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Betas for French airports based on empirical and regulatory evidence

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Abstract: We present the results of our analysis on the appropriate level Asset Betas for airports under ART's mandate.

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Executive Summary

The Autorité de regulation des transports (ART) determines the appropriate level of remuneration for cost of equity, to which airports under its mandate are entitled for. The French transport law foresees that the Capital Asset Pricing Model (CAPM) is used to estimate airports' cost of equity. A key component of the CAPM is the Beta, which measures the airport's systematic risk (i.e. non-diversifiable risk).

Swiss Economics (2020) identifies groups of comparator airports, which can serve to determine the appropriate level of the Beta for each of the airports under ART's mandate. In this report, we present our estimates of comparator airport Betas and describe our methodology for estimating them.

We use evidence from actual stock market data and regulatory precedent to determine comparator Betas.

- We use stock return data for Fraport (Frankfurt), Aéroports de Paris (Group), Copenhagen, AENA Aeropuertos, and Zurich Airport to estimate empirical Asset Betas.
- We use evidence from regulatory precedent for Amsterdam Schiphol Airport, Aeroporti di Roma, Dublin Airport, London Gatwick Airport, and London Heathrow Airport.

We combine the comparator Betas with the Weighting Matrix outlined in our previous report to obtain Asset Betas per comparator group (see **Table 1)**.

Table 1: Group Asset Betas and ranges

	Asset Beta (point estimate)	Asset Beta (Range)
Group 1 (Amsterdam Schiphol Airport and Fraport (Frankfurt))	0.44	0.39 – 0.49
Group 2 (Aeroporti di Roma, Aéroports de Paris (Group), and Copenhagen Airport)	0.49	0.44 – 0.53
Group 3 (AENA Aeropuertos, Dublin Airport, London Gatwick Airport, London Heathrow Airport, and Zurich Airport)	0.53	0.49 – 0.58

Source: Swiss Economics

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Abbreviations

ACM	Authority for Consumers & Markets
AdP	Aéroports de Paris
AENA	Aeropuertos Españoles y Navegación Aérea
ART	Autorité de regulation des transports
CAPM	Capital Asset Pricing Model
CAA	Civil Aviation Authoriy
CAR	Commission for Aviation Regulation
EEA	European Economic Area
ENAC	Ente Nazionale per l'Aviazione Civile [Italian Civil Aviation Authority]
e.g.	for example
ERA	Economic Regulation Agreement
GARCH	Generalized AutoRegressive Conditional Heteroskedasticity
i.e.	id est
OLS	Ordinary Least Squares
pax	Passengers
WACC	Weighted Average Cost of Capital

1 Introduction

1.1 Background

As per 1 October 2019, the Autorité de régulation des transports (ART) has become the supervising authority for airport tariffs levied to airlines and users by French airports with traffic above 5 million passengers (pax) over the last civil year, or airports part of an airport system with at least one airport with traffic above 5 million pax over the last civil year. In this capacity, ART approves the annual tariff schemes prepared and submitted by airports or gives a binding opinion on the Economic Regulation Agreement (ERA) the airports might enter into with the French Ministry in charge of transportation.

In accordance with Article L. 6325-1 of the French transport law, ART uses the Capital Asset Pricing Model (CAPM) to determine the cost of equity faced by airports under its regulatory mandate. A key component of the CAPM is the Beta, which measures a company's systematic (i.e. non-diversifiable risk).

In a first report from January 2020, Swiss Economics has grouped airports under ART's mandate, based on their underlying risk profile, and identified comparator airports that can be used to inform the appropriate level of the Betas for each group (Swiss Economics, 2020).

1.2 Aim of this Report

ART commissioned this second report with the aim to determine the appropriate level of the Beta for airports under ART's mandate, depending on their risk exposure.

For this purpose, we retrieve a list of comparator Betas either via empirical analysis of airport stock returns or via regulatory precedent. The report discusses the applied methodology and presents Betas for comparator airports as well as for various risk groups.

1.3 Structure

The remainder of this report is structured as follows:

- in **Section 2**, we recall to the reader the framework we apply to determine Asset Betas dependent on the airports' risk exposure;
- in **Section 3**, we describe our methodology to retrieve comparator Betas;
- in **Section 4**, we report the comparator Betas we retrieve based on our methodology; and
- in **Section 5**, we present the resulting point estimates and ranges of Betas for each risk group.

