is the long-term expected inflation at time t.

35 The rate of expected inflation cannot be observed directly in the market. Rather, it must be approximated using benchmark variables. We use two different sources to estimate long-term inflation expectations.

- Firstly, we use survey data on inflation expectations maintained by the European Central Bank (ECB). The ECB regularly surveys professional forecasters on their expectations of inflation rates in the Euro area at several time horizons and publishes the results quarterly.[2] Survey participants are expert economists who work at financial or non-financial institutions, such as banks or independent economic research institutes. **Figure 4** shows that surveyed inflation expectations have remained relatively stable over the past 5 years, ranging from 1.5 percent to 1.8 percent. In Q4 of 2018, expected average inflation over the next 10

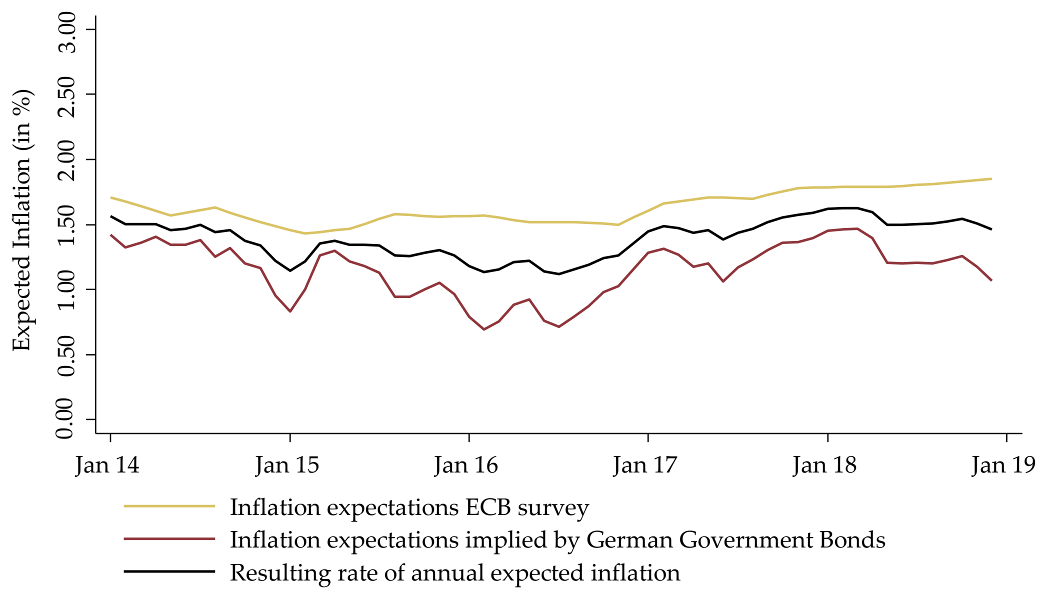
[2] See https://www.ecb.europa.eu/stats/ecb_surveys/survey_of_professional_forecasters/html/index.en.html.

years is close to 1.5 percent. One potential problem with this source is that expectations of surveyed experts do not necessarily coincide with true market expectations.

- Secondly, we use yield data on inflation-linked German government bonds, which directly incorporate the market's inflation expectations. Inflation-linked bonds have frequently been suggested as a proxy of the real RFR (see for example UKRN, 2018). In addition to strong creditor risk profiles, inflation-linked government bonds eliminate risks related to changes in general price levels, which, in theory, brings them closer to the concept of a risk-free asset. However, in practice, inflation-linked bonds often have issues of reduced liquidity, which offset the inflation risk advantage compared to nominal bonds (see for example Auckenthaler et. al, 2015).

36 Figure 4 illustrates the rate of expected long-term inflation derived from the two sources. We use an average of the two series to convert nominal to real rates.

Figure 4: Expected annual inflation over the next 10 years

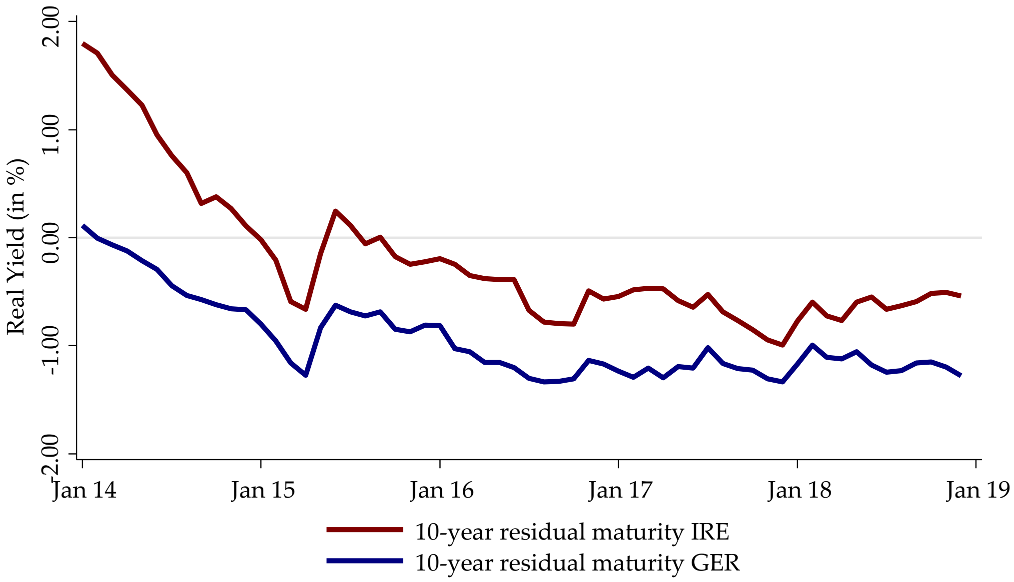


Note: The expected rate of inflation based on the ECB survey of professional forecasters was calculated using the geometric mean of expected annual inflation over the period for the next 10 years. Monthly values are derived interpolating quarterly values.
Inflation expectations implied by German government bonds were derived from the spread between nominal German government bonds and inflation-linked German government bonds using the Fisher transformation. We used monthly averages of the nominal yield series displayed in Figure 3 and a series of average yields from German inflation-linked bonds with a remaining 8 to 12 years to maturity (DE0001030542, DE0001030526, DE0001030559, DE0001030567, DE0001030575). We limit ourselves to German inflation-linked government bonds because of data availability for the few existing Irish linkers.

Source: Swiss Economics based on ECB's Survey of Professional Forecasters and Infront data.

37 The converted real yield series of German and Irish government bonds are presented in **Figure 5**.

Figure 5: Real government bond yields



Source: Swiss Economics based on Infront data.

38 We use averages over various time periods ranging from 1 to 5 years to inform our estimate of the real RFR based on current market rates.

39 Short averaging periods or even spot rates risk picking up random fluctuations or temporary market sentiments that do not bear any meaningful information about the true RFR. Long averaging periods, on the other hand, risk including yields that do no longer reflect relevant market conditions.

Table 5: Average real yields

Bond	1-year average	2-year average	5-year average
Irish Government Bonds	-0.62%	-0.64%	-0.21%
German Government Bonds	-1.16%	-1.19%	-0.95%

Note: 1-year averages are calculated over the period from January 2018 to December 2018, 2-year averages are calculated over the period from January 2017 to December 2018, and 5-year averages are calculated over the period from January 2014 to December 2018. Only Euro denominated bonds with a remaining 8 to 12 years to maturity were considered. Conversion from nominal to real terms based on inflation expectations derived from ECB survey and spread between nominal and inflation-linked German government bonds.

Source: Swiss Economics based on Infront data.

3.2 Forward rates

40 Forward rates reflect market expectations about future yields. They are not directly observable in the market, but they can be backed out from spreads between spot rates of bonds with various maturities.

41 Formally, the relationship between spot rates and forward rates is given by the following formula:

$$i_{t_y t_x}^{FOR} = \left[\frac{(1+i_x)^x}{(1+i_y)^y}\right]^{\frac{1}{x-y}} - 1 \tag{4}$$

where

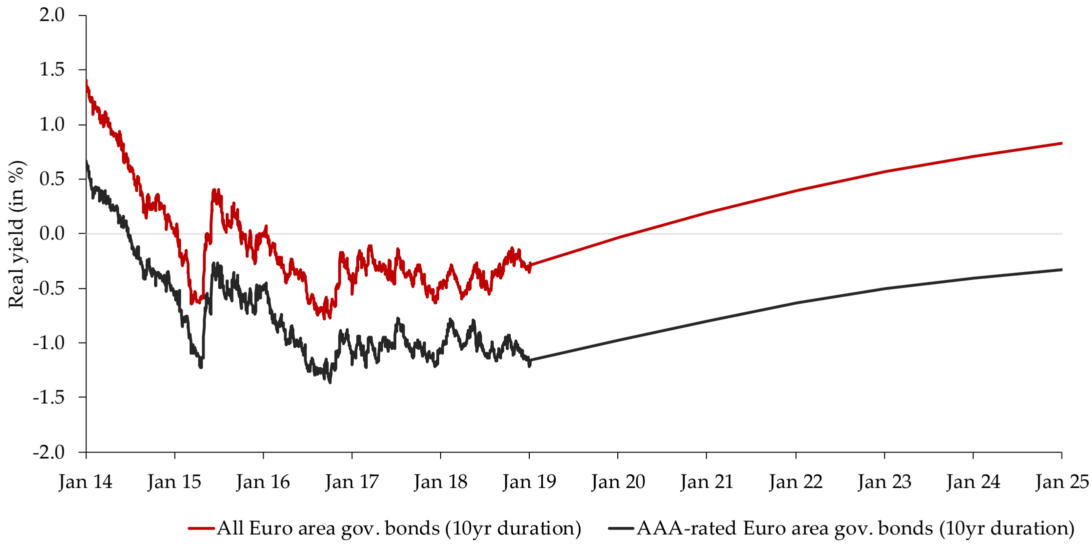
- $i_{t_y t_x}^{FOR}$: implicit forward rate for a bond from t_y to t_x;

- i_x: spot rate at time t_x; and
- i_y: spot rate at time t_y (where t_y is closer to the present than t_x).

42 We use ECB data rather than country-specific German or Irish data for reasons of data availability. The calculation of reliable forward rates requires a wide range of maturities, which is not readily available for Ireland and only to a limited extent for Germany.[3]

43 **Figure 6** depicts implied real forward yields of Euro area government bonds with a remaining duration to maturity of 10 years from January 2019 onwards. Data points before 2019 are actual real yields.

Figure 6: Forward rates implied by government bond spot rates



Note: Spot rates at 31 December 2018 were used as the basis for the calculation of forward rates.

Source: Swiss Economics based on ECB data.

44 The clear upwards trend in forward rates suggests that the market expects an increase in government bond yields over the next years. This holds for all Euro area government bonds as well as for AAA-rated bonds, although the expected increase for the latter is slightly less pronounced.

45 **Table 6** summarises market expectations about the increase in yields during the upcoming regulatory period.

[3] In addition, the ECB data also contains government bond yields series for AAA-rated Euro area government bonds as shown in Figure 6. These represent valid proxies for German bond yields since, next to Germany, Luxembourg and the Netherlands are the only AAA-rated countries in the Eurozone. However, their government bond markets are much smaller than the German market and their influence on the AAA-rated Euro area government bonds yields series is limited.

Table 6: Expected real future yields during the upcoming regulatory period

Year	Expected real yields (all Euro area bonds)	Delta to December 2018 actuals	Expected real yields (AAA-rated Euro area bonds)	Delta to December 2018 actuals
2020	-0.03%	26 bps	-0.97%	15 bps
2021	0.20%	49 bps	-0.79%	33 bps
2022	0.40%	69 bps	-0.63%	49 bps
2023	0.57%	86 bps	-0.50%	62 bps
2024	0.71%	100 bps	-0.40%	72 bps
2020 – 2024	**0.37%**	**66 bps**	**-0.66%**	**47 bps**

Note: Last row shows arithmetic means across all years. Delta to December 2018 values represent the difference in yields to 28 December 2018.

Source: Swiss Economics.

46 The markets expect an average increase in real yields for the period from 2020 to 2024 of 66 basis points for all Euro area bonds and 47 basis points for AAA-rated Euro area bonds.

3.3 The impact of Quantitative Easing

47 Over the past years, several regulators have considered the effects of central banks' Quantitative Easing policy when setting allowed rates of return of capital. Their reasoning has typically been that large-scale asset purchase programs have the potential to temporarily increase demand for government bonds leading to inflated prices and hampered yields.

48 Ofgem, the energy regulator in the UK, adjusted its estimate of the RFR from market evidence by 100 basis points in order to compensate for the Bank of England's £375bn purchase of gilts in 2014 (Ofgem, 2014).

49 For the same reason, the Italian regulator for gas and water AEEGSI added a premium on its estimate of the RFR of around 50 basis points in 2015 (AEEGSI, 2015).

50 In December 2018, the ECB ended its net purchases of European bonds implying a departure of the Quantitative Easing (QE) policy of the past three years.[4] The ECB will however continue to reinvest the principal payments from maturing securities it purchased for an unlimited time. Thus, the change in policy may be assumed to have a stabilising impact on total demand for Euro bonds rather than a decreasing impact.

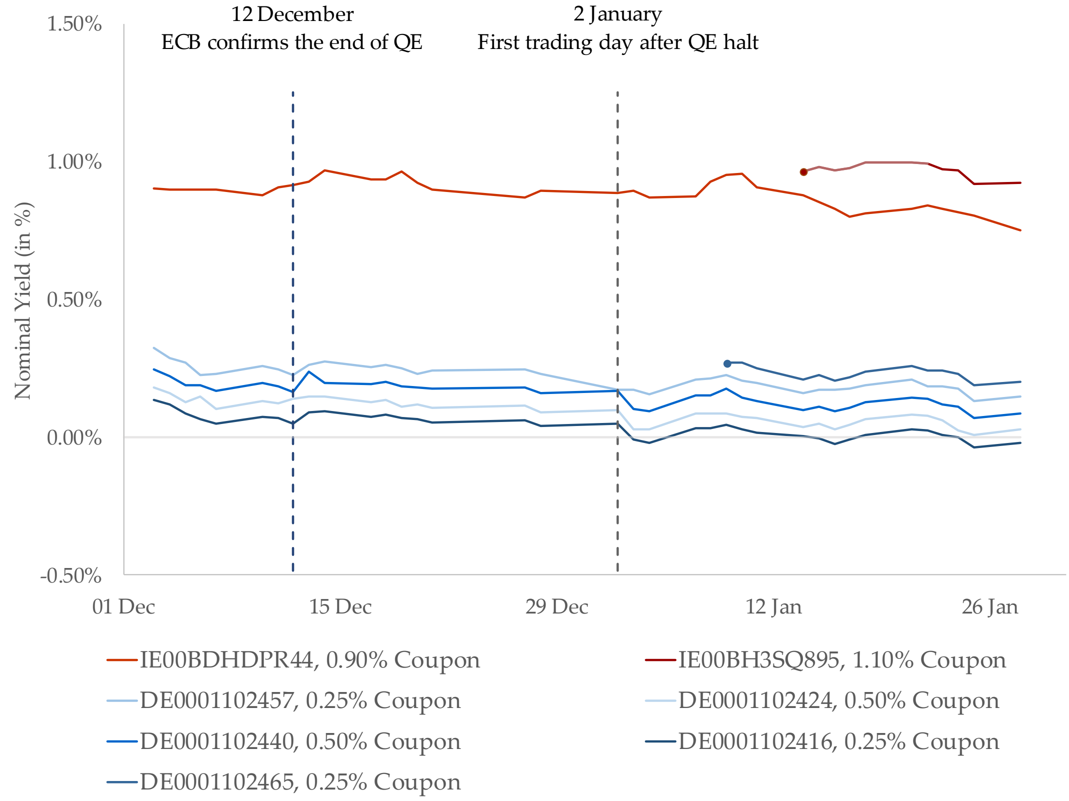
51 First bond issuances after the halt of QE suggest that the overall impact is of limited extent. On 9 January 2019, the Irish government raised €4bn through a new 10-year benchmark treasury bond maturing in May 2029. The funds were raised at a nominal yield of 1.12 percent, which is comparable to past debt issuances in 2018 (at 0.94 percent) and 2016 (at 1.15 percent).[5]

52 Similarly, a distinctive effect of the ECB's confirmation in December to taper QE cannot be observed on the bond markets. **Figure 7** presents daily changes in yields between December 2018 to January 2019. The new Irish bond and a new German bond issued in early January have resulted in marginally higher yields than existing bonds. However, we accept that more significant effects may become visible over time.

[4] https://www.ecb.europa.eu/mopo/implement/omt/html/index.en.html.

[5] See Irish Times (2019) https://www.irishtimes.com/business/economy/state-s-first-bond-deal-of-year-most-popular-ever-1.3752255

Figure 7: Nominal yields of selected government bonds from Dec 2018 to Jan 2019



Source: Swiss Economics based on Infront data.

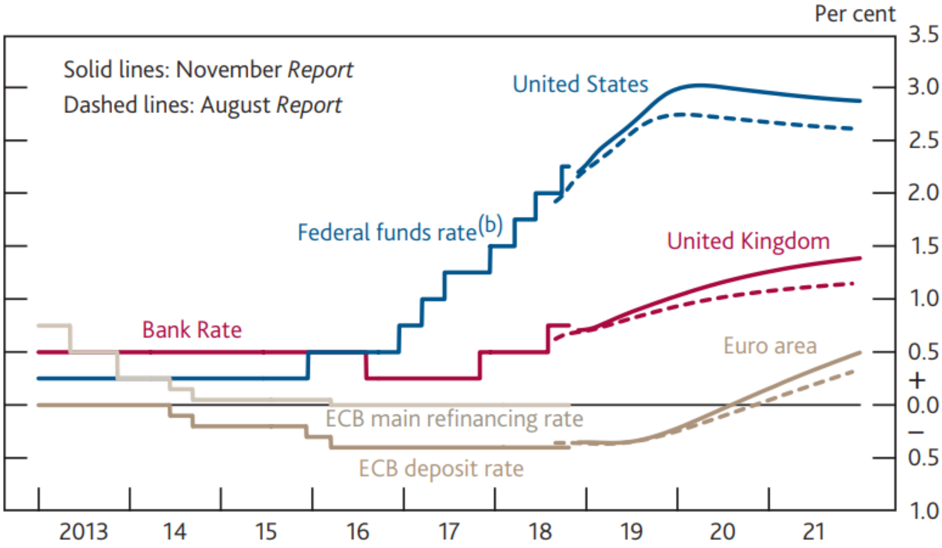
53 In addition to ending the purchase of net assets, the ECB could increase short-term interest rates at some point over the next years. In December 2018, the ECB signalled that for the foreseeable short-term future, at least until Q3 in 2019, key interest rates will remain at their current levels, i.e. 0.0 percent for the main refinancing rate.[6] However, research from the Bank of England suggests that in the longer term the market expects several central banks to increase interest rates.

54 **Figure 8** presents central bank base rates and their implied market forward rates as calculated by the Bank of England (2018). The forward rates are estimated using instantaneous forward overnight index swap rates in the 15 working days prior to 24 October and 25 July for the November and August report, respectively.

55 The chart reveals market expectations of an increase in interest rates in the Euro area of 100 basis points by the end of 2021.

[6] https://www.theguardian.com/business/2018/jun/14/ecb-calls-halt-to-quantitative-easing-despite-soft-euro.

Figure 8: International central bank base rates expectations by the Bank of England



Source: Bank of England November 2018 Inflation Report.

56 The Bank of England's research on market expectations of future central bank interest rates is consistent with the results of our analysis on forward rates of European government bonds. Increases in central banks' short-term interest rates can be expected to be passed through to long-term interest rates, such as government bond yields, to some extent.

57 We believe evidence on current market rates should be complemented by market expectations about future yields.

3.4 Regulatory consistency and long-term evidence of the RFR

58 During our meetings with stakeholders, we have been asked to reflect Irish precedent with reference to the RFR in our report and to consider the importance of consistency across regulatory periods and across regulated sectors.

3.4.1 Regulatory consistency

59 Indeed, we find that many past regulatory decisions in Ireland referred to past levels of the RFR as a source of evidence to find the RFR going forward.

60 For example, in their most recent decision from 2017, the Commission for Energy Regulation (CER) set a RFR in line with older decisions in order to support Irish regulatory stability. The regulator set a RFR close to 2 percent, which was significantly above current rates of real government bond yields at the time. CER noted that there was no conclusive evidence on whether the current state of low government bond yields was of temporary nature or due to longer-term macroeconomic changes. CER stated that, on the one hand, factors such as demographic changes and expectations of weak future growth speak for a long-term change in the RFR; on the other hand, factors such as increased risk aversion and market distortions resulting from monetary policy following the financial crisis point to current rates being short-lived (CER, 2017).

61 **Table 7** summarises other recent Irish precedent regarding the RFR.

Table 7: Recent Irish precedent on the RFR

Regulator	Decision	Range	Point estimate	Based on
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	n/a	1.90%	Upper end of recent UK regulatory determinations and recent CER determinations
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	1.80% – 2.00%	2.00%	Combination of pre-2008 sovereign bond yields, recent regulatory precedent, changes in output growth rate for the Eurozone
CER (2016)	ESBN/EirGrid PR4	1.75% – 2.10%	1.90%	Upper bound in line with recent Irish regulatory precedent, lower bound in line with 2000-2014 average yield of German 10-year bonds
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	Ranges only given in preliminary report	2.10%	Yields on 10-year German government bonds from 2000-October 2014, risk-free rates from recent Irish regulatory precedent
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	0.00% – 2.00%	1.50%	Yields on AAA-rated 10-year government bonds from 2009 to 2014, risk-free rates from previous Irish regulatory precedent

Note: Information regarding calculation of CER (2016) ESBN/EirGrid risk-free rate found in Europe Economics report prepared for CER. The AAA-rated government bonds used in CAR (2014) determination are Finnish and German government bonds

Source: Swiss Economics based on Irish regulatory decisions.

62 However, we believe that our focus on current market evidence is not inconsistent with past decisions. For its 2014 Determination, CAR set the lower bound of the RFR range with reference to current German government bond yields at the time. We follow the exact same approach, the difference being that financial markets have evolved and German government bond yields have dropped. A decrease in the RFR must be anticipated when using the same methodology today as has been applied in the 2014 Determination. Thus, setting a lower RFR than in 2014 is not inconsistent with regulatory precedent.

63 English regulators have adopted a similar view in their current thinking for a range of upcoming regulatory decisions. For example, the CAA recently published a working paper that confirms the authority's plan to reflect current negative government bond yields in Heathrow Airport's regulatory control period H7 (CAA, 2019). Based on a consultancy report, the CAA plans to set a RFR within the range of -1.50 percent to -1.00 percent. The underlying analysis recognises that a RFR in this range is significantly below other recent regulatory decisions, but argues that consistency in the way various WACC components are calculated (i.e. broadly in line with current market observations) is more important than consistency with precedent (PwC, 2017).

3.4.2 Long-term averages of the RFR

64 We are sceptical whether a long-term average (i.e. over 10 years) of government bond yields reflects the appropriate RFR for the 2019 Determination more accurately than current yields combined with forward-looking evidence.

65 Even Dimson, Marsh, and Staunton (2018), who are often cited for their preference to use long-term averages, acknowledge that bond yields have undergone systematic changes in the past and that "many alleged distortions are likely to be permanent". For example, they refer to the

period of permanently low prices over the 1981-2008 period as the golden age of bonds (DMS, 2018).

66 We accept that from a historical point of view, bond yields are currently on a low level. However, we do not believe that the current state is the result of momentary market distortions.

67 Periods of negative bond returns are relatively rare in recent history, but they were quite normal for the most part during the 20th century. In fact, DMS (2018) reveal that European bonds have yielded negative real rates on average between 1900 to 1980. The difference to today's situation is the rate of inflation. Considerably higher rates of inflation during most of the 20th century resulted in positive nominal rates despite real rates being negative.

68 Real German government bonds have yielded negative rates since early 2014 and there are no signs that they will increase to levels of the past close to 2 percent in the near future. Even if it is possible that government bonds recover in the longer term, we have not seen any compelling evidence that suggests that this would happen within the next 5 years.

3.5 Conclusion

69 We believe the true RFR to be used for the 2019 Determination ranges **from -0.72 percent to 0.45 percent**. This conclusion is based on the following observations:

70 Historic averages of government bond yields suggest a range from approximately -1.19 percent to -0.21 percent. Forward rates reveal market expectations of an increase in government bond yields over the 2020-2024 period from 47 basis points to 66 basis points.

71 Table 8 summarises our findings on the RFR.

Table 8: Evidence on the RFR

		SE lower bound	SE upper bound	SE point estimate
	Evidence from current yields	-1.19%	-0.21%	
+	Evidence from forward rates and monetary policy	47 bps	66 bps	
=	**RFR**	**-0.72%**	**0.45%**	**-0.14%**

Source: Swiss Economics.

72 Our advice for the 2019 Determination implies a significant decrease in the RFR compared to CAR's 2014 Determination consistent with recent developments on international bond markets. **Table 9** compares our advice to the values used in the 2014 Determination.

Table 9: Summary real RFR

	Range (in %)	Point estimate (in %)
2019 SE advice	-0.72 – 0.45	-0.14
CAR 2014 Determination	0.00 – 2.00	1.50

Source: Swiss Economics.

4 The equity risk premium

73 The WACC-CAPM framework predicts that investors will require a premium for holding risky equity instead of a risk-free asset such as government bonds. The equity risk premium (ERP) is typically expressed as the difference between expected returns of the market portfolio (TMR) and the RFR.

74 We base our estimate of the ERP on the following evidence:

- a review of academic literature and empirical evidence of systematic changes in the level of the ERP, indicating that a so called CAPM-TMR approach for estimating the cost of equity is to be preferred;
- forward-looking evidence of the TMR based on a dividend discount model; and
- backward-looking evidence of the TMR using long-term averages of market returns.

4.1 Traditional approach may neglect changes in the ERP over time

75 Irish regulators have mostly employed a so called CAPM-ERP approach when setting the regulatory cost of equity in past decisions.

76 The CAPM-ERP approach looks at the ERP as an isolated and stable component of financial markets. Typically, the ERP is estimated based on a long-run average of the difference between market returns and government bond yields. The underlying assumption is that a long-run average adequately reflects future values of the ERP. In practice, regulators have often referred to the annual Credit Suisse Global Investment Returns Yearbook by Dimson, Marsh, and Staunton (e.g. DMS, 2018).

77 However, theoretical and empirical research suggests that the ERP is counter-cyclical. In times of increased market uncertainty, investors demand higher premiums. Even Dimson, Marsh, and Staunton (2018), who are often cited as proponents for assuming a stable ERP, admit that in times of higher stock market volatility the ERP is likely to increase as well.

> *The risk premium […] should be higher at times when the equity market is riskier and/or when investors are more risk averse.*

DMS (2018), page 37.

78 Dimson, Marsh, and Staunton (2018) argue that market volatility usually reverts to the mean quickly, which implies that changes in the ERP are rather short-lived. However, during a relatively short regulatory period between 4 to 5 years, deviations from the long-term average of the ERP may have a substantial impact on the estimated WACC and should be investigated carefully.

4.2 Evidence of systematic negative co-movements between ERP and RFR

79 We find a relatively broad consensus that the ERP and the RFR systematically move in opposite directions, implying that total market returns (the sum of the RFR and the ERP) are more stable over time than either of the individual components. This raises the question whether a CAPM-TMR approach, which assumes stable total market returns (TMR) over time, is better suited to inform the appropriate level of the equity risk premium than a CAPM-ERP approach.

4.2.1 Academic literature

80 The CAPM was developed in the 1960s based on Markowitz' (1952) portfolio theory. The early literature was of theoretical nature and focused on the conceptual relation between returns of

an efficient market portfolio and the RFR. The fact that neither expected market returns, market premia, nor risk-free returns could be directly observed in the market was not of primary concern.

81 With an increasing number of empirical studies, numerous inconsistencies between market data patterns and theoretical predictions became apparent. One of these puzzles was that empirical estimates of the ERP were consistently higher and empirical estimations of the risk-free rate were consistently lower than predicted by financial theory (see, for example, Mehra and Prescott, 1985).

82 Scholars in financial economics have attempted to explain this puzzle through the existence of frequent extreme outliers (referred to as fat tails in statistics). The most influential studies in this respect are articles by Rietz (1988) and Barro (2006), who attempt to explain observations of inflated ERP through microeconomic consumption theory.

83 Their argument builds on a simple theorem that in equilibrium, the price of an investment is determined by the sum of expected future discounted cashflows. A discount factor reflects how much investors prefer sooner cashflows over later ones. This factor is dependent on preferences of consumption today versus consumption in the future and, additionally for risk averse investors, on the relative differences in risk associated with the cashflows. Investors prefer assets which generate cashflows also in times when they most need them: in times of "economic disasters". The utility of financial returns from an asset is much higher in times when there are few alternative sources of income, than in times of prosperity when income can be generated from a multitude of other sources. The idea that identical returns can result in different levels of utility dependent on the economy's condition is described in Cochrane (2005) as follows:

> *Given that an asset must do well sometimes and do badly at other times, investors would rather it did well when they are otherwise desperate for a little bit of extra wealth, and that it did badly when they do not particularly value extra wealth.*
>
> Cochrane (2005), Page 2.

84 In times of increased market volatility, the probability of "economic disaster" increases. Investors' willingness to pay for low-risk assets that generate similar cashflows, regardless of the economic situation, increases as well and results in a reduction of government bond yields and simultaneously in an increase in the premium for holding equity. Rietz (1988) describes this connection as follows:

> *[By considering] a low-probability, depression-like […] state, I can explain both high equity risk premia and low risk-free returns […]. Risk-averse equity owners demand a high return to compensate for the extreme losses they may incur during an unlikely, but severe, market crash. To the extent that equity returns have been high with no crashes, equity owners have been compensated for the crashes that happened not to occur. High risk premia should not be puzzling in such a world.*
>
> Rietz (1988), Page 117-118.

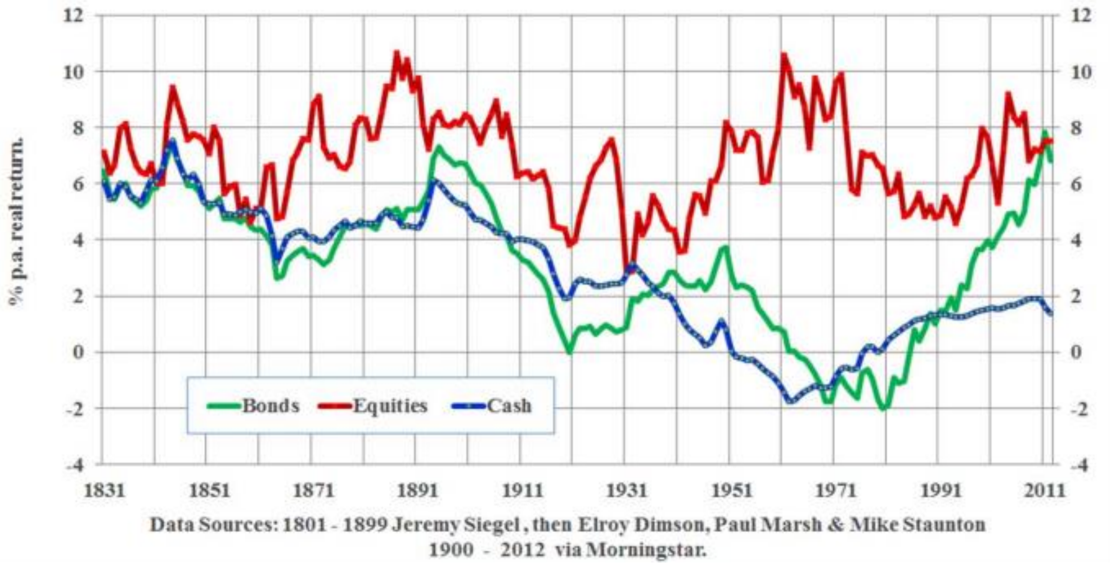
85 As an example of an economic disaster, Barro (2006) refers to real GDP growth rates during the Second World War in countries like Germany and Greece. He estimates, that a disaster event of this magnitude reduces the risk-free rate by 5.9 percent and increases the ERP by 3.7 percent.

4.2.2 Empirical evidence

86 Various empirical studies confirm the existence of a negative correlation between the RFR and the ERP.

87 The English electricity regulator Ofgem commissioned studies from Mason, Miles and Wright (2003) and Wright and Smithers (2014) that analyse historical returns of different investment classes to investigate whether ERP or TMR is more stable over time.

Figure 9: US Data on Changes in Yields of Different Investment Classes (30 Year Moving Average)



Source: Wrights and Smithers (2014).

88 The results of the studies are illustrated in **Figure 9**. Historical equity yields are much more stable over time than historical bond yields. Wright and Smithers comment:

> *A glance at [Figure 9] demonstrates very clearly, on the basis of US data, that real stock returns have shown a remarkable degree of stability over more than two centuries. This is consistent […] with the average* ***expected*** *return having been stable. In marked contrast, there is no such stability evident in either the bond return or the risk-free return.*

Wright and Smithers (2014), Page 14.

89 The authors go further and exclude the possibility that the ERP remains constant over time:

> *[T]here is no evidence of stability of the [ERP]. Without such evidence, there is no empirical basis for the assumption that falls in risk-free rates should translate to falls in expected market returns.*

Wright and Smithers (2014), Page 15.

90 They come to the clear conclusion that ERP and RFR are negatively correlated:

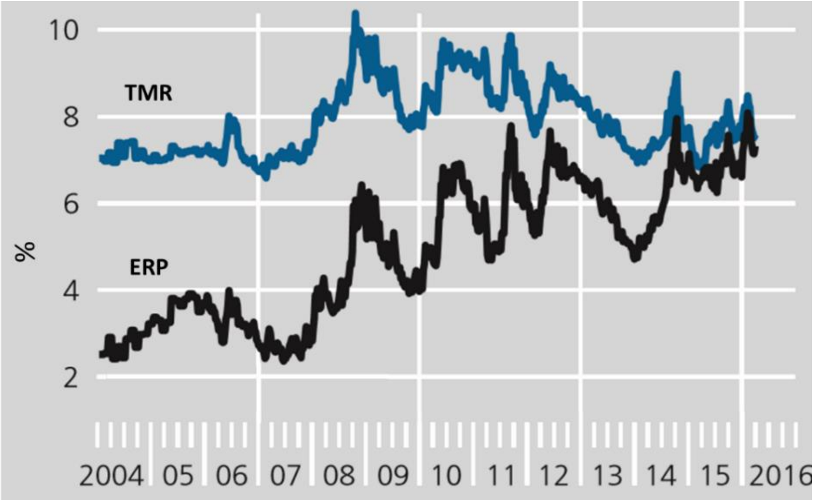
> *It is therefore an application of simple arithmetic to conclude that, applying our methodology, the (assumed) [ERP] and the risk-free rate must move in opposite directions, i.e. must be perfectly negatively correlated.*

Wright and Smithers (2014), Page 16.

91 A different approach to analyse movements in ERP and RFR is chosen by the German Bundesbank (2016). They use data on stock prices and analyst surveys on expected profits and dividends to back out implicit values for the ERP and TMR.

92 The time series predicted by their Dividend Discount Model is displayed in **Figure 10**.

Figure 10: TMR and ERP estimates from German Bundesbank analysis



Source: German Bundesbank (2016), page 24, adopted and translated by Swiss Economics.

93 Their estimate of the level of the ERP has been increasing since the beginning of the financial crisis in 2007 whereas their estimate of the level of the TMR has remained relatively stable over time. In late 2014, the ERP reached a level that is comparable to the long-term level of the TMR. The ERP has stayed on this level since.

94 The German Bundesbank concludes that the ERP does not remain constant over time, but it is rather correlated negatively with the RFR. In its August 2018 report, the Bundesbank writes:

> *The risk premium continued to be significantly above the long-run average. From this it can be drawn that the risk-free rate and the risk premium consistently evolve in opposite directions and therefore cancel each other out in their effect on the cost of equity.*

German Bundesbank (2018), page 46, translated by Swiss Economics.

4.2.3 Implications on the methodology for estimating the ERP

95 Based on the theoretical and empirical evidence of the existence of a negative covariation between the RFR and the ERP above, we choose a CAPM-TMR approach for estimating the cost of equity. Rather than estimating the ERP directly, we first determine the TMR and subsequently subtract our estimate of the RFR from Section 3.

96 The reason behind this choice is that the TMR is more stable over time and thus more predictable than the ERP. We are less likely to neglect systematic changes in the ERP when using evidence from long-term averages or dividend discount models, which both assume true population means to remain constant over time.

4.3 Quantification of the TMR

97 In a first step, we estimate the appropriate level of the TMR. We employ a backward-looking method based on long-term historic averages and a forward-looking method based on a Dividend Discount Model.

4.3.1 Backward-looking estimate

98 We use long-term averages of actual total market returns as primary evidence regarding the appropriate level of the TMR. The assumption behind this approach is that historical outturn market returns fluctuated around stable expected TMR. With increasing sample size, a long-run

average of actual returns will converge to the true TMR even if annual returns have great volatility and deviate substantially from their mean.

99 We use DMS (2018) to estimate long-term averages. The yearbook contains data on Irish and European real equity returns from 1900 to 2017. **Table 10** reports mean equity returns for Ireland and Europe using arithmetic, geometric, and Blume's averaging methods.

Table 10: Average equity returns over the 1900-2017 period

Equity returns	Arithmetic mean	Geometric mean	Blume's method
Irish equity returns	7.00	4.40	6.80
European equity returns	6.20	4.30	6.05

Note: Blume's method (BM) gives a weighted estimate of the arithmetic (AM) and geometric means (GM) based on the time period over which the mean was calculated (N) and on the time period over which returns are to be forecasted (T). The method is based on the following formula:
$BM = (T-1)/(N-1) \times GM + (N-T)/(N-1) \times AM$, with T = 10 years holding period and N = 116 observations of historic returns

Source: Swiss Economics based on DMS (2018).