2 Framework

2.1 Betas based on risk exposure

Our proposed methodology aims to isolate comparator Betas with similar exposure to systematic risk for each of the airports under ART's mandate.

In our previous report to ART, we assessed the drivers of Beta risk and defined three groups of similar risk exposure. Airports' exposure to risk primarily depends on the extent of how market's profit fluctuations translate into an airport's profit fluctuations. The degree to which fluctuations are passed on to an airport's profits depends on the rigidity of the regulatory environment (in particular the tariff cap), demand-related factors, as well as supply-related factors.

We scored the risk exposure of airports under ART's mandate as well as comparator airports and categorised them into one of the risk groups. We focus on comparator airports from the same group, when determining airport Betas.

2.2 Airports under ART's mandate

In Swiss Economics (2020), we found that airports under annual tariff review belong to the first group with a relatively low risk profile. This is primarily due to the very flexible nature of price caps these airports face. Only the Parisian airports, whose owner Aéroports de Paris (AdP) have signed an Economic Regulation Agreement (ERA) with the French government, are exposed to more Beta risk and belong to Group 2[1]. An overview of the airports under ART's mandate and their membership of risk groups is illustrated in **Table 2**.

Table 2: List of airports under ART's mandate

Airport	Group Membership (as per end of 2019)
Bâle-Mulhouse Airport	1
Bordeaux-Mérignac Airport	1
Lyon-Saint Exupéry Airport	1
Marseille-Provence Airport	1
Nantes-Atlantique Airport	1
Nice-Côte d'Azur Airport	1
Parisian airports	2
Toulouse-Blagnac Airport	1

Source: Swiss Economics Report.

2.3 List of comparator airports

We use a sample of exchange-listed airport stocks to assess empirical estimates of comparator Betas. In line with the recommendations of the Thessaloniki Forum of Airport Charges Regulators (Thessaloniki Forum), we focus on airports located within the European Economic Area (EEA) and Switzerland. **Table 3** presents the list of exchange-listed airport stocks.

[1] The allocation of airports to a specific group represents the current situation and depends on the specific ERA.

Table 3: List of exchange-listed airport stocks

Airport	Stock	Group Membership
AENA Aeropuertos (Madrid, Barcelona, and 48 more Spanish airports)	BME: AENA	3
Aéroports de Paris (Group)	EPA: ADP	2
Copenhagen Airport	CPH: KBHL	2
Fraport (Frankfurt)	ETR: FRA	1
Zurich Airport	SWX: FHZN	3

Source: Swiss Economics.

We complement empirically estimated comparator Betas with Betas, which were set by European airport charges regulators in the recent past as shown in **Table 4**.

Table 4: List of airports with regulated Betas

Airport	Regulator	Group Membership
Aeroporti di Roma	Italian Civil Aviation Authority (ENAC)	2
Amsterdam Schiphol Airport	Dutch Authority for Consumers & Markets (ACM)	1
Dublin Airport	Irish Commission for Aviation Regulation (CAR)	3
London Gatwick Airport	UK Civil Aviation Authority (CAA)	3
London Heathrow Airport	CAA	3

Source: Swiss Economics Report.

The airports in Table 4 are chosen such as to supplement the list of empirically estimated airports in Table 3 with airports under other relevant regulatory oversights. The combined list of airports that form the basis for our set of comparator airports is set out in **Table 5**. This whole set of comparator airports represents not only airports from the most relevant regulatory jurisdictions but also airports from the main European consumer markets.

Table 5: List of comparator airports

Airport	Empirical evidence / Evidence from regulatory precedent	Group Membership
AENA Aeropuertos	Empirical	3
Aeroporti di Roma	Regulatory precedent	2
Aéroports de Paris (Group)	Empirical	2
Amsterdam Schiphol Airport	Regulatory precedent	1
Copenhagen Airport	Empirical	2
Dublin Airport	Regulatory precedent	3
Fraport (Frankfurt)	Empirical	1
London Gatwick Airport	Regulatory precedent	3
London Heathrow Airport	Regulatory precedent	3
Zurich Airport	Empirical	3

Source: Swiss Economics.

2.4 Weighting Matrix

The ART-regulated airports can then be matched with the appropriate set of comparator companies. The Weighting Matrix presented in our previous report for ART (Swiss Economics, 2020) attaches weights to the sample comparator Betas depending on group membership of the airport under ART's regulation.[2]

Table 6: Weighting Matrix

Airport	Group 1	Group 2	Group 3
AENA Aeropuertos	0%	0%	20%
Aeroporti di Roma	0%	33%	0%
Aéroports de Paris (Group)	0%	33%	0%
Amsterdam Schiphol Airport	50%	0%	0%
Copenhagen Airport	0%	33%	0%
Dublin Airport	0%	0%	20%
Fraport (Frankfurt)	50%	0%	0%
London Gatwick Airport	0%	0%	20%
London Heathrow Airport	0%	0%	20%
Zurich Airport	0%	0%	20%

Source: Swiss Economics Report

ART-regulated airports are allocated to the three risk groups as follows:

- **Group 1** includes Bâle-Mulhouse Airport, Bordeaux-Mérignac Airport, Lyon-Saint Exupéry Airport, Marseille-Provence Airport, Nantes-Atlantique Airport, Nice-Côte d'Azur Airport, and Toulouse-Blagnac Airport;
- **Group 2** includes Parisian airports;
- **Group 3** does currently not encompass an airport under ART's regulation.

3 Methodology for retrieving Comparator Betas

3.1 Empirical comparator Betas

We empirically estimate raw Betas from airport stock returns using ordinary least squares (OLS). The raw Betas, which are likely to be affected by airports' financial leverage, are converted into Asset Betas. In the following, we discuss our choices of market indices, time horizon and frequency of the underlying data, and de-levering formula.[3]

3.1.1 Market indices

We use national stock market indices, which cover at least 85 percent of the respective national markets, or if such an index was not available, the widest available index. National indices allow

[2] The Weighting Matrix takes into account differences in risk profiles across comparator airports, which are driven by differences in the regulatory environment, differences in the demand structure, and differences in supply-related factors. The comparator airports are categorised into groups with ascending Beta risk. Depending on the number and reliability of comparator airports within a group, comparators are given different weights.

[3] All market data used in the analysis are obtained from Refinitiv.

for risks which have a common impact on all national companies, assuming the notional investor may not be able to diversify them away[4].

We use total return series for stock returns as well as market indices in order to adjust for dividend payments. **Table 7** reports the indices that were used in the calculation of Betas.

Table 7: Market indices used as regressors

Airport company	Market index used	Number of constituents	Size of companies represented
AENA Aeropuertos	IBEX 35	35	Large and mid caps
Aéroports de Paris (Group)	CAC All	250 (ca.)	Mixed
Copenhagen Airport	OMXC 25	25	Large and mid caps
Fraport (Frankfurt)	CDAX	420 (ca.)	Mixed
Zurich Airport	SPI	215 (ca.)	Mixed

Notes: The number of constituents of each index varies as smaller markets are represented by indices with a smaller number of constituents. However, all indices are highly representative of the national investment horizon.

Source: Swiss Economics based on Refinitiv data.

3.1.2 Dataset frequency and time horizon

We use a dataset of weekly returns over the 5-year period from 18 December 2014 to 17 December 2019. Combining a longer time-horizon of five years with a weekly returns frequency results in a large enough dataset to accurately estimate Betas but, at the same time, avoids biasing the results due to short-term noise such as negative serial correlations in daily returns. Also, a recent study commissioned by Ofgem, the UK energy sector regulator, finds that daily stock returns suffer from higher degrees of heteroskedasticity than weekly returns.[5]

3.1.3 De-levering

We adjust raw estimates for the financial leverage underlying the companies and convert them into Asset Betas, which only reflect systematic business risk.

In line with the Thessaloniki Forum of Airport Charges Regulators (Thessaloniki Forum, 2016) recommendations, we use the Hamada-formula (Hamada, 1972, and Modigliani and Miller, 1963) for the conversion to Asset Betas:

$$\beta_{Asset} = \frac{\beta_{raw\ estimate}}{1 + \frac{D}{E} \times (1 - t)} \tag{1}$$

where

- β_{Asset} is the Asset Beta;
- $\beta_{raw\ estimate}$ is the estimated raw Beta;
- D is the net debt;
- E is the equity; and
- t is the effective tax rate.

[4] Another reason for relying on national indices is the existence of investor's home bias. Recent empirical evidence supports the persistent existence of a home bias effect (Geranio & Lazzari, 2019).

[5] See Indepen (2018).