100 Blume's method accounts for the fact that the geometric mean and arithmetic mean are both likely to be biased due to measurement errors (see Blume 1974).

- The arithmetic mean is an unbiased estimate of the return over a holding period of one year, but likely overestimates the annual returns over a multi-year holding period.
- The geometric mean is an unbiased estimate of the annual returns over a holding period of 116 years, but likely underestimates annual returns over shorter holding periods, as movements between the first and last period are cancelled out.

101 Blume's method weights the geometric and arithmetic means depending on the length of the underlying estimation and holding periods. Consistent with the assumptions underlying our estimate of the RFR, we assess the appropriate return for a notional investor with investment horizon of 10 years (i.e. we use a 10-year-holding period).

102 One stakeholder asked us to use an unweighted average of arithmetic and geometric means as a point estimate for the TMR. However, this approach would not adequately address the issue underlying the biased estimator. Cooper (1996) shows that the geometric mean is always more biased than the arithmetic mean. The skewed weighting applied through Blume's method leads to an approximately unbiased estimate of the average annual return over the holding period and as such is to be preferred to an unweighted average.

103 Another stakeholder asked us to consider historic equity returns of the United Kingdom in addition to Irish and European equity returns. The underlying argument was that the UK equity market was closely intertwined with the Irish equity market during most of the last century and has only recently become less relevant than the European equity market since Ireland joined the Euro area in 1999. We accept that UK markets may have been slightly more relevant for Irish investors than the broader European equity markets for most of the time span covered in the DMS time series. However, in order to maintain consistency across the various WACC components, we refrain from introducing the UK as another benchmark market.

4.3.2 Forward-looking estimate

104 We use evidence from a forward-looking dividend discount model (DDM) as a second source of evidence for the level of the TMR.

105 DDMs are based on the idea that stock prices should reflect the sum of expected future dividend payments, discounted back to their present value. The discount rate accounts for investors' preference of current payments over future payments and compensates them for the risks of holding equity rather than a risk-free asset. The discount rate hence conceptually corresponds to a TMR.

106 Our model is based on a standard representation of the DDM, as, for example, presented by the Bank of England in its report on modelling equity prices (2017):

$$P_t = \sum_{k=1}^{\infty} \frac{E_t(D_{t+k})}{(1+TMR)^k}, \tag{5}$$

where

- P_t is the stock's price at time t; and
- $E_t(D_{t+k})$ is the expected dividend at time t for time $t+k$.

107 Following the classic model of Gordon (1962) which assumes a constant dividend growth rate, and using a formula for simplifying geometric series, we get the following expression:

$$P_t = \sum_{k=1}^{\infty} \frac{D_t(1+g)^k}{(1+TMR)^k} = \frac{D_t(1+g)}{TMR-g}, \tag{6}$$

where g denotes the constant dividend growth rate.

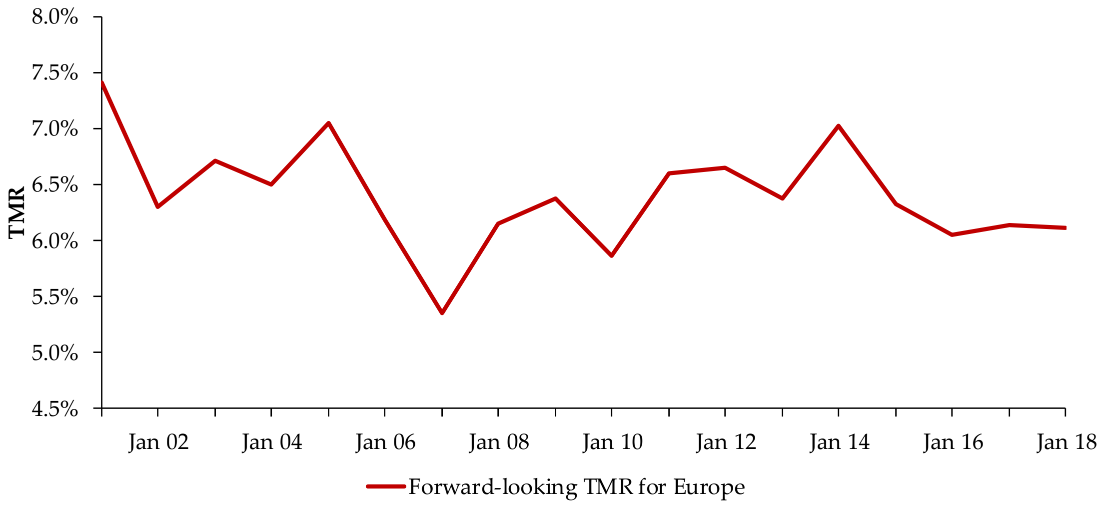
108 Solving for TMR we get:

$$TMR = \frac{D_t(1+g)}{P_t} + g. \tag{7}$$

109 A key issue of dividend discount modelling is the estimation of future dividends. Here we assume a constant dividend growth rate, i.e. that dividends are expected to grow in line with past average growth rates. Using data from the STOXX Europe 50 price index, which represents the 50 largest stock-traded companies in Europe, we compiled a dataset containing dividends and prices of all index constituents from 2001 to 2018. An analysis of this dataset revealed an average dividend growth rate from 2001 to 2018 of 1.99 percent.[7] Using this information and using yearly average market prices of the index constituents, we obtain relatively constant TMR values over time with an average of 6.4 percent. **Figure 11** displays the TMR estimates from our DDM.

[7] The level of the estimated dividend growth rate is relatively sensitive with respect to the chosen time averaging period. The assumption that future dividend growth equals average past growth requires long-term averages in order to smoothen yearly dividend volatility. Hence, we based the calculation of the average dividend growth rate on the maximum years of reliable data of the dataset (2001 to 2018).

Figure 11: Forward-looking TMR for Europe (assuming constant dividend growth)



Note: The analysis spans the time period of 2001 to 2018 due to unreliable dividend data for the time before 2001. Yearly price and dividend data were summed over all constituents of the STOXX Europe 50 price index. A constant dividend growth rate was assumed. The constant dividend growth rate was calculated by taking an arithmetic average of the yearly dividend growth of all index constituents over the period 2001 to 2018.

Source: Swiss Economics based on Infront data.

110 **Table 11** below (and Figure 11) confirm the long-term stability of the TMR. In addition, our forward-looking estimates are comparable in magnitude to DMS' long-term backward-looking estimates.

Table 11: Average forward-looking TMR estimates over the recent past

	1-year average	2-year average	5-year average
TMR	6.11%	6.12%	6.33%

Source: Swiss Economics.

4.4 Regulatory precedent on the TMR

111 The majority of past Irish WACC determinations is based on a CAPM-ERP approach and rarely reports an explicit value for the TMR.

112 One exception constitutes CER's determination of the WACC for Gas Networks Ireland (GNI) from October 2017. To our knowledge, CER's (2017) was the first Irish decision using a TMR-Approach. CER referred to regulatory practice in the UK (particularly Ofgem) to justify its choice.

113 **Table 12** gives an overview over recent Irish regulatory decisions in respect of the level of TMR. For decisions that are based on a CAPM-ERP approach, we present the implied TMR, given by the sum of RFR and ERP.

Table 12: Irish regulatory precedent on TMR

Regulator	Decision	Range	Point estimate	Approach	Based on
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	6.50% – 6.75%	6.65%	CAPM-TMR	UK and Irish regulatory precedent, DMS data
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	6.30% – 6.75%	6.75%	CAPM-ERP	UK and Irish regulatory precedent, DMS data
CER (2016)	ESBN/EirGrid PR4	6.35% – 7.10%	6.65%	CAPM-ERP	Irish regulatory precedent, DMS data
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	6.35% – 7.75%	7.30%	CAPM-ERP	Irish regulatory precedent, DMS data
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	4.50% – 7.00%	6.50%	CAPM-ERP	Recent regulatory precedent, DMS data

Note: The listed TMR are calculated as the sum of the RFR and ERP. CER (2016) Irish Water TMR calculated as 2.00% (RFR) + 4.75% (ERP). CER (2016) ESBN/EirGrid TMR calculated as 1.90% (RFR) + 4.75% (ERP). Comreg (2014) TMR calculated as 2.30% (RFR) + 5.00% (ERP). CAR (2014) Irish Water TMR calculated as 1.50% (RFR) + 5.00% (ERP).

Source: Swiss Economics.

114 We note that our estimates of the TMR, which were obtained using empirical methods, are very close to the values used in Irish precedent.

4.5 Conclusion

115 We believe the appropriate value for the ERP ranges from 6.19 percent to 6.94 percent. This range is based on the following evidence:

116 Academic research shows that the TMR is more stable over time than the ERP, implying that a CAPM-TMR approach is the preferred choice for estimating the cost of equity.

- backward-looking evidence based on DMS data suggests a TMR between 6.05 percent to 6.80 percent; and
- forward-looking evidence from our Dividend Discount Model suggests a TMR between 6.11 percent and 6.33 percent.

117 Thus, we estimate a range for the TMR between 6.05 percent and 6.80 percent with a point estimate at 6.43 percent. **Table 13** summarises our findings regarding the level of the TMR.

Table 13: Evidence on the TMR

		SE lower bound	SE upper bound	SE point estimate
	Evidence from backward-looking evidence	6.05%	6.80%	
	Evidence from forward-looking evidence	6.11%	6.33%	
Min./Max.	TMR	6.05%	6.80%	6.43%

Source: Swiss Economics.

118 **Table 14** summarises our advice regarding the level of the TMR and compares our advice with the values set by CAR in the 2014 Determination.

Table 14: TMR summary

	Range (in %)	Point estimate (in %)
2019 SE advice	6.05 – 6.80	6.43
CAR 2014 Determination	6.00 – 6.50	6.50

Note: CAR have not explicitly determined a value for TMR in their 2014 Decision. The reported values represent the sum of the RFR point estimate and the boundaries of the ERP range used in 2014.

Source: Swiss Economics.

119 The range for the ERP was derived by subtracting our point estimate of the RFR of -0.14 percent from the TMR range. **Table 15** summarises our advice regarding the level of the ERP.

Table 15: ERP summary

	Range (in %)	Point estimate (in %)
2019 SE advice	6.19 – 6.94	6.56
CAR 2014 Determination	4.50 – 5.00	5.00

Source: Swiss Economics.

120 Our advice for the 2019 Determination implies an increase in the ERP of 156 basis points compared to CAR's 2014 Determination. This is caused by the change from a CAPM-ERP to CAPM-TMR approach, which captures systematic negative co-movements between the ERP and RFR.

5 Beta

121 The Beta coefficient captures the extent of systematic or undiversifiable risk related to holding Dublin Airport equity. It measures the degree of correlation between returns of Dublin Airport equity and returns of a market portfolio.

122 We use the following evidence to determine Dublin Airport's Asset Beta:

- Asset Beta estimates of exchange-listed comparator airports on 1 year / daily, 2 years / daily, and 5 years / weekly stock price data;
- comparator Betas from international regulatory precedent; and
- weights for comparator airports indicating their relevance for Dublin Airport.

123 In addition, we consider results of the following robustness checks:

- rolling values of historical Asset Betas;
- sensitivity analyses regarding the effect of changes in data frequencies, time horizons, and market indices (see Appendix A.2.1, A.2.2, and A.2.3);
- GARCH models (see Appendix A.2.4);
- sensitivity analyses in connection with weighting schemes (see Section 5.3); and
- Beta adjustments according to Blume and Vasicek (see Appendix A.4).

5.1 Comparator Asset Betas

5.1.1 Empirically estimated Asset Betas

124 The majority of airports is not exchange-listed and, as such, has no public stock data available that could be used to analyse returns. Thus, the number of airports that can be used to estimate a comparator Beta empirically is limited. In total, we collected stock data for 9 exchange-listed airports. We excluded recently listed or unlisted airports.[8] Following the Thessaloniki Forum recommendations, we ran regressions of the airport stock returns on their respective national stock price indices.[9]

125 **Table 16** lists the data of comparator airports and market indices we used in our regressions.

[8] SAVE (Venice and Treviso) and Toscana Aeroporti (Florence and Pisa). Due to limited data availability, we decided to exclude them. SAVE was acquired by private equity investors in August 2017 and was unlisted in October 2017. Toscana Aeroporti was only listed in June 2015.

[9] See Thessaloniki Guidelines, 2016: p. 5. We could have opted to use European area wide stock indices for airports located within the European area, which would be consistent with our choice of including evidence from other European countries in other WACC components, such as the RFR. However, the impact on the Asset Betas and on the final WACC value are marginal. We present a corresponding sensitivity analysis in Appendix A.2.3.

Table 16: Exchange-listed comparator airports

Airport	Price index
Aena (Spain), AENA	Madrid IBEX 35
Aeroports de Paris, ADP	Paris CAC 40 Index
Auckland Airport, AIA	MSCI New Zealand
Copenhagen Airport, KBHL	OMX Copenhagen Benchmark
Fraport (Frankfurt), FRA	DAX Kursindex
Sydney Airport, SYD	S&P/ASX Australian 200 Index
TAV (Turkey), TAVHL	MSCI Turkey
Vienna Airport, FLU	Austria Traded Index
Zurich Airport, FHZN	Swiss Performance Index

Note: Aena is the operator of 47 Spanish airports, including, amongst others, Madrid-Barajas Adolfo Suarez Airport, Barcelona-El Prat Airport, and Palma de Mallorca Airport. TAV operates 15 airports in Turkey, Tunisia, Macedonia, Saudi Arabia, and Croatia. Aeroports de Paris is the operator of Charles de Gaulle Airport, Orly Airport, and Le Bourget Airport. All other comparator airports are operated by stand-alone companies. We use price rather than performance indices.

Source: Swiss Economics based on Infront data.

126 We used three different datasets with varying time horizon and frequency. Shorter time horizons reduce the sample size, making it more likely that random noise in the data is interpreted as meaningful variation. Longer time horizons risk include observations from time periods that are no longer relevant for current and future Beta values (e.g. Wright et al., 2018).

127 Similarly, there is a trade-off underlying the choice of data frequency. Lower data frequency reduces the sample size and leads to less accurate Beta estimates. Higher data frequency may put too much emphasis on correlations caused by events that dissipate over longer periods (e.g. Brotherson et al., 2013).[10]

128 We use the following dataset parameters:

- Daily stock returns over the 1-year-period from January 2018 to December 2018
- Daily stock returns over the 2-year-period from January 2017 to December 2018
- Weekly stock returns over the 5-year-period from January 2014 to December 2018

129 To adjust the estimated Equity Betas for differences in financial leverage across airports, we convert them to Asset Betas using the Hamada-Formula reflecting net debt ratios and effective tax rates.[11]

130 **Table 17** reports the resulting Asset Betas based on the various datasets.[12]

[10] Further analysis regarding the behaviour of Asset Beta estimates with respect to data frequency, time horizon, and the choice of market indices are presented in Appendix A.2.

[11] We describe the Hamada-Formula in more detail in Appendix A.3.

[12] The parameters in Table 17 are estimated by Ordinary Least Squares (OLS). A sensitivity analysis using the GARCH methodology can be found in Appendix A.2.4.

Table 17: Asset Betas of exchange-listed comparator airports

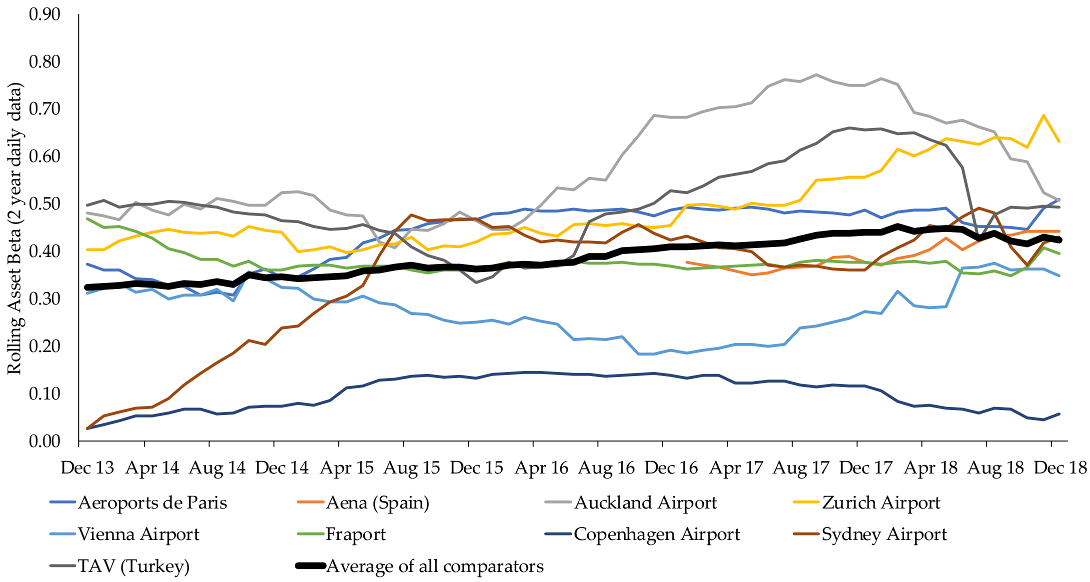
Airport	1 year / daily data	2 years / daily data	5 years / weekly data	Average
Aena (Spain), AENA	0.47	0.44	0.36	0.42
Aeroports de Paris, ADP	0.48	0.51	0.41	0.47
Auckland Airport, AIA	0.47	0.51	0.58	0.52
Copenhagen Airport, KBHL	0.03	0.06	0.13	0.07
Fraport (Frankfurt), FRA	0.40	0.40	0.36	0.39
Sydney Airport, SYD	0.47	0.43	0.30	0.40
TAV (Turkey), TAVHL	0.46	0.49	0.45	0.47
Vienna Airport, FLU	0.28	0.35	0.27	0.30
Zurich Airport, FHZN	0.63	0.63	0.54	0.60

Note: Based on OLS regressions of stock market data from airports and national price indices. Estimated Betas were unlevered using the Hamada-formula based on net debt/equity ratios and effective tax rates. All datasets cover data until 31 December 2018.

Source: Swiss Economics based on Infront data.

131 **Figure 12** shows 2-year rolling Asset Betas of the exchange-listed comparator airports. The black line displays the mean value across all comparator airports. A slight upwards trend can be observed from 2013 to the beginning of 2018. Recently, this trend seems to have reverted and Betas tend to decrease again.

Figure 12: 2-year rolling Asset Betas for comparator airports

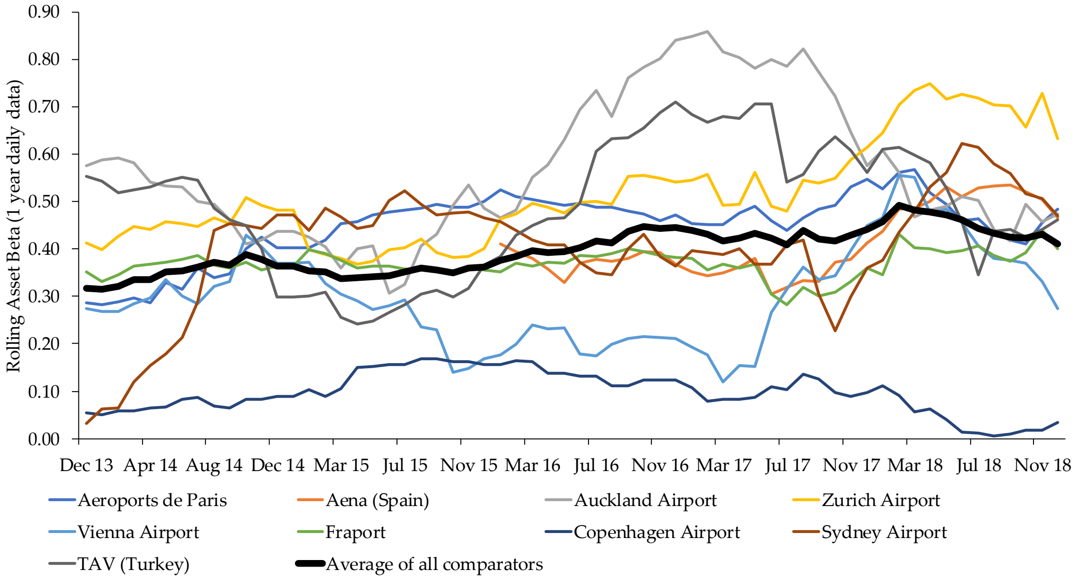


Notes: Estimates based on daily return data and a time horizon of two years. Betas were de-levered using the Hamada-formula and most recent data on net debt, equity and effective tax rates. No data is available for Aena (Spain) before February 2015.

Source: Swiss Economics based on Infront data.

132 **Figure 13** displays rolling 1-year Asset Betas. The reduced averaging period increases volatility in the estimates. Nevertheless, the trend across all comparator airports, evidenced through the arithmetic average series, is comparable in Figure 12.

Figure 13: 1-year rolling Asset Betas for comparator airports



Notes: Estimates are based on daily return data and a time horizon of one year i.e. for each month, Betas were estimated using daily data of the last 365 days (up till 31 December 2018). Betas were un-levered using the Hamada-formula and most recent data on net debt, equity and effective taxes. No data is available for Aena (Spain) before February 2015.

Source: Swiss Economics based on Infront data.

133 We decided against using Blume's (1971, 1975) or Vasicek's (1973) Beta adjustments for reversion to the mean. We are concerned that Blume's adjustment is too mechanistic. The decision against a Vasicek adjustment is due to estimation issues (see Appendix A.4 for a detailed discussion and sensitivity analyses of Blume's and Vasicek's adjustments).

134 We also refrained from using evidence from GARCH models to estimate Asset Betas (see Appendix A.2.4 for an analysis using the GARCH method). The reason is that GARCH has been primarily of academic interest and has, to the best of our knowledge, not been adopted in a regulatory context to date.

135 Also, as shown in Appendices A.2.4 and A.4, GARCH models tend to decrease Beta values whereas Blume's and Vasicek's adjustments tend to increase Beta values, offsetting their respective effects to some degree.

136 For the reasons outlined above, we concentrate our empirical assessment of comparator Betas on OLS regression analysis.

5.1.2 Asset Betas from regulatory precedent

137 We complement the list of empirically estimated comparator Asset Betas with values from relevant regulatory precedent.

138 Of particular relevance for Dublin Airport's Beta is precedent from London Heathrow Airport due to the high comparability of the regulatory regime to CAR's approach. Also included are Asset Betas for London Gatwick Airport and Aeroporti di Roma. We are not aware of any other public regulatory decisions regarding the level of the Asset Beta for unlisted European airports.

139 **Table 18** summarises the evidence on Asset Betas determined by European regulators for comparator airports that are not exchange-listed.

Table 18: Asset Betas from regulatory precedent

Airport	Decision and Regulatory Period	Asset Beta
Aeroporti di Roma	ENAC (2016), 2017-2021	0.57
London Gatwick Airport	CAA (2014), Q6	0.52
London Heathrow Airport	CAA (2014), Q6	0.47

Note: Aeroporti di Roma is the operator of Rome airports Fiumicino and Ciampino.

Source: CAA (2014), ENAC (2016).

5.2 Weighting of comparator airports

140 We consider differences between regulatory environments, demand structure, and business structure by weighting comparator airports according to their relevance as adequate benchmarks for Dublin Airport. The variables we use to assess comparability reflect the real-world parameters that determine the level of undiversifiable risk (i.e. the degree of correlation between returns on airport equity and total market returns) and coincide with the risk affecting factors named by the Thessaloniki Forum (2016).

141 We use a point-based system for our weightings. Some of the variables that determine comparability of airports' risk profiles are of a qualitative nature and are difficult to quantify. We outline the reasoning behind all choices that are not trivial.

5.2.1 Differences in regulatory environment

142 Central to the systematic risk profile of an airport is the regulatory scheme under which it is operated. The regulatory scheme determines to what extent the airport is exposed to risk associated with fluctuating passenger volumes and flight numbers. These are heavily driven by economic activity (as is evidenced by strong correlations between economic growth and passenger numbers observed at Dublin Airport).

143 In particular, the following dimensions of the regulatory scheme are central to the extent of volume risk an airport is subject to:

- **Length of the regulatory period**: Short regulatory periods (e.g. annual reviews) reduce the risks of changes in volume compared to longer regulatory periods. Changes in passenger numbers typically evolve slowly over time and can be predicted to some extent via flight schedules, which are usually determined well in advance. Regulators can anticipate and react to changing traffic volumes when regulatory periods are short, e.g. annual review periods. Regulatory periods of 4 to 5 years, as in the case of Dublin Airport, create incentives to become more efficient over time, but they transfer significant risks to airport operators. Comparator airports were awarded a point if the length of the regulatory period is long enough to create substantial volume risk for the airport.
- **Involvement of regulator**: The type of involvement of a regulator can have an impact on the extent of systematic risk an airport is exposed to. For example, the risk profile of an airport may differ to Dublin Airport if the regulator, unlike CAR, only approves tariffs or only intervenes in the tariff setting process if stakeholders do not find an agreement. In this case, the comparator airport may react to changes in passenger volumes, which is likely to lower the extent of systematic risk. Comparator airports were awarded a point if tariffs are set by an independent regulator.

- **Till system:** The choice of a single till, dual till, or hybrid till regulation regime has an impact on an airport's non-diversifiable risk. Specifically, a single till regime considers commercial revenues in addition to aeronautical revenues to determine the appropriate level of airport charges. A single till system is likely to increase the regulated entity's systematic risk as increased diversification in cashflows supposedly leads to a higher degree of correlation between returns on its equity and the development of the overall economy. Comparator airports were awarded a point if their regulatory regime is single till.
- **Price or revenue control:** The level of systematic risk depends on whether the regulator sets a cap on total revenues or on tariffs per passenger. For example, a per passenger cap, as employed by CAR, limits an airport's manoeuvring space for increasing prices in the case of unexpectedly low passenger volumes.[13] This is due airport's cost structure with a relatively high share of total costs being fixed. Thus, the choice between price or revenue control poses a source of systematic risk for an airport, making it more or less affected by volatility in traffic volumes (which in turn is known for its high correlation with economic growth). Comparator airports were awarded a point if the regulatory regime caps tariffs per passenger.
- **Within period adjustments**: Some regulators have implemented rules to adjust airport tariffs within the regulatory period depending on passenger number outturn. These rules mitigate the volume risk to which an airport is exposed to. CAR has set Capex triggers in the past to eliminate the risk of underinvestment in the case of faster growth than expected. However, the 2014 Determination did not include any rules for adjusting tariffs if passenger volumes fall below a certain threshold. Within period adjustments lower the degree of undiversifiable risk for an airport as macroeconomic shocks on the overall economy are cushioned. Comparator airports were awarded a point if tariff adjustments within the regulatory period are not foreseen or foreseen only to a limited extent.

144 **Table 19** reports our assessment of the comparability of regulatory environments between airports.

[13] However, the airport may also profit from an unexpected increase in passenger numbers.

Table 19: Regulatory environment of comparator airports

Airport	Length of regulatory period	Involvement of regulator	Till approach	Price or revenue control	Within period adjustments for volume risk	Comparability with Dublin
Aena (Spain)	5 years	Approval of charges	Dual till	Price cap	No within-period adjustments	★★★☆☆
Aeroports de Paris	5 years	Approval of charges	Hybrid till	Price cap	Adjustment factors linked to traffic, investments, operating costs etc.	★★☆☆☆
Aeroporti di Roma	5 years	Approval of charges	Dual till	Price cap	Annual tariff reviews resulting from verified progress on capex plans	★★★☆☆
Auckland Airport	5 years	Monitoring	Dual till	Price cap	Adjustments when operating or capital expenditure resulting from airline-requested or unforeseen regulatory requirements	★★☆☆☆
Copenhagen Airport	Negotiated; max. 6 years	Regulator sets charges If no agreement b/w airport and airlines	Hybrid till	Revenue cap (if regulated)	Adjustments upon request if significant changes occur	☆☆☆☆☆
Fraport (Frankfurt)	Operator discretion	Approval of charges	Operator discretion Dual till in the past	Price cap	Operator can initiate consultation on new charges at own discretion	★☆☆☆☆
London Gatwick Airport	7 years	Monitoring	Single till	Price cap	n/a	★★★☆☆
London Heathrow Airport	5 years	Regulator sets charges	Single till	Price cap	Adjustments only for increases in security costs	★★★★★
Sydney Airport	Annual	Monitoring	Dual till	Price cap	n/a	★☆☆☆☆
TAV (Turkey)	Annual	Regulator sets charges	n/a	Price cap	n/a	★★☆☆☆
Vienna Airport	Annual	Regulator sets charges	Dual till	Price cap	Adjustments possible but should not result in additional revenues	★★☆☆☆
Zurich Airport	Negotiated; max. 4 years	If no agreement b/w airport and airlines; regulator sets charges	Hybrid till	Price cap	Adjustments under exceptional circumstances affecting costs	★☆☆☆☆

Note: At Copenhagen and Zurich airports, regulators only step in if bilateral agreements between the airport and airlines fail.

Source: Swiss Economics based on annual reports, regulatory reports, and legal texts.

5.2.2 Differences in demand structure

145 Demand structure is another variable that determines the extent of systematic risk an airport is faced with. We consider the following dimensions to be relevant:

- **Number of passengers**: The number of passengers is a proxy for airport size. Airports of different sizes are likely perceived to have different risk profiles. This is demonstrated by the small firm stock premium, which has been consistently observed in empirical studies (e.g. Fama & French (2012)).
- **Number of flights**: The number of flights is an alternative proxy for airport size. The ranges regarding the number of flights and passengers in our comparator airport dataset is large. For this reason, we set a large range around Dublin airport's number of passengers and flights to award comparison points. We awarded comparator airports a point if the number of passengers *and* the number of flights are within a range of between half and double the levels of Dublin Airport. In 2017, Dublin airport had 29.6 million annual passengers and 232.2 thousand flights, which translates to a range of comparable airports with between 14.8 million and 59.2 million passengers per annum and between 116.1 thousand and 464.4 thousand annual flights.
- **Aeronautical revenue share**: Greater shares of commercial revenues are the result of income diversification and may imply a closer correlation between airport returns and the market portfolio. The dispersion of aeronautical revenue shares across comparator airports is small, ranging from 44 to 84 percent, with Dublin's share amounting to 51 percent. We use 60 percent as the threshold, up to which airports are still comparable to Dublin Airport.

146 **Table 20** reports our assessment of the demand structure comparability of Dublin Airport and its comparators.

Table 20: Demand structure comparability with Dublin airport

Airport	Annual passengers (in millions)	Annual flights (in thousands)	Aeronautical revenue share	Comparability with Dublin
Aena (Spain)	249.2	2174.3	66.8%	☆☆
Aeroport de Paris	101.5	704.7	50.0%	★☆
Aeroporti di Roma	46.9	351.7	73.0%	★☆
Auckland Airport	20.5	174.3	44.0%	★★
Copenhagen Airport	29.2	259.2	60.1%	★☆
Fraport (Frankfurt)	64.5	475.5	54.4%	★☆
London Gatwick Airport	45.7	280.8	51.9%	★★
London Heathrow Airport	78.0	474.2	60.7%	☆☆
Sydney Airport	43.3	348.5	48.4%	★★
TAV (Turkey)	115.0	836.0	46.1%	★☆
Vienna Airport	30.9	273.9	84.0%	★☆
Zurich Airport	29.4	270.5	60.2%	★☆

Note: Aeronautical Revenue includes Ground Handling Services. The annual number of passengers and flights was treated as one criterion (maximum one star was awarded) because both characteristics are highly correlated.

Source: Swiss Economics.

5.2.3 Differences in business structure

147 Finally, the comparability between Asset Betas depends on the corporate structure of the airport operator. This includes whether the airport is listed and thus, the Beta was estimated using actual market data or whether it was determined during the regulatory process. In particular, the following criteria can influence an airport's risk profile:

- **Geographical diversification:** An internationally diversified airport operator differs in systematic risk from an airport operator that is active exclusively in one country. An internationally diversified airport operator is likely to face less undiversifiable risk because of effects from national economic shocks are dampened (see Appendix A.2.3 for a discussion of the Beta sensitivities with respect to different market indices). Comparator airports were awarded a point if the holding company is active only in one country.
- **Stock-market listed**: We believe the most accurate methodology for estimating airport Betas is based on regression analysis of current stock market data. Weights for Beta estimates set by regulators should reflect that they may be inaccurate (e.g. due to lobbying work during the regulatory process or outdated market conditions). Comparator airports with Asset Betas from our regression analysis were awarded a point.

148 **Table 21** reports our assessment of how comparable the business structure is between Dublin Airport and the comparator airports we estimated Asset Betas for.

Table 21: Structural comparability

Airport	Geographical diversification	Stock-market listed	Comparability with Dublin
Aena (Spain)	Yes; Participation in managing airports in 5 countries	Yes	★☆
Aeroport de Paris	Yes; Stakes in airports in 14 countries	Yes	★☆
Aeroporti di Roma	No	No (2016 regulatory decision)	★☆
Auckland Airport	No	Yes	★★
Copenhagen Airport	No	Yes	★★
Fraport (Frankfurt)	Yes; Stakes in airports in 3 countries	Yes	★☆
London Gatwick Airport	No	No (2014 regulatory decision)	★☆
London Heathrow Airport	No	No (2014 regulatory decision)	★☆
Sydney Airport	No	Yes	★★
TAV (Turkey)	Yes; Airports under management in 7 countries	Yes	★☆
Vienna Airport	Yes, Airports under management in 3 countries	Yes	★☆
Zurich Airport	Yes; Stakes in airports in 5 countries	Yes	★☆

Source: Swiss Economics.

5.2.4 Summary of weights

149 Finally, **Table 22** presents an overview of awarded points and the resulting weights for all airports across all criteria.

Table 22: Overview of comparability

Airport	Regulatory environment	Demand structure	Business structure	Total	Resulting weight
Aena (Spain)	★★★☆☆	☆☆	★☆	★★★★☆☆☆☆	8%
Aeroport de Paris	★★☆☆☆	★☆	★☆	★★★★☆☆☆☆	8%
Aeroporti di Roma	★★★☆☆	★☆	★☆	★★★★★☆☆☆	9%
Auckland Airport	★★☆☆☆	★★	★★	★★★★★★☆☆	11%
Copenhagen Airport	☆☆☆☆☆	★☆	★★	★★★☆☆☆☆☆	6%
Fraport (Frankfurt)	★☆☆☆☆	★☆	★☆	★★★☆☆☆☆☆	6%
London Gatwick Airport	★★★☆☆	★★	★☆	★★★★★★☆☆	11%
London Heathrow Airport	★★★★★	☆☆	★☆	★★★★★★☆☆	11%
Sydney Airport	★☆☆☆☆	★★	★★	★★★★★☆☆☆	9%
TAV (Turkey)	★★☆☆☆	★☆	★☆	★★★★☆☆☆☆	8%
Vienna Airport	★★☆☆☆	★☆	★☆	★★★★☆☆☆☆	8%
Zurich Airport	★☆☆☆☆	★☆	★☆	★★★☆☆☆☆☆	6%

Note: The total points represent the sum of points awarded to regulatory, demand, and business comparability. The weights for each airport were then calculated by dividing each airport's number of points by the total number of points awarded to all airports. Weights may not sum to 100% due to rounding errors.

Source: Swiss Economics.

150 Auckland Airport, Aeroports de Paris, and London Heathrow Airport achieve the highest weights (11 percent). The lowest weight is assigned to Copenhagen Airport and Fraport (Frankfurt) (6 percent). However, the difference from lowest to highest weight as well as the variability between the weights is limited. The reason for this is that, in general, airports with a high comparability in terms of the regulatory environment tend to be less comparable with respect to the demand and business structure, and vice versa.

5.3 Weighted Asset and Equity Betas

151 Based on the analysis above, we derive Dublin Airport's weighted Asset Betas for all comparator airports in **Table 23**.

Table 23: Asset Betas of comparator airports and their weights

Airport	1 year / daily data	2 years / daily data	5 years / weekly data	Average	Weight
Aena (Spain)	0.47	0.44	0.36	0.42	8%
Aeroport de Paris	0.48	0.51	0.41	0.47	8%
Aeroporti di Roma	0.57	0.57	0.57	0.57	9%
Auckland Airport	0.47	0.51	0.58	0.52	11%
Copenhagen Airport	0.03	0.06	0.13	0.07	6%
Fraport (Frankfurt)	0.40	0.40	0.36	0.39	6%
London Gatwick Airport	0.52	0.52	0.52	0.52	11%
London Heathrow Airport	0.47	0.47	0.47	0.47	11%
Sydney Airport	0.47	0.43	0.3	0.40	9%
TAV (Turkey)	0.46	0.49	0.45	0.47	8%
Vienna Airport	0.28	0.35	0.27	0.30	8%
Zurich Airport	0.63	0.63	0.54	0.60	6%
Weighted Asset Beta	**0.45**	**0.46**	**0.43**	**0.45**	

Note: Asset Betas are assumed identical irrespectively of the time horizon and frequency for Aeroporti di Roma, London Gatwick Airport, and London Heathrow Airport. Weights may not sum to 100% due to rounding errors.

Source: Swiss Economics.

152 Based on the above weights, we calculate average weighted Asset Betas of 0.45, 0.46, and 0.43 for daily data over 1 year, daily data over 2 years, and weekly data over 1 month, respectively. The overall weighted average across all time horizons and frequencies is 0.45.

153 **Table 24** reports the effects of different, alternative weighting schemes on the average weighted Asset Beta (i.e. the Betas averaged over the estimates based on 1 year and daily data, 2 years and daily data, and 5 years and weekly data).