We rely on Refinitiv's measure of net debt, i.e. total debt minus cash and short-term investments. Equity is approximated by a stock's daily market value, i.e. share price multiplied by the number of ordinary shares in issue.

3.2 Betas from regulatory precedent

We use regulatory decisions as a source for the Betas of the comparator airports listed in **Table 8**.

Table 8: List of regulatory decisions on airport Betas

Airport	Decision / Source of Beta
Aeroporti di Roma	ENAC (2016), 2017-2021
Amsterdam Schiphol Airport	Own calculations based on public WACC elements from ACM's (2019) determination, 2019-2021
Dublin Airport	CAR, CP8/2019 (2019), 2020-2024
London Gatwick Airport	CAA (2014), Q6
London Heathrow Airport	CAA (2014), H6

Notes: The ACM has not published the Asset Beta it uses to determine Amsterdam Schiphol Airport's allowed cost of capital. We hence use other publicly available elements of the regulatory WACC from its 2019 Determination to approximate the Asset Beta.

Source: Swiss Economics.

4 Comparator Beta estimates

4.1 Raw Betas based on empirical market evidence

The methodology set out in Section 3 results in the empirical raw Beta estimates summarized in **Table 9**.

Table 9: Raw Betas, leverage, and tax rate

Airport	Raw Beta	Leverage	Tax rate
AENA Aeropuertos	0.61	42%	23%
Aéroports de Paris (Group)	0.57	28%	33%
Copenhagen Airport	0.47	17%	22%
Fraport (Frankfurt)	0.63	57%	29%
Zurich Airport	0.69	9%	21%

Notes: Raw Beta estimates are based on 5-year, weekly data from 18 December 2014 to 17 December 2019. Correspondingly, values for leverage and tax rate are based on 5-year averages. Leverage is defined as net debt to market capitalisation. The estimation of AENA's Beta is based on data starting in February 2015 since no earlier data are available.

Source: Swiss Economics.

4.2 Betas from regulatory precedent

The comparator Betas from regulatory precedent are reported in **Table 10**.

Table 10: Comparator Betas from regulatory precedent

Airport	Asset Beta	Decision / Source of Beta	Comment
Aeroporti di Roma	0.57	ENAC (2016), 2017-2021	ENAC uses the following methodology to determine Asset Beta for Aeroporti di Roma: ▪ Empirical Betas based on the following comparator airports: Copenhagen Airport, Fraport (Frankfurt), Aéroports de Paris (Group), Vienna Airport and Zurich Airport ▪ Euro Stoxx 600 index as proxy for the market portfolio ▪ Data ranges from 3 to 5 years ▪ De-levering based on Hamada-formula with debt from balance sheet and market value of equity ▪ Venice was eliminated as a comparator due to concerns of illiquidity
Amsterdam Schiphol Airport	0.43	Own calculations based on public WACC elements from ACM's (2019) determination, 2019-2021	We use publicly available elements of the regulatory WACC from ACM's 2019 Determination to approximate the Asset Beta. The following information is obtained from ACM's document: ▪ Gearing: 0.4 ▪ Risk-free rate: 0% (ACM states that a 10-year Dutch government bond is used, which is currently -0.17%) ▪ Debt premium: 3% (difference between the yield of a AAA bond and the risk-free rate) ▪ Debt Beta: 0.08125 ▪ Dutch tax rate: 25% Using these values and the WACC formula, we were able to calculate an Asset Beta for Amsterdam Schiphol.
Dublin Airport	0.50	CAR, CP8/2019 (2019), 2020-2024	CAR's estimated Beta is based on a weighted average of listed comparator airports' Betas (AENA Aeropuertos, Aéroports de Paris (Group), Auckland, Copenhagen, Fraport (Frankfurt), Sydney, TAV (Turkey), Vienna, Zurich) and Beta from regulatory precedent (Aeroporti di Roma, London Gatwick, London Heathrow). The following methodology was used: ▪ Average on 1-year/daily, 2-year/daily, and 5-year/weekly data ▪ STOXX Europe 600 index and national indices as proxy values for the market portfolio ▪ Hamada de-levering
London Gatwick Airport	0.56	CAA (2014), Q6	After the de-listing of London airports, the Asset Beta was split into a value for Gatwick airport and a value for Heathrow airport. For the following regulatory periods it has been tested whether the Asset Betas should be adjusted. The tests for the need for adjustments are mainly based on empirical estimates of comparator airports' Betas. National and international indices as well as various time horizons and frequencies are used.
London Heathrow Airport	0.50	CAA (2014), H6	After the de-listing of London airports, the Asset Beta was split into a value for Gatwick and a value for Heathrow airport. For the following regulatory periods it has been tested whether the Asset Betas should be adjusted. The tests for the need for adjustments are mainly based on empirical estimates of comparator airports' Betas. National and international indices as well as various time horizons and frequencies are used.