Table 24: Effect of different weighting schemes

Airport	Actual weights (Table 23)	Equal weights	Only regulatory factors	Only demand and structural factors
Aena (Spain)	8%	8%	12%	4%
Aeroport de Paris	8%	8%	8%	7%
Aeroporti di Roma	9%	8%	12%	7%
Auckland Airport	11%	8%	8%	14%
Copenhagen Airport	6%	8%	0%	11%
Fraport (Frankfurt)	6%	8%	4%	7%
London Gatwick Airport	11%	8%	12%	11%
London Heathrow Airport	11%	8%	20%	4%
Sydney Airport	9%	8%	4%	14%
TAV (Turkey)	8%	8%	8%	7%
Vienna Airport	8%	8%	8%	7%
Zurich Airport	6%	8%	4%	7%
Weighted Asset Beta	**0.45**	**0.43**	**0.47**	**0.43**

Source: Swiss Economics.

154 Table 24 reports a weighting scheme with equal weights, a scheme which considers exclusively the regulatory factors (see Table 19), and a scheme based on demand and structural comparability only (see Table 20 and Table 21). The last row in Table 24 shows the corresponding weighted Asset Beta. The variation in the weighted Asset Betas with respect to different weighting schemes is very small, ranging from 0.43 when only demand and business factors are considered to 0.47 when only regulatory factors are taken into account.

155 We re-levered the estimated Asset Betas to Equity Betas using the Hamada-Formula (see Appendix A.3), reflecting Dublin Airport's notional gearing level and tax rate. We use Dublin Airport's effective tax rate of 12.5 percent and assume a notional gearing of 50 percent (see Section 2 for a discussion).

Table 25: Dublin Airport Asset and Equity Beta

Airport	1 year / daily data	2 years / daily data	5 years / weekly data
Asset Beta	0.45	0.46	0.43
Equity Beta	0.85	0.86	0.81

Source: Swiss Economics.

156 **Table 25** reveals a range for the Equity Beta from 0.81 to 0.86, depending on the time horizon and the data frequency that is used in the estimation.

5.4 Conclusion

157 The appropriate value for Dublin Airport's Equity Beta ranges from 0.81 to 0.86, with a point estimate of 0.84.

158 This finding is based on a range for Dublin Airport's Asset Beta from 0.43 to 0.46 that was determined using:

- empirical estimates of exchange-listed comparator airport Asset Betas;
- regulatory precedent of Asset Betas at comparator airports that are not listed; and
- an assessment of comparability between airports.

159 Asset Betas were re-levered to Equity Betas using the notional gearing rate and effective tax rate. **Table 26** reports the resulting Equity Betas.

Table 26: Evidence on the Beta estimation

		SE lower bound	SE upper bound	SE point estimate
	Evidence from weighted average Asset Betas	0.43	0.46	
x	Re-levering multiplicator	1.88	1.88	
=	**Equity Beta**	**0.81**	**0.86**	**0.84**

Note: The re-levering multiplicator is defined by the following formula [1 + debt / equity x (1 - tax rate)]. We used a gearing ratio of 50 percent for all values.

Source: Swiss Economics.

160 **Table 27** summarises our advice on the range of the Equity Beta and compares it to CAR's 2014-Determination.

Table 27: Equity Beta summary

	Range	Point estimate
2019 SE advice	0.81 – 0.86	0.84
CAR 2014 Determination	1.00 – 1.50	1.20

Source: Swiss Economics.

161 Our advice implies a decrease of the Equity Beta point estimate from 1.20 to 0.84. It is unclear what has driven the decline. However, we note that our estimate of 0.84 is consistent with Thessaloniki Forum recommendations, which suggest that airport Betas should be lower than 1 (Thessaloniki Forum Guidelines, 2016, p. 5). This is due to commercial and traffic risk being strongly mitigated by the resilience of air transport demand and due to the low level of competition.

6 Cost of debt

162 We aim to set a rate for the cost of debt that reflect the efficient level of Dublin Airport's expected debt payments during the next regulatory period. These consist of payments for borrowings raised before 2020 (i.e. embedded debt) and new debt raised over the 2020-24 period.[14]

163 We estimate the cost of embedded debt based on the following evidence:

- the extent of daa's current cost of debt; and
- expected cost of debt for borrowings with floating rates.

164 To estimate the rate on new debt, we use the following evidence:

- current yields of bonds from comparator airports; and
- evidence on the existence of a country-specific premium.

165 To determine the relative shares of embedded and new debt, we analyse how much new debt is required to meet a notional gearing ratio of 50 percent for the growing RAB during the next regulatory period.

166 Finally, we adjust our estimate of the cost of debt for a notional "BBB"-credit rating and transaction costs.

6.1 Cost of embedded debt

6.1.1 Evidence from daa's current debt obligations

167 As a first indicator of the efficient cost of debt, we refer to daa's actual cost of borrowings. In October 2018, daa had a total of [✂] in debt outstanding. Apart from its Euro bond, daa raised [✂]. The annual nominal interest rate on total debt is [✂] percent. Not included in this rate are bank margins and commissions to intermediaries paid over the lifetime of the loans. We will consider transaction costs separately under Section 6.4.

168 **Table 28** lists all currently outstanding daa borrowings.

Table 28: daa debt structure

Name	Current Loan Amount (€m), Oct 2018	Weight	Nominal interest rate	Real interest rate Oct 2018
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
All borrowings	**[✂]**	**100%**	**[✂]**	**[✂]**

Note: Figures represent actuals per October 2018. Interest rates exclude bank margins.

[14] In past decisions, CAR has focused on the cost of new debt exclusively, emphasising that actual cost of embedded debt may contain inefficiencies that should not be considered. We accept that embedded debt may have been raised at inefficient rates. However, the regulatory rate for cost of debt should imply an efficiency target that is achievable within the next regulatory period. Without the possibility of refinancing inefficiently raised debt, the scope for achieving efficiencies for existing debt is limited.

Source: Swiss Economics based on daa data.

169 Table 28 also reports interest rates in real terms for all borrowings. The weighted real interest rate on total debt is [✂] percent. Real rates were calculated using October 2018 long-term inflation expectations of [✂] percent per annum (see Section 3.1.2 for a discussion on expected inflation).

6.1.2 Forward rate-adjustment for floating debt

170 The appropriate rate for cost of embedded debt takes into account expected changes in the floating interest rate payments. Most daa borrowings have a fixed interest rate, which will not change over the next years. Only the interest rate of [✂], which represents [✂] percent of total debt, is floating because it is pegged to the ECB interest rate.

171 Our assessment of the RFR shows that bond yields are expected to raise over the next regulatory period. Section 3.2 shows that Euro area government bond yields are expected to raise between 47 basis points to 66 basis points over the 2020-24 period.

172 **Table 29** reports expected real interest rates on daa's debt during the 2020-24 period, which include an adjustment for floating rates based on our assessment of forward rates.

Table 29: Adjusted real interest rate on embedded debt

Name	Fixed/Floating	Real interest rate Oct 2018	Low real interest rate 2020-24	High real interest rate 2020-24
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Fixed	[✂]	[✂]	[✂]
[✂]	Floating	[✂]	[✂]	[✂]
All borrowings		**[✂]**	**[✂]**	**[✂]**

Source: Swiss Economics.

173 The forward rate-adjustment to daa's floating [✂] loan results in an uptick of [✂] to [✂] basis points for total debt. This follows from an expected increase in floating interest rates of at least 47 basis points, which increases the overall interest rate from [✂] percent to [✂] percent, and from an expected increase in floating interest rates of at most 66 basis points, which increases the overall interest rate from [✂] percent to [✂] percent.

174 **Table 30** summarises our findings on the cost of embedded debt.

Table 30: Summary on cost of embedded debt

	Cost of embedded debt	SE lower bound	SE upper bound	SE point estimate
	Current cost of debt	[✂]	[✂]	
+	Forward-looking adjustment of floating debt	[✂]	[✂]	
=	**Cost of embedded debt**	**0.00%**	**0.04%**	**0.02%**

Source: Swiss Economics.

6.2 Cost of new debt

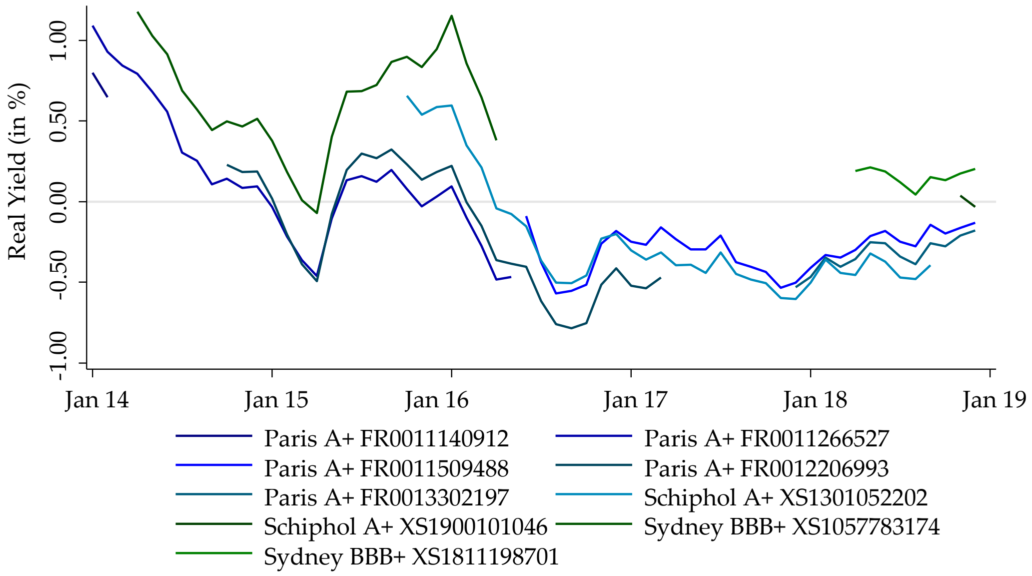
6.2.1 Evidence from comparator airport bonds

175 We use bond yields of other airports as a first source of evidence for Dublin Airport's cost of new debt.

176 To ensure consistency with our analysis of the RFR and other WACC components, we limit the analysis to Euro-denominated bonds with a remaining time to maturity between 8 to 12 years. Also, we disregard any bonds below investment-grade credit rating or without a credit rating at all.

177 **Figure 14** plots real yields of comparable bonds issued by Aeroports de Paris, Schiphol Airport, and Sydney Airport over time.

Figure 14: Real yields of comparator Euro bonds from airports



Note: Illustrated are real yields of Euro denominated airport bonds with a residual period to maturity of 8 to 12 years.
Source: Swiss Economics based on Infront data.

178 **Table 31** shows collated yields of all comparator bonds per airport and summarises averages over the past 1 year, 2 years, and 5 years.

Table 31: Average Airport Euro bond yields

Airport	1-year average	2-year average	5-year average
Aeroports de Paris	-0.28%	-0.30%	-0.13%
Amsterdam Schiphol	-0.35%	-0.37%	-0.22%
Sydney Airport	0.16%	0.16%	0.51%
Average	**-0.16%**	**-0.17%**	**0.05%**

Note: Based on arithmetic averages of monthly yields across all Euro bonds of the airport with remaining 8 to 12 years until maturity.
Source: Swiss Economics based on Infront data.

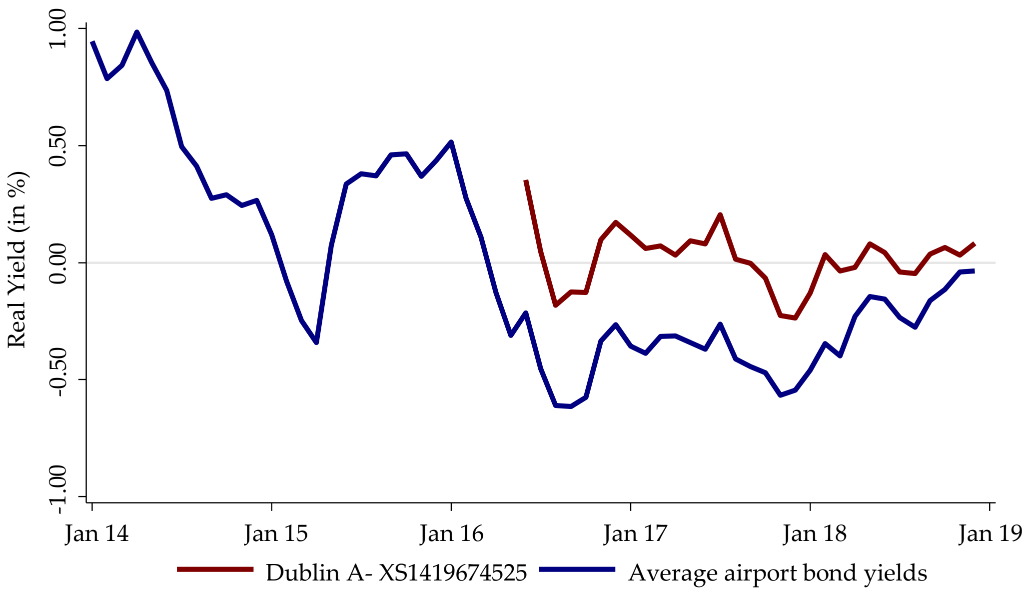
179 In June 2016, daa issued its only Bond (ISIN XS1419674525) with a maturity date in June 2028. On the total loan amount of €400m, daa pays an all-in coupon payment of 1.55 percent,

including bank margins. Based on June 2016 long-term inflation expectations of 1.14 percent, this translates to a Coupon payment of 0.41 percent in real terms.

180 High demand for the daa bond on the capital market led to a decrease in yields quickly after issuance. After an initial adjustment, yields have remained relatively stable over time ranging between -0.25 percent and 0.10 percent in real terms.

181 When comparing yields of the daa bond with an arithmetic average of the of comparator bond yields, a consistent spread becomes apparent (as illustrated in **Figure 15**).

Figure 15: Average bond yields of comparator airports vs daa bond yields



Note: Real yields of comparator airport bonds with a residual period to maturity of 8 to 12 years.

Source: Swiss Economics based on Infront data.

182 Without further analysis, it is not clear what causes the observed spread. There are two potential causes that should be distinguished:

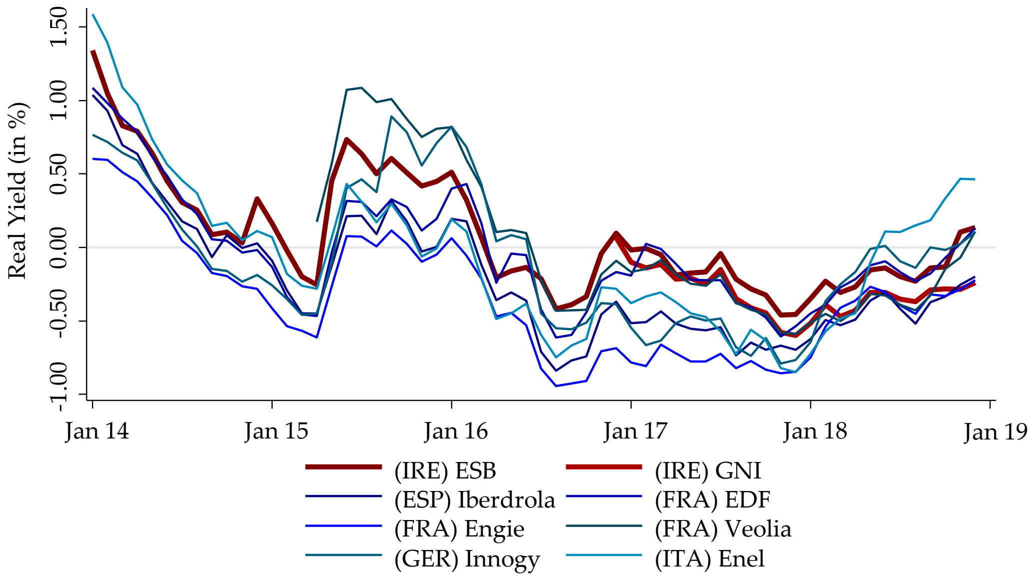
- **Factors under Dublin Airport's control** include causes such as inefficient risk or financial management on behalf of Dublin Airport. Dublin Airport should not be reimbursed for any inefficiencies under its control when raising new debt.
- **Structural differences outside of Dublin Airport's control** include causes such as differences between economic environments, e.g. macroeconomic risks. In past decisions, Irish regulators have considered the possibility of a country-specific spread. Factors outside of Dublin Airport's control should be reflected in the allowed rate for cost of debt.

6.2.2 Evidence of an Ireland-specific risk premium

183 Given the observed spread between daa bonds and other airport bonds, we deem it appropriate to employ our own analysis of systematic spreads between Irish and European bond yields.

184 We compare Euro bonds of Irish and European utility companies to understand whether there is a systematic spread between them. **Figure 16** illustrates yields for Irish bonds of the Electricity Supply Board (ESB) and Gas Networks Ireland (GNI) in red. These are contrasted with yields for bonds of electricity and gas utility companies of Spain, France, Germany, and Italy.

Figure 16: Real yields of Euro bonds from selected Irish and European utilities



Note: Real yields of utility bonds with a residual period to maturity of 5 to 15 years.

Source: Swiss Economics based on Infront data.

185 Yields of Irish utility bonds tend to be on the higher end of the observed range. A clearer picture is revealed when individual bond yield series are collated into average Irish and average European series.

186 **Figure 17** illustrates that Irish utilities have traded at higher yields than other European countries' utilities for the most part of the past years. Recently, the gap seems to have narrowed.

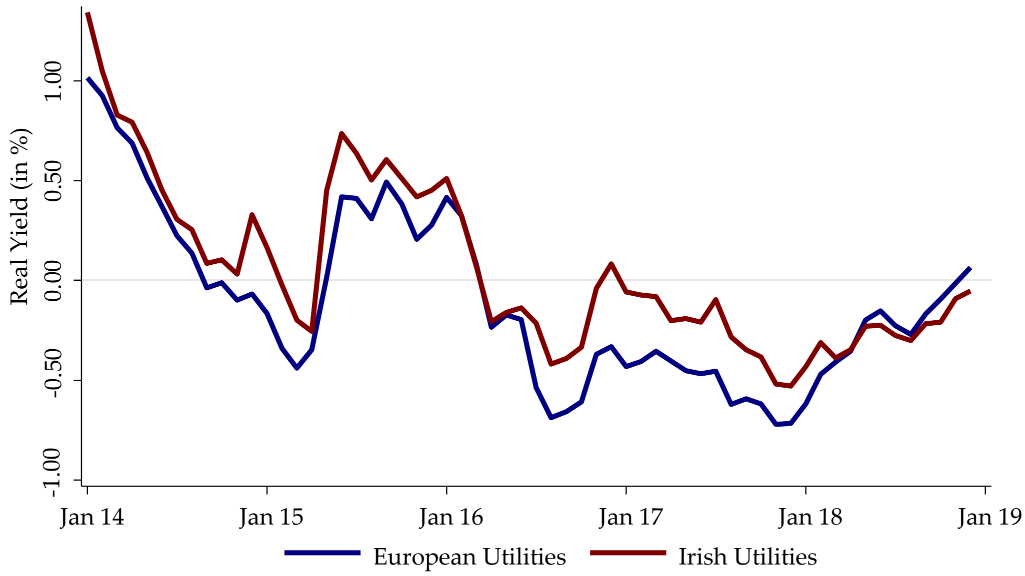


Figure 17: Average bond yields of Irish and European utility companies

Note: Real yields of utility bonds with a residual period to maturity of 5 to 15 years.

Source: Swiss Economics based on Infront data.

187 **Table 32** reveals a spread range between 1 basis point to 18 basis points over various time periods in the recent past.

Table 32: Average yields for utility bonds in Ireland and other Euro area countries

	1-year average	2-year average	5-year average
Yields on Irish utility bonds	-0.19%	-0.21%	0.03%
Yields on European utility bonds	-0.20%	-0.23%	-0.15%
Country-specific spread	**1 bps**	**2 bps**	**18 bps**

Source: Swiss Economics based on Infront data.

188 Many Irish regulators have considered the possibility of an Ireland-specific premium in past decisions, but we are only aware of Comreg's 2014 determination that explicitly uses combination of a premium for Irish debt and a premium related to the telecom industry to arrive at their estimate of cost of debt. CAR considered the possibility of a country-specific risk premium but decided against it in their 2014 Determination.

189 However, based on our own analysis, we believe it is appropriate to add a country-specific adjustment of between 1 to 18 basis points to the benchmark yields from comparator airports.

190 **Table 33** summarises our findings regarding the cost of new debt.

Table 33: Evidence on cost of new debt

	Cost of new debt	SE lower bound	SE upper bound	SE point estimate
	Cost of comparator debt	-0.17%	0.05%	
+	Country-specific premium	1 bps	18 bps	
+	Forward-looking adjustment of new debt	47 bps	66 bps	
=	**Cost of new debt**	**0.31%**	**0.89%**	**0.60%**

Source: Swiss Economics.

6.3 Weighting of embedded and new debt

191 The appropriate weighting of new and embedded debt depends on two factors. Firstly, the level of embedded debt will decrease over the next regulatory because of loans that mature in the near future. In order to maintain debt levels, the expiring debt must be replaced with new debt. Secondly, the RAB is expected to increase significantly over the next years due Dublin Airport's ambitious investment capital projects (e.g. CIP 2020+ or the North Runway) over €2bn that will result in significant funding requirements.

6.3.1 Maturing debt

192 daa's existing debt level will decrease over the next regulatory period, as several loans reach maturity. **Table 34** gives an overview of the relevant loans.

Table 34: daa debt reaching maturity

	Issuance date	Current loan amount (€m)	Nominal interest rate	Loan Maturity
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]	[✂]

Note: All expiring loans have a fixed interest rate. Current loan amounts are per October 2018. Bank fees are excluded.

Source: Swiss Economics based on daa data.

193 Compared to the total level of debt, which is currently at above [✂], the share of embedded debt that will reach maturity over the next regulatory period is small.

6.3.2 Additional funding requirements

194 Dublin Airport's ambitious Capital Investment Plan (CIP 2020+) forecasts investments of at least €1.8bn related to asset care, commercial revenue, information technology, security, and capacity projects at terminal 1, terminal 2, and the airfield raising the need for additional debt. In addition to the CIP 2020+, the airport needs to invest in other capital projects such as the construction of the North Runway and the Programme of Airport Campus Enhancement (PACE). In total, the CIP 2020+ combined with the other ongoing capital projects over €2bn that will result in significant funding requirements.

195 **Table 35** lists current investment plans over the next regulatory period.

Table 35: Dublin Airport Capex forecast according to CIP 2020+

Project Type	Amount (in €m)
Capital Maintenance Projects	284.70
Capacity Development Projects	1'230.18
Commercial Projects	125.64
IT Projects	78.63
Security Projects	56.40
Other Projects	21.97

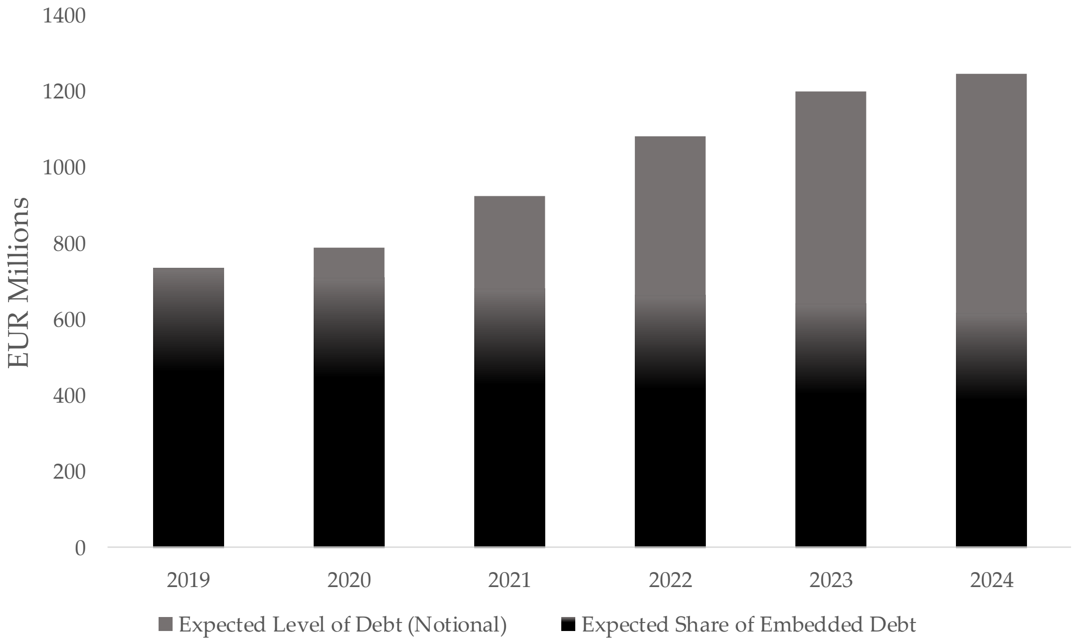
Note: Figures may deviate from summary figures of CIP 2020+ due to rounding errors.

Source: Swiss Economics based on CIP 2020+.

6.3.3 Split between embedded and new debt

196 Based on the assumption that embedded debt covers 50 percent of the current RAB, we illustrate the scope for new debt in **Figure 18** considering the extent of maturing debt and additional investments over the 2020-2024 period.

Figure 18: **Expected debt financed regulatory asset base**



Note: The expected level of debt (notional) is calculated as the RAB plus planned Capex (based on Dublin Airport's CIP2020+) minus depreciation, assuming a notional gearing of 50 percent. A constant depreciation rate of 1.52 percent per quarter has been applied (equivalent to actual depreciation in the 2015-2019 regulatory period). The share of embedded debt is calculated assuming that the split between capital employed for Dublin Airport and other business activities remains constant over time. Embedded loans are assumed to be amortised linearly over their lifetime.

Source: Swiss Economics based on Dublin Airport data.

197 According to our analysis, the share of debt raised before 2020 will decrease over the regulatory period from [✂] percent in 2020 to [✂] percent in 2024. We use an approximation of the arithmetic average of 67 percent across all years over the 2020-24 period as the point estimate for the share of embedded debt.

Table 36: **Unadjusted cost of weighted debt**

	Weights	SE lower bound	SE upper bound	SE point estimate
	67% x cost of embedded debt	0.00%	0.03%	
+	33% x cost of new debt	0.10%	0.29%	
=	**Unadjusted cost of weighted debt**	**0.10%**	**0.32%**	**0.21%**

Note: Unadjusted cost refers to the cost of weighted debt which does not include any adjustments for transaction costs or notional financeability requirements.

Source: Swiss Economics.

6.4 Transaction costs

198 Transaction costs include issuance costs for new debt and maintenance cost for existing debt (e.g. bank fees and margins, interest rate hedges, and costs related to maintaining a credit rating). These costs are not included in financial market data and must be considered separately.

199 On embedded debt, daa currently pays [✂] percent in bank margins weighted across all borrowings as illustrated in **Table 37**.

Table 37: Bank margins on embedded debt

Name	Nominal interest rate	Bank margin	Total cost of funds
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
[✂]	[✂]	[✂]	[✂]
All borrowings	**[✂]**	**[✂]**	**[✂]**

Source: Swiss Economics.

200 The efficient level of transaction costs remains unclear. Actual bank margins paid by daa may contain inefficiencies that should not be reflected in the regulatory rate. On the other hand, additional transaction costs may exist that are not included in bank margins. In particular, daa faces additional costs for one-off bank and legal fees, costs for maintaining the credit rating and costs to support liquidity facilities.

201 Regulatory precedence from Ireland regarding the allowance for debt issuance costs is rare. We are not aware of any explicit allowances in recent decision from CAR, or CER. Comreg added an uptick of 25 basis points to its cost of debt estimate in its most recent decision (Comreg, 2014). UK regulators have regularly added upticks to cost of debt rates in order to meet transaction costs. For example, the CAA have included an uptick of 15 basis points to 20 basis points for London Heathrow Airport and London Gatwick Airport for the current regulatory period Q6.

202 Reflecting our analysis of daa's bank margins on actual debt, we set an uptick of 50 to 60 basis points for transaction costs.

6.5 Financial viability at a notional "BBB" credit rating

203 In January 2019, S&P confirmed its "A-"-credit rating for daa and signalled a positive outlook for an increase in the future based on the following reasoning:

> *The positive outlook on Irish airport operator DAA reflects our view that, all else being equal, we could raise the ratings on DAA by one notch if the company maintains S&P Global Ratings-adjusted FFO to debt above 30% on a sustainable basis, while completing significant investments, and managing uncertainties regarding aeronautical charges in the next price control period.*
>
> S&P (2019), page 2.

204 The credit report identifies two risks that potentially threaten daa's current credit rating:

- **An increase in investments**, exceeding the current CIP2020+ plan, could weaken daa's financial metrics. This is dependent on whether additional investments will be accounted for in the 2019 Determination. S&P considers the regulatory framework under which daa has operated as predictable and supportive, which should mitigate the extent of this threat.
- **A potential traffic decline** constitutes the other threat to daa's "A-"-ranking. In particular, S&P sees an increased possibility of a disruptive No-Deal Brexit. Unfavourable changes to the liberalised service agreements or the Common Travel Area could lead airlines to redirect their routes. In addition, Brexit could cause a weakening of trade between Ireland and the UK, which could affect GDP and result in hampered passenger numbers and reduced commercial revenues per passenger.

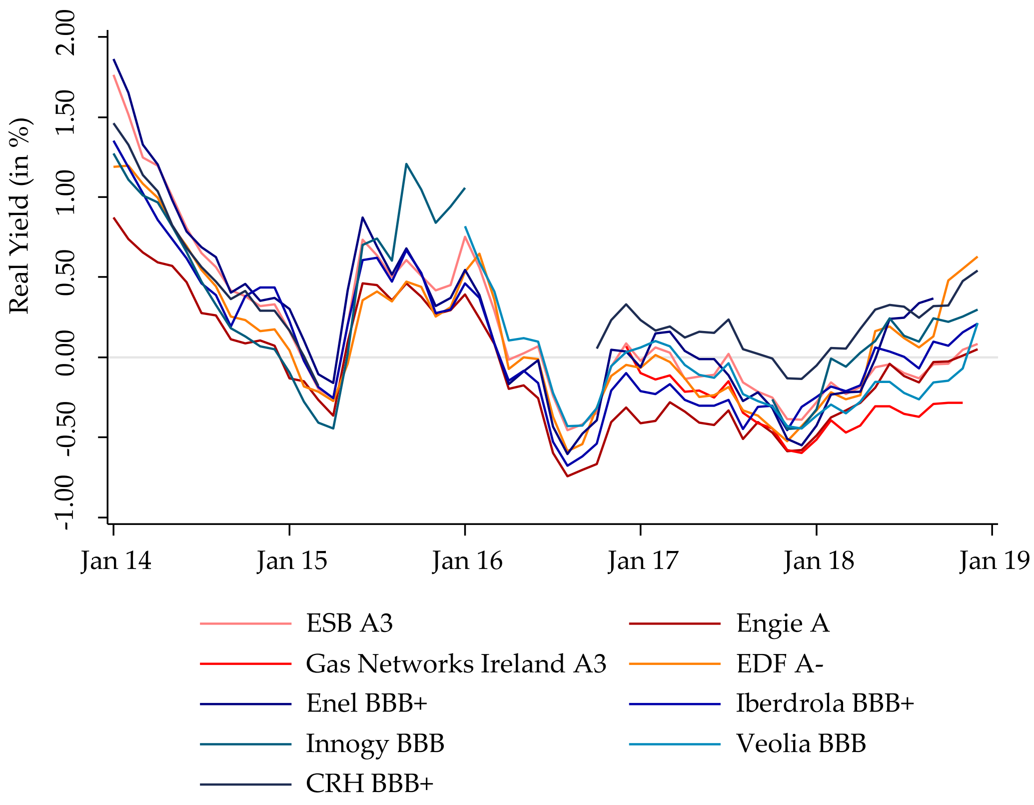
205 A downgrading of daa's credit rating would presumably lead to an increase in the cost of debt.

206 In addition, the allowed rate on capital should be consistent with the credit rating that is used in other building blocks. Currently, CAR is statutorily required to enable financial viability of the regulated entity and allow it to raise debt at reasonable costs for a healthy company. This encompasses a rate on capital that allows daa to raise debt under any investment grade credit rating.

207 In order to comply with this requirement, we investigate whether the cost of debt under a notional "BBB"-credit rating, which is the lowest S&P credit rating still considered as investment grade, comes at a significant spread compared to Dublin Airport's actual "A-"-rating.

208 **Figure 19** illustrates real bond yields of selected utilities and corporations with credit ratings between "A" and "BBB".

Figure 19: Average bond yields of Irish and European utility companies



Note: Real yields of utility and corporate bonds with a residual period to maturity of 8 to 12 years and credit ratings ranging between "A" to "BBB".

Source: Swiss Economics based on Infront data.

209 A consistent difference between yields of bonds with varying credit ratings is not observable. However, **Table 38** reveals that on average bonds with a lower level investment grade credit rating (i.e. "BBB" and "BBB+") trade at slightly higher yields (i.e. a small positive spread) compared to bonds with a credit rating in the middle of investment grade (i.e. "A" to "A-").

Table 38: Spread across credit ratings implied by utility bonds

Bond yields	A to A-	BBB+ to BBB	Spread (bps)
1-year average	-0.10%	-0.01%	9
2-year average	-0.20%	-0.08%	12
5-year average	0.07%	0.12%	5

Note: Utility bonds with "A-"-ratings include EDF, Gas Networks Ireland. Utility bonds with a "BBB"-rating include Veolia.

Source: Swiss Economics based on Infront data.

210 Although the evidence on the spread between "A"-rated and "BBB"-rated bonds is only indicative, we believe an uptick of between 5 basis points to 12 basis points is appropriate.

6.6 Regulatory precedent

211 Irish regulators have traditionally chosen a debt premium approach to determine the regulatory rate on the cost of debt. Rather than estimating the cost of debt directly, this approach estimates the spread relative to the RFR creditors expect for borrowings to the regulated entity. The sum of RFR and debt premium represents the total cost of debt.

212 **Table 39** summarises regulatory precedent for cost of debt set. The sum of RFR and debt premium ranges from 2.50 percent to 5.08 percent in recent Irish decisions.

Table 39: Cost of debt based on Irish precedent

Regulator	Decision	Range	Point Estimate	Based on
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	n/a	2.50%	Sum of debt premium and reference bond yield. Cost of new debt approach to calculate the debt premium
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	2.65% – 3.10%	3.00%	Sum of debt premium and risk-free rate. Debt premium approach with focus on new debt. Debt premium based on benchmark bonds with the same credit rating.
CER (2016)	ESBN/EirGrid PR4	2.50% – 3.25%	2.90%	Sum of debt premium and risk-free rate. Debt premium approach with focus on new debt. Debt premium based on benchmark bonds with the same credit rating.
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	n/a	5.08%	Sum of debt premium and risk-free rate. Debt premium approach with focus on new debt. Debt premium based on benchmark bonds with the same credit rating.
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	2.50% – 3.00%	3.00%	Sum of debt premium and risk-free rate. Debt premium approach with focus on new debt. Debt premium based on benchmark bonds with the same credit rating.

Source: Swiss Economics based on Irish regulatory decisions.

213 In recent decisions, all Irish regulators have used a debt premium approach to estimate the cost of debt. In contrast to our approach of estimating the cost of debt directly, a debt premium approach typically assesses the spread creditors require to lend to the regulated entity rather

than investing in a risk-free asset with a guaranteed return on the level of the RFR. The cost of debt is the sum of RFR and debt premium.

214 Given that the RFR fluctuates significantly over time, as evidenced by current yields on government bonds, it is useful to include a comparison of the various rates of cost of debt set in recent precedent that adjusts for differences in the RFR. **Table 40** presents the values for the RFR and the debt premium set in recent decisions separately and shows an adjusted level for the cost of debt that would have resulted if the regulator had used our point estimate of the RFR of -0.14 percent instead. It should be noted that Table 40 illustrates that cost of debt from regulatory precedent is comparable to our estimate when adjusting for changes in the RFR.

Table 40: Cost of debt from regulatory precedent adjusted for changes in RFR

Regulator	Decision	RFR	Debt Premium	Regulatory cost of debt	Adjusted cost of debt
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	1.50%*	1.00%	2.50%	0.86%
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	2.00%	1.00%	3.00%	0.86%
CER (2016)	ESBN/EirGrid PR4	1.90%	1.00%	2.90%	0.86%
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	2.10%	1.45%	5.08%**	1.31%
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	1.50%	1.50%	3.00%	1.36%

Note: Reported adjusted cost of debt values are based on a RFR of -0.14 percent instead of the value that was actually used by the regulator during the decision.
* CER uses a reference bond yield of 1.50% to determine the cost of debt. CER's point estimate for the RFR lies 1.90%.
** For Comreg (2014), the sum of RFR and Debt Premium does not equal the regulatory cost of debt. This is because the RFR and Debt Premium are reported in real terms, whilst the regulatory cost of debt is reported in nominal terms.

Source: Swiss Economics.

215 When adjusting for current levels of the RFR, regulatory precedent of the cost of debt indicates a range between 0.86 percent to 1.36 percent.

6.7 Conclusion

216 We believe the real cost of debt for Dublin Airport ranges from 0.65 percent to 1.04 percent. The range is based on the evidence presented above, which is summarised in **Table 41**.

Table 41: Evidence on the cost of debt

	Cost of debt	SE lower bound	SE upper bound	SE point estimate
	Unadjusted cost of weighted debt	0.10%	0.32%	
+	Issuance costs	50 bps	60 bps	
+	Uptick for notional credit rating	5 bps	12 bps	
=	**Cost of debt**	**0.65%**	**1.04%**	**0.85%**

Source: Swiss Economics.

217 **Table 42** summarises our findings on the range of the cost of debt and compares it to the range set in the 2014 Determination.

Table 42: Summary cost of debt

	Range (in %)	Point estimate (in %)
2019 SE advice	0.65 – 1.04	0.85
CAR 2014 Determination	2.50 – 3.00	3.00

Note: CAR have not explicitly determined a value for the cost of debt in the 2014 Determination. We report the range that is implicitly given by the sum of CAR's estimate of the RFR of 1.5 percent and a debt premium for Dublin Airport of 1 percent to 1.5 percent.

Source: Swiss Economics.

218 Our point estimate of the cost of debt is 214 basis points below CAR's 2014 point estimate and below most of recent Irish precedent as is illustrated by Table 39.

219 However, the substantial decrease is mainly due to the observed decrease in government bond yields, which resulted in a decrease of the RFR. CAR's 2014 point estimate of the RFR of 1.5 percent compares to our estimate of the RFR of -0.14 percent, constituting a delta of 164 basis points. The range of our implicit debt premium (i.e. the spread between RFR and the range for cost of debt) spans from 0.79 percent to 1.18 percent. This range overlaps with CAR's 2014 range of 1.00 percent to 1.50 percent.

7 Aiming Up

7.1 Asymmetric risks from estimation errors

220 Following UKRN recommendations, we assess whether the regulatory WACC should be uplifted compared to the point estimate, or most likely value of the true WACC. Aiming-up the point estimate is appropriate if the consequences of under-estimating the true WACC are more severe than the consequences of over-estimating the true WACC.

221 Asymmetric consequences may be due to decreased investment activities of Dublin Airport as a result of under-estimating the true WACC. If the level of investment falls below the optimal level, the negative consequences for airport users from missing infrastructure may exceed the positive effects of lower airport charges. The UK Competition Commission (2007) described the risks associated with under- and overestimating the true WACC as follows:

> *If the WACC is set too high then the airports' shareholders will be over-rewarded and customers will pay more than they should. However, we consider it a necessary cost to airport users of ensuring that there are sufficient incentives for [the airport operator] to invest, because if the WACC is set too low, there may be underinvestment from [the airport operator] or potentially costly financial distress […] Most importantly, we note that it is difficult for a regulator to reduce the risks of underinvestment within a regulatory period.*

Competition Commission (2007).

222 In economic terms, under-investments are likely to have dynamic effects on welfare. In the context of airports, dynamic effects are likely to include a worsening of user experience compared to an optimal level of investment. For example, waiting times for departing passengers during security checks may increase due to a lack of infrastructure or flight delays may increase due to missing capacity. In the longer run, travellers, especially transfer passengers, may try to avoid or bypass Dublin Airport, which comes with negative consequences on the Irish air transport industry and tourism and economic activity in general.

223 Over-estimating the true WACC leads to excessive airport charges, which harm consumers directly. However, there likely exist fewer indirect dynamic effects on welfare than in the case of underinvestment since fewer long-run negative effects on economic development are to be expected.

224 The argument for aiming-up is particularly strong when new investments must be incentivised. The UKRN argues that the WACC on new investments should be set above the 90th percentile of the range depending on their importance. For sunk investments, the UKRN argues that the point estimate of the true WACC is enough (UKRN, 2018).

225 Dublin Airport's plans for investments over the next years are in excess of €2bn higher than its current RAB. The CIP 2020+ comprises capacity projects that will enable growth in passenger numbers from currently 31mppa to 40mppa.

226 Given the level and importance of planned investments, we believe aiming up the WACC is prudent and necessary.

7.2 Regulatory precedent on aiming up

227 Aiming up has been part of most Irish regulatory decisions on the WACC of the recent past.

228 Recent CER decisions for water and electricity sectors include small upticks between 15 basis points to 22 basis points. Comreg added an average of 53 basis points to mobile, fixed, and broadband WACC estimates.

229 CAR did not explicitly aim up the WACC in its 2014 Determination. However, CAR chose point estimates towards the higher end of the range for most of the WACC components, which suggests that risk asymmetry was considered implicitly.

230 **Table 43** summarises the regulatory precedent.

Table 43: Aiming up based on Irish precedent

Regulator	Decision	Aiming-Up Adjustment	Based on
CER (2017)	Decision on October 2017 to September 2022 Transmission Revenue for Gas Networks Ireland	Do not consider aiming-up to be necessary	Estimated WACC already appropriately conservative; scale and direction of future impact of risks like Brexit unclear.
CER (2016)	Second Revenue Control period 2017 – 2018 for Irish Water	Aim up to the 80th percentile. Translates into an increase of 15 bps in WACC.	The longer-term consequences of underestimating the WACC outweigh those of overestimating the WACC. Aiming-up percentile determined as one standard deviation above the mean.
CER (2016)	ESBN/EirGrid PR4	Aiming-up allowance of 22 bps	Prefer to add aiming-up allowance in determination, rather than adjust the WACC in the annual adjustment to address new economic circumstances. Aiming-up percentile determined as one standard deviation above the mean.
Comreg (2014)	2014-Decision on Cost of Capital for mobile, fixed, and broadcasting	Aim up to the 66th percentile on certain parameters used in the WACC calculation. This translates to an average increase of 53 bps	Aiming-up reflects that the negative consequences of setting the cost of capital too low greatly outweigh the negative consequences of setting the WACC too high. Aiming-up percentile determined as one standard deviation above the mean.
CAR (2014)	Maximum Level of Airport Charges at Dublin Airport 2014 Determination	No explicit aiming-up mentioned, but point estimates are at the higher end of ranges for most WACC components	

Note: The calculation of the aiming-up percentile in both CER (2016) Irish Water and ESBN/EirGrid determinations were in the respective Europe Economics report.
The aiming-up methodology in Comreg (2014) was applied to the nominal risk-free rate, the asset beta and the debt premium. Tax rate and notional gearing were not aimed up, as there is little uncertainty concerning these parameters. The basis point change in the Comreg WACC is calculated as the average change to mobile telecommunications (49 basis points), fixed line telecommunications (51 basis points), and broadcasting (58 basis points), resulting from aiming up.

Source: Swiss Economics based on regulatory decisions.

7.3 Conclusion

231 We advise to uplift the best estimate of the true WACC by 50 basis points in order to mitigate risks associated with measurement errors. This value is at the higher end of regulatory precedent in Ireland. However, we believe this value is justified because of the following reasons:

- Dublin Airport's CIP 2020+, combined with other ongoing capital projects (e.g. North Runway), will result in investments in excess of €2bn;
- regulatory precedent in Ireland is likely to have relied on implicit aiming up in the past, in contrast to the numbers estimated in this report which are best estimates; and
- the dynamic effects of air transport due to the industry's strong effects on trade, tourism, and economic growth are expected to be larger compared with other utilities (e.g. water)[15].

232 **Table 44** summarises our advice on aiming up.

Table 44: Summary aiming up

	Range	Point estimate
2019 SE advice	n/a	50 bps
CAR 2014 Determination	n/a	n/a

Source: Swiss Economics.

233 CAR has not explicitly aimed up the WACC in its 2014 Determination, but the chosen point estimates indicate that similar considerations were made.

[15] See e.g. Sellner & Nagl (2010) for an estimate on the economic effects of airport capacity expansions.

8 Conclusion

234 We estimate the efficient level of real cost of capital for Dublin Airport over the 2020-24 period to be between 2.80 percent and 4.20 percent. This range reflects the evidence from actual market data, academic literature, and regulatory precedent on each of the individual WACC components we presented in this report. We believe the most likely value of the true WACC is 3.49 percent.

235 **Table 45** summarises our findings for each WACC component.

Table 45: Ranges and point estimates for all individual WACC components

	Range	Point estimate
Gearing	45% - 55%	50%
Tax rate		12.50%
RFR	-0.72% - 0.45%	-0.14%
TMR	6.05% - 6.80%	6.43%
ERP	6.19% - 6.94%	6.56%
Asset Beta	0.43 - 0.46	0.45
Equity Beta	0.81 - 0.86	0.84
Cost of equity	4.75% - 5.94%	5.38%
Cost of debt	0.65% - 1.04%	0.85%
True pre-tax WACC	**2.80% - 4.20%**	**3.49%**

Note: All values are reported in real terms. Point estimates reflect our estimates of the most likely true values.

Source: Swiss Economics.

236 The point estimate of the true WACC does not coincide with our advice to CAR on the rate that should be used in the 2019 Determination. This is because we accept that there is uncertainty regarding the true value of each individual component and the level of the true WACC in general. However, the consequences from underestimating the true WACC are likely to be more severe than the consequences of overestimating the true WACC. Thus, our advice to CAR is to set a regulatory WACC above the point estimate that reflects these asymmetric risks. An uptick of 50 basis points seems appropriate to us given ambitious plans at Dublin Airport over the next regulatory period.

237 **Table 46** summarises our advice regarding the efficient level of the pre-tax real WACC of Dublin Airport for the 2019 Determination.

Table 46: SE regulatory WACC advice and comparison with 2014 Determination

	CAR 2014	SE Advice 2019	Difference
Gearing	50%	50%	-
Tax rate	12.50%	12.50%	-
RFR	1.50%	-0.14%	164bps ▼
ERP	5.00%	6.56%	156bps ▲
Asset Beta	0.60	0.45	0.15 ▼
Equity Beta	1.20	0.84	0.36 ▼
Cost of equity	8.60%	5.38%	322bps ▼
Cost of debt	3.00%	0.85%	215bps ▼
Aiming up	n/a	0.50%	n/a
Advice on regulatory pre-tax WACC	**5.80%**	**3.99%**	**181bps ▼**

Note: All values are reported in real terms.

Source: Swiss Economics.

238 Our advice implies a decrease in the regulatory WACC of 181 basis points compared to the 2014 Determination. This decrease is mainly due to reductions in the cost of debt, the RFR, and the Equity Beta. Given the trends in prices of Euro government bonds and corporate bonds over the last 5 years, we believe a decrease of this magnitude is legitimate.

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A Appendix

A.1 Bonds

Table 47: Government bonds

ISIN	Country	Credit rating	Type	Issue date	Coupon	Maturity date
DE0001030526	Germany	AAA+	Inflation Linked	10.06.2009	1.75%	15.04.2020
DE0001030542	Germany	AAA+	Inflation Linked	21.03.2012	0.10%	15.04.2023
DE0001030559	Germany	AAA+	Inflation Linked	08.04.2014	0.50%	15.04.2030
DE0001030567	Germany	AAA+	Inflation Linked	10.03.2015	0.10%	15.04.2026
DE0001030575	Germany	AAA+	Inflation Linked	09.06.2015	0.10%	15.04.2046
DE0001102309	Germany	AAA+	Nominal	16.01.2013	1.50%	15.02.2023
DE0001102317	Germany	AAA+	Nominal	22.05.2013	1.50%	15.05.2023
DE0001102325	Germany	AAA+	Nominal	11.09.2013	2.00%	15.08.2023
DE0001102333	Germany	AAA+	Nominal	29.01.2014	1.75%	15.02.2024
DE0001102358	Germany	AAA+	Nominal	21.05.2014	1.50%	15.05.2024
DE0001102366	Germany	AAA+	Nominal	10.09.2014	1.00%	15.08.2024
DE0001102374	Germany	AAA+	Nominal	14.01.2015	0.50%	15.02.2025
DE0001102382	Germany	AAA+	Nominal	15.07.2015	1.00%	15.08.2025
DE0001102390	Germany	AAA+	Nominal	13.01.2016	0.50%	15.02.2026
DE0001102408	Germany	AAA+	Nominal	13.07.2016	0.00%	15.08.2026
DE0001102416	Germany	AAA+	Nominal	11.01.2017	0.25%	15.02.2027
DE0001102424	Germany	AAA+	Nominal	12.07.2017	0.50%	15.08.2027
DE0001102440	Germany	AAA+	Nominal	10.01.2018	0.50%	15.02.2028
DE0001102457	Germany	AAA+	Nominal	11.07.2018	0.25%	15.08.2028
DE0001135374	Germany	AAA+	Nominal	12.11.2008	3.75%	04.01.2019
DE0001135382	Germany	AAA+	Nominal	20.05.2009	3.50%	04.07.2019
DE0001135390	Germany	AAA+	Nominal	11.11.2009	3.25%	04.01.2020
DE0001135408	Germany	AAA+	Nominal	28.04.2010	3.00%	04.07.2020
DE0001135416	Germany	AAA+	Nominal	18.08.2010	2.25%	04.09.2020
DE0001135424	Germany	AAA+	Nominal	24.11.2010	2.50%	04.01.2021
DE0001135440	Germany	AAA+	Nominal	27.04.2011	3.25%	04.07.2021
DE0001135457	Germany	AAA+	Nominal	24.08.2011	2.25%	04.09.2021
DE0001135465	Germany	AAA+	Nominal	23.11.2011	2.00%	04.01.2022
DE0001135473	Germany	AAA+	Nominal	11.04.2012	1.75%	04.07.2022
DE0001135499	Germany	AAA+	Nominal	05.09.2012	1.50%	04.09.2022
DE0001141687	Germany	AAA+	Nominal	15.01.2014	1.00%	22.02.2019
DE0001141695	Germany	AAA+	Nominal	07.05.2014	0.50%	12.04.2019
DE0001141703	Germany	AAA+	Nominal	03.09.2014	0.25%	11.10.2019
DE0001141711	Germany	AAA+	Nominal	21.01.2015	0.00%	17.04.2020
DE0001141729	Germany	AAA+	Nominal	01.07.2015	0.25%	16.10.2020
DE0001141737	Germany	AAA+	Nominal	03.02.2016	0.00%	09.04.2021
DE0001141745	Germany	AAA+	Nominal	20.07.2016	0.00%	08.10.2021
DE0001141752	Germany	AAA+	Nominal	01.02.2017	0.00%	08.04.2022

DE0001141760	Germany	AAA+	Nominal	05.07.2017	0.00%	07.10.2022
DE0001141778	Germany	AAA+	Nominal	31.01.2018	0.00%	14.04.2023
DE0001141786	Germany	AAA+	Nominal	25.07.2018	0.00%	13.10.2023
IE00B4S3JD47	Ireland	A+	Nominal	15.03.2013	3.90%	20.03.2023
IE00B4TV0D44	Ireland	A+	Nominal	18.10.2009	5.40%	13.03.2025
IE00B6089D15	Ireland	A+	Nominal	24.06.2009	5.90%	18.10.2019
IE00B60Z6194	Ireland	A+	Nominal	15.01.2010	5.00%	18.10.2020
IE00B6X95T99	Ireland	A+	Nominal	07.01.2014	3.40%	18.03.2024
IE00BDHDPQ37	Ireland	A+	Nominal	14.10.2017	0.00%	18.10.2022
IE00BDHDPR44	Ireland	A+	Nominal	13.01.2018	0.90%	15.05.2028
IE00BV8C9418	Ireland	A+	Nominal	17.01.2016	1.00%	15.05.2026

Source: Swiss Economics based on Infront data.

Table 48: Airport bonds

ISIN	Airport	Credit rating	Issue date	Coupon	Maturity date
XS1419674525	Dublin	A-	17.06.2016	0.01554	07.06.2028
FR0011140912	Paris	A+	04.11.2011	0.03875	15.02.2022
FR0012206993	Paris	A+	07.10.2014	0.015	07.04.2025
FR0013302197	Paris	A+	13.12.2017	0.01	13.12.2027
XS1301052202	Schiphol	A+	05.10.2015	0.02	05.10.2026
XS1900101046	Schiphol	A+	05.11.2018	0.015	05.11.2030
XS1057783174	Sydney	BBB+	23.04.2014	0.0275	23.04.2024
XS1811198701	Sydney	BBB+	26.04.2018	0.0175	26.04.2028

Source: Swiss Economics based on Infront data.

Table 49: Utility bonds

ISIN	Utility company	Credit rating	Issue Date	Coupon	Maturity Date
FR0010800540	EDF	A-	11.09.2009	4.63%	11.09.2024
FR0010891317	EDF	A-	24.04.2010	4.63%	26.04.2030
FR0010961540	EDF	A-	12.11.2010	4.00%	12.11.2025
FR0011182641	EDF	A-	18.01.2012	3.88%	18.01.2022
FR0011318658	EDF	A-	10.09.2012	2.75%	10.03.2023
FR0013213295	EDF	A-	13.10.2016	1.00%	13.10.2026
FR0013368545	EDF	A-	02.10.2018	2.00%	02.10.2030
XS123958659	ESB	A3	05.06.2015	2.13%	08.06.2027
XS156085367	ESB	A3	07.02.2017	1.75%	07.02.2029
XS99264691	ESB	A3	12.11.2013	3.49%	12.01.2024
XS0452187916	Enel	BBB+	10.09.2009	5.00%	14.09.2022
XS0842659426	Enel	BBB+	15.10.2012	4.88%	17.04.2023
XS1176079843	Enel	BBB+	27.01.2015	1.97%	27.01.2025
XS1425966287	Enel	BBB+	01.06.2016	1.38%	01.06.2026
XS1750986744	Enel	BBB+	16.01.2018	1.13%	16.09.2026
FR0010952770	Engie	A	18.10.2010	3.50%	18.10.2022
FR0011261924	Engie	A	01.06.2012	3.00%	01.02.2023
FR0011289230	Engie	A	20.07.2012	2.63%	20.07.2022
FR0011911247	Engie	A	19.05.2014	2.38%	19.05.2026
FR0012602761	Engie	A	13.03.2015	1.00%	13.03.2026
FR0013284254	Engie	A	28.09.2017	1.38%	28.02.2029
XS1529684695	Gas Networks Ireland	A3	05.12.2016	1.38%	05.12.2026
XS0990109240	Iberdrola	BBB+	13.11.2013	3.00%	31.01.2022
XS1057055060	Iberdrola	BBB+	24.04.2014	2.50%	24.10.2022
XS1116408235	Iberdrola	BBB+	08.10.2014	1.88%	08.10.2024
XS1398476793	Iberdrola	BBB+	21.04.2016	1.13%	21.04.2026
XS1490726590	Iberdrola	BBB+	15.09.2016	0.38%	15.09.2025
XS1682538183	Iberdrola	BBB+	13.09.2017	1.25%	13.09.2027
XS1726152108	Iberdrola	BBB+	29.11.2017	1.62%	29.11.2029
XS1847692636	Iberdrola	BBB+	28.06.2018	1.25%	28.06.2026
XS0158243013	Innogy	BBB	31.01.2018	1.50%	31.07.2029
XS09872019126	Innogy	BBB	17.10.2013	3.00%	17.01.2024
XS1702729275	Innogy	BBB	19.10.2017	1.25%	19.10.2027
XS1829217345	Innogy	BBB	30.05.2018	1.63%	30.05.2026
FR0012663169	Veolia	BBB	09.04.2009	1.59%	10.01.2028
FR0013210416	Veolia	BBB	04.10.2016	0.93%	04.01.2029
FR0013246733	Veolia	BBB	30.03.2017	1.50%	30.11.2026
FR0013385473	Veolia	BBB	05.12.2018	1.94%	07.01.2030

Source: Swiss Economics based on Infront data.

A.2 Beta Sensitivity analyses

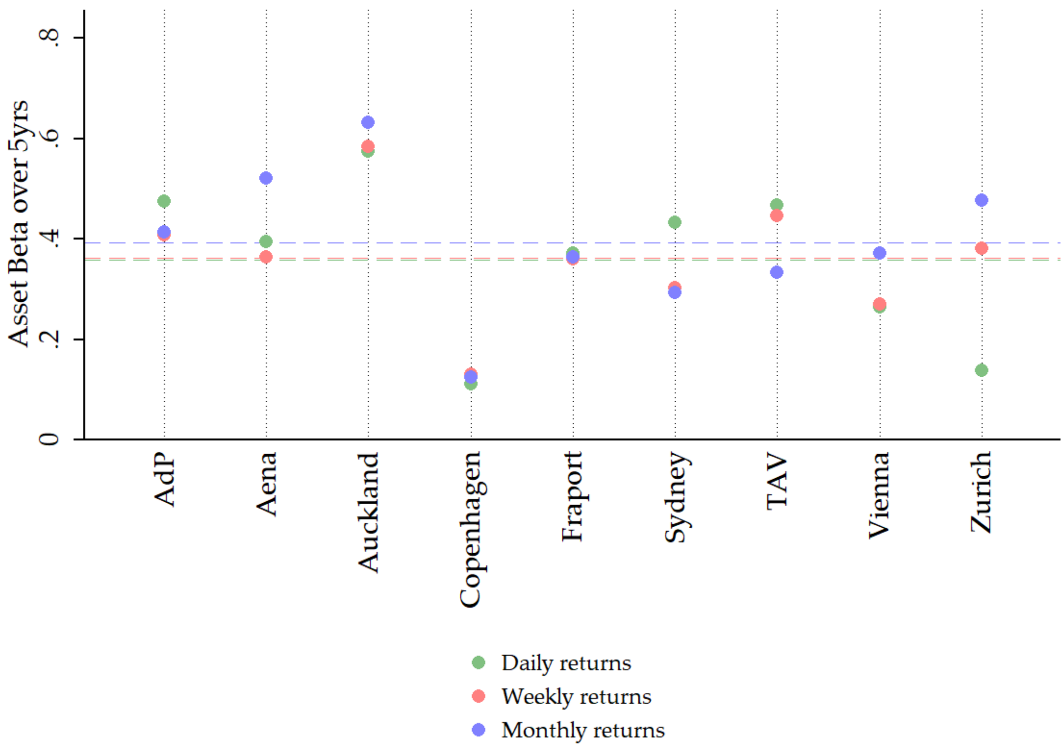
239 This section presents various sensitivity analyses of Betas. Appendix A.2.1 introduces a sensitivity analysis of the Beta estimates with respect to the frequency of the underlying return data. Appendix A.2.2 shows a similar analysis with respect to the choice of different time horizons. Differences in Betas estimated on national or supranational market indices are presented in Appendix A.2.3. Finally, Appendix A.2.4 contrast Betas estimated by OLS with Betas estimated by GARCH.

A.2.1 Data frequency

240 An important decision in the estimation of Asset Betas is the choice of the data frequency. Betas are estimated on daily, weekly, monthly, or sometimes even quarterly return data. In general, there is a trade-off between the sample size and accuracy of the Beta estimates. Whereas shorter frequencies increase the sample size and therefore the statistical reliability, they may yield observations that are not normally distributed and may introduce unwanted noise.

241 **Figure 20** shows the sensitivity of the estimated Asset Betas with respect to the data frequency chosen, i.e. whether the Asset Betas are estimated on daily, weekly, or monthly returns. All estimates in Figure 20 result from a time horizon of 5 years. The dashed lines represent the average Asset Beta values for daily (0.358), weekly (0.362), and monthly (0.392) estimates. In general, the sensitivity of the estimates to changes in the data frequency is limited, as the small differences in the average values show. The estimates for monthly data frequencies are highest, whereas the estimates for daily frequencies are lowest, albeit only slightly different to weekly data. A potential explanation is provided by the literature on overshooting, which suggests some negative serial correlation in daily returns. In other words, periods of exceptionally high or low returns tend to be followed by some reversal in succeeding days (e.g. Wright et al., 2018).

Figure 20: Sensitivity with respect to data frequency



Note: Based on OLS regressions with national price indices. Un-levering using Hamada-formula based on net debt/equity ratios and effective tax rates. Data until 31 December 2018 was used.

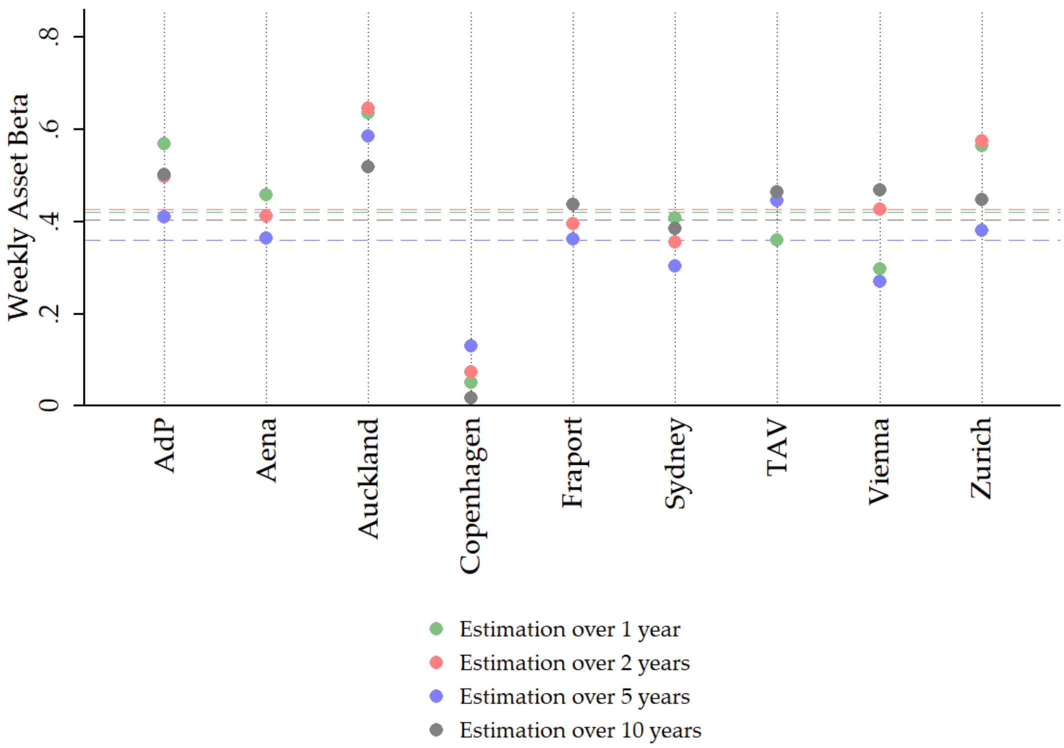
Source: Swiss Economics based on Infront data.

A.2.2 Time horizon

242 Another crucial decision in estimating Asset Betas is the choice of an appropriate time horizon. Time horizons of 1 year, 2 years, 5 years, and 10 years or longer are common. Again, a trade-off is involved. The drawback of shorter time horizons is a smaller sample size, which makes it more likely that random noise is interpreted as meaningful variation in the data. Longer time horizons increase the number of observations and reduce the impact of noise in the data. However, they risk representing data variation which is no longer relevant and, at the same, diluting the impact of recent risks which are relevant.

243 **Figure 21** reports weekly Asset Betas estimated over different time horizons. As in the case of different data frequencies, the sensitivity of the Asset Betas with respect to different time horizons is very low. The averages Asset Beta values correspond to 0.420, 0.427, 0.360, and 0.404 for time horizons of 1, 2, 5, and 10 years, respectively.

Figure 21: Sensitivity with respect to the time horizon



Note: Based on OLS regressions with national price indices. Unlevering using Hamada-formula based on net debt/equity ratios and effective tax rates. Data until 31 December 2018 was used.

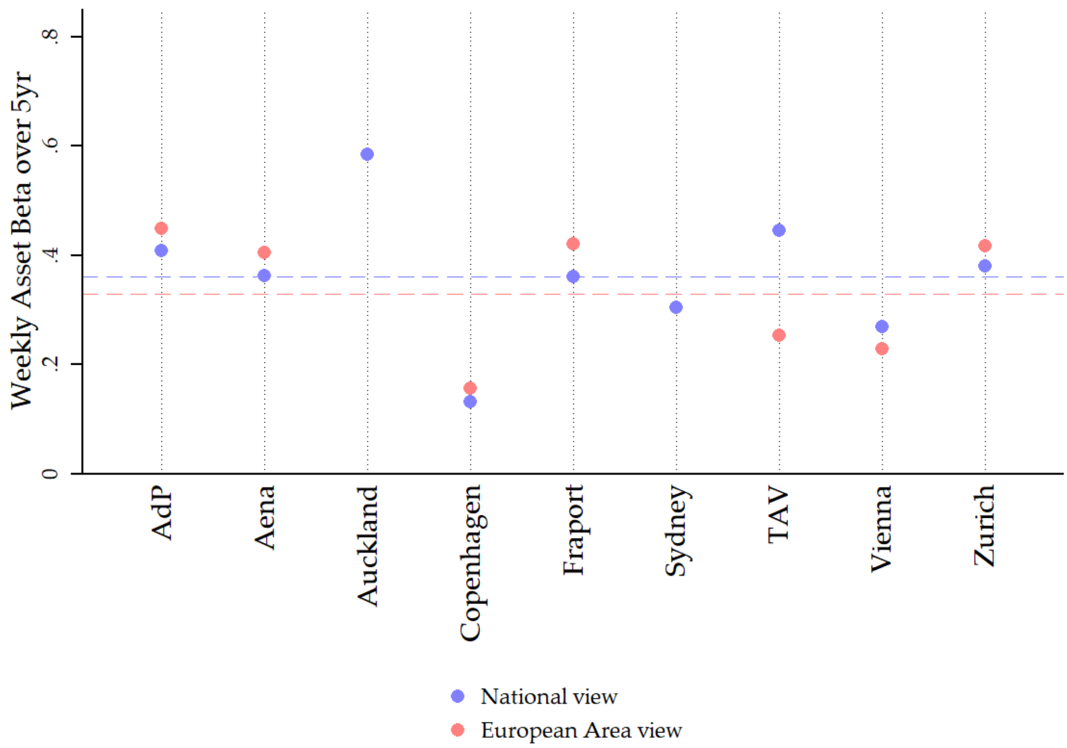
Source: Swiss Economics based on Infront data.

A.2.3 Market indices

244 The estimation of Asset Betas necessitates the choice of an appropriate market index. This is primarily a choice between national indices and indices that represent a larger economic entity. The rationale for national indices originates from the assumption that idiosyncratic national risks exist which have a common impact on all national companies.

245 **Figure 22** shows the sensitivity of weekly Asset Betas with respect to the choice of market indices. All Asset Betas in Figure 22 are estimated over 5 years. Betas based on national indices are slightly higher (average of 0.36) than Betas estimated on a European Area index[16] (average of 0.33). The slightly higher Asset Betas which result from estimations using national indices may reflect common impact of national risks. The European Area index is more broadly diversified and hence subject to other risks than national Airport operators. Nevertheless, the differences between Asset Betas regressed on national and European indices are small. Wright et al. (2018) suggest that the dominance of large multinational corporations in many national stock markets render the differences between national and broader indices less relevant.

Figure 22: Sensitivity with respect to the choice of market indices



Note: Based on OLS regressions using price indices. Unlevering using Hamada-formula based on net debt/equity ratios and effective tax rates. Data until 31 December 2018 was used. European Area view indicates that airport returns were regressed on the STOXX Europe 50 price index. Auckland and Sydney airports are only estimated on national indices.

Source: Swiss Economics based on Infront data.

A.2.4 Estimation method

246 The most common methodology to estimate Beta coefficients is Ordinary least squares (OLS). OLS models usually assume homoskedasticity, which is frequently violated in practice. Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models depart from the assumption of homoskedasticity by treating heteroskedasticity as a variance to be modelled. GARCH-based approaches to estimate Beta coefficients have been primarily of academic interest and, to the best of our knowledge, not been adopted in a regulatory context to date. However, given the possibility of GARCH models to explicitly model heteroskedasticity, and given the widespread occurrence of heteroskedasticity in financial data (e.g. volatility clustering), we conducted sensitivity analyses using GARCH models. The GARCH models estimated here

[16] STOXX Europe 50 price index.

correspond to the most commonly employed GARCH(1,1) specification, in which the variance is specified as a function of the previous period's squared error and the previous period's variance.

247 **Table 50** represents the results of the sensitivity analysis. In general, GARCH estimates are slightly lower than OLS estimates. The difference in GARCH and OLS estimates tends to be larger for estimates based on higher frequency data. This may be a consequence of a more pronounced presence of volatility clustering in daily than in weekly data.

Table 50: Asset Betas estimated by OLS, GLS and GARCH

Estimation period/frequency	**OLS** (unweighted Asset Beta averages)	**GARCH** (unweighted Asset Beta averages)	Deviation vs. OLS
1 year / daily data	0.411	0.379	-7.7%
2 year / daily data	0.423	0.417	-1.6%
5 year / weekly data	0.379	0.378	-0.3%

Note: Average values are based on nine comparator airports (excluding Aeroporti di Roma, London Heathrow and London Gatwick). Equity Betas are adjusted for differences in leverage and converted to Asset Betas using the Hamada-formula based on net debt/equity ratios and effective tax rates.

Source: Swiss Economics based on Infront data.

A.3 Levering and de-levering

248 The de-levered Betas (Asset Betas) only reflect each airport's business risk and can be compared with each other. The following formula is used in order to derive Asset Betas (Hamada, 1962):

$$\beta_{Asset} = \frac{\beta_{Equity}}{1 + \frac{D}{E} * (1 - t)} \tag{8}$$

where

- β_{Asset} is the Asset Beta;
- β_{Equity} is the Equity Beta;
- D is the net debt (debt minus cash and cash equivalents);
- E is the equity; and
- t is the effective tax rate.

A.4 Beta adjustments

249 One reason for possible distortions in the estimation of Betas is caused by the fact that Betas vary over time. Marshall E. Blume has shown (1971, 1975) that the variation of Betas over time is often associated with "reversion to the mean". Reversion to the mean means that a portfolio with a high or low Beta is likely to have a less extreme Beta in the following period, i.e. that Betas tend to approximate the average of all Betas which is 1. This may be an issue for the setting of Betas for multiannual regulatory periods, since the estimated Betas for future years may be too low (for a Beta below 1) or too high (for Betas above 1). The occurrence of reversion to the mean has been taken into account by Blume and others through the following formula:

$$\beta_{Blume\ adjusted} = \frac{2}{3} * \beta_{raw} + \frac{1}{3} * \beta_{market} \tag{9}$$

where

- β_{raw} is the estimated Beta; and
- β_{market} is the market Beta, by definition equal to 1.

250 An alternative adjustment of Beta parameters based on the idea of reversion to the mean is provided by Oldrich Vasicek (1973). In contrast to the Blume's adjustment, the Vasicek's adjustment assumes that Beta values with a high estimation error tend to move more strongly towards the market average than Betas which are estimated more precisely. There are many versions of Vasicek's adjustment and a common formula is the following (e.g. Hollstein et al., 2017):

$$\beta_{Vasicek\ adjusted} = \frac{\sigma^2[\beta_{raw}]}{\sigma^2[\beta_{market}] + \sigma^2[\beta_{raw}]} * \beta_{market} + \frac{\sigma^2[\beta_{market}]}{\sigma^2[\beta_{market}] + \sigma^2[\beta_{raw}]} * \beta_{raw} \qquad (10)$$

where

- β_{raw} is the estimated Beta;
- β_{market} is the market Beta, by definition equal to 1;
- $\sigma^2[\beta_{raw}]$ is the variance of the estimated Beta; and
- $\sigma^2[\beta_{market}]$ is the variance of the market Beta.

251 Klemkosky and Martin (1975) compared the Vasicek's adjustment with the Blume's adjustment and concluded that Vasicek led to somewhat better results. Other studies have concluded otherwise (Eubank & Zumwalt 1979). A study from a purely theoretical point of view finds that Vasicek's adjustment is at least theoretically superior to the Blume's adjustment (Lally, 1998). Nevertheless, contemporary empirical research advises against the use of Beta adjustments (e.g. Echterling & Eierle, 2015).

252 **Table 51** shows the effect of the Blume's and Vasicek's adjustment on our Asset Beta values.

Table 51: Blume/Vasicek's adjustment of Asset Betas

Airport	Unadjusted (2 yrs / daily data)	Blume's adjustment (2 yrs / daily data)	Vasicek's adjustment (2 yrs / daily data)
Aena (Spain)	0.44	0.51	0.57
Aeroport de Paris	0.51	0.61	0.67
Aeroporti di Roma	0.57	0.76	0.86
Auckland Airport	0.51	0.59	0.65
Copenhagen Airport	0.06	0.15	0.20
Fraport (Frankfurt)	0.40	0.47	0.51
London Gatwick Airport	0.52	0.70	0.79
London Heathrow Airport	0.47	0.63	0.71
Sydney Airport	0.43	0.50	0.50
TAV (Turkey)	0.49	0.55	0.56
Vienna Airport	0.35	0.53	0.62
Zurich Airport	0.63	0.66	0.67
Average increase relative to unadjusted Betas		**+24%**	**+36%**

Notes: Blume's and Vasicek's adjustment for Aeroporti di Roma, London Heathrow, and London Gatwick were calculated based on the average increase of Blume's and Vasicek's Asset Betas relative to the unadjusted Asset Betas of the nine estimated comparator airports. Blume's and Vasicek's adjustments were applied on the "raw" Betas before delevering. We use the cross-sectional variance of the estimated Betas within the comparator group as a proxy for the variance of the market Beta in the case of Vasicek's adjustment.

Source: Swiss Economics.

253 As shown in Table 51 for the case of Asset Betas estimated on daily data over a period of 2 years, both, the Blume's and the Vasicek's adjustment exert a considerable impact on the values

obtained. On average, the Blume's adjustment increases Asset Betas by 24 percent, whereas the Vasicek's adjustment increases the same values by 36 percent.

254 We oppose the use of Blume's or Vasicek's adjustment since both suffer from serious shortcomings. The main issue in the case of Blume's adjustment is that it mechanically moves all Betas towards a value of 1 by attaching a weight of only two-thirds to the estimated Betas and a weight of one-third to 1. Vasicek's adjustment is less mechanical, as it more strongly moves Betas that are statistically imprecise, i.e. that have large variances, to 1 than Betas based on more precise estimations. Nevertheless, its issues are related to estimation feasibility. Theoretically, a calculation of the market Beta variance would involve calculating the cross-sectional variance of all Betas in the market portfolio. This is a very data-intensive calculation, which is the reason why the usual procedure is to use the cross-sectional variance of the estimated Betas within the comparator group as a proxy for the variance of the market Beta. Such an approach, however, reduces the validity of the Vasicek's adjustment and negatively affects the transparency and understanding of the adjustment.

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