Notes: The ACM has not published the Asset Beta it uses to determine Amsterdam Schiphol Airport's allowed cost of capital. We use other publicly available elements of the regulatory WACC from its 2019 Determination to approximate the Asset Beta.

4.3 Comparator Asset Betas

Table 11 lists group membership, and total risk score for all comparator airports and reports the corresponding Asset Betas from empirical evidence and regulatory precedent.

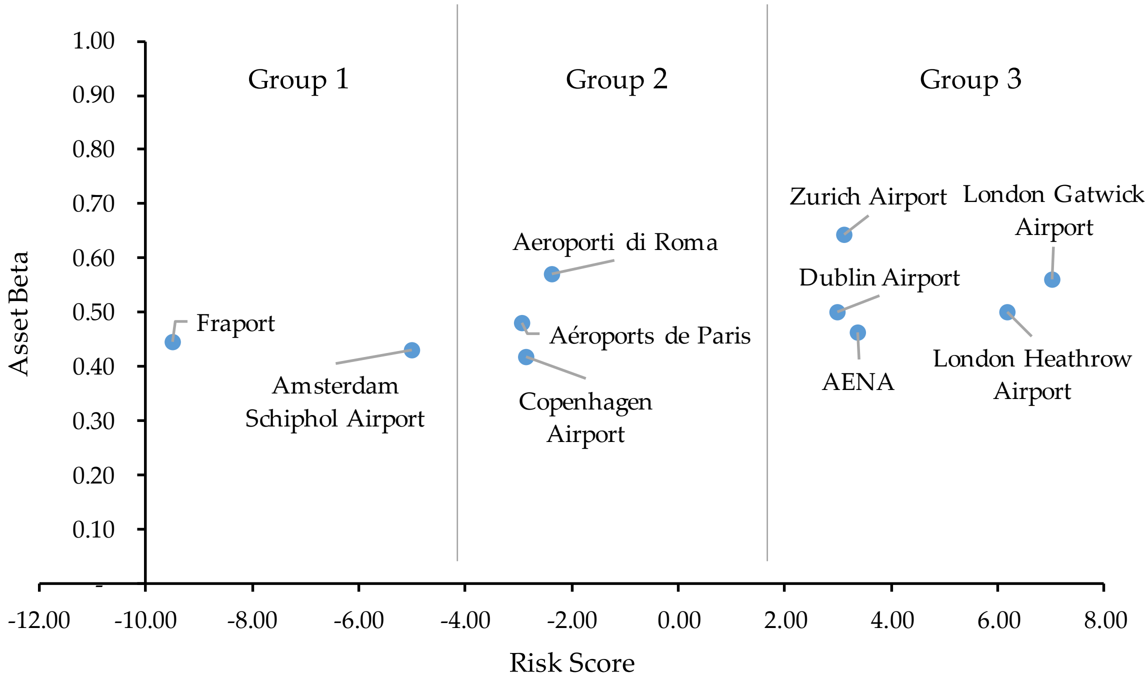
Table 11: Comparator airport Betas

Airport	Group Membership	Total Risk Score	Asset Beta estimate
AENA Aeropuertos	3	3.4	0.46
Aeroporti di Roma	2	-2.4	0.57
Aéroports de Paris (Group)	2	-2.9	0.48
Amsterdam Schiphol Airport	1	-5.0	0.43
Copenhagen Airport	2	-2.9	0.42
Dublin Airport	3	3.0	0.50
Fraport (Frankfurt)	1	-9.5	0.45
London Gatwick Airport	3	7.0	0.56
London Heathrow Airport	3	6.2	0.50
Zurich Airport	3	3.1	0.64

Notes: Asset Beta estimates are based on 5-year/weekly data, Hamada de-levering, and the indices discussed in Table 7.
Source: Swiss Economics.

Figure 1 shows the relationship between Asset Beta estimates and the Total Risk Score described in Swiss Economics (2020). As expected, there exists a positive correlation between Asset Betas and Total Risk Scores.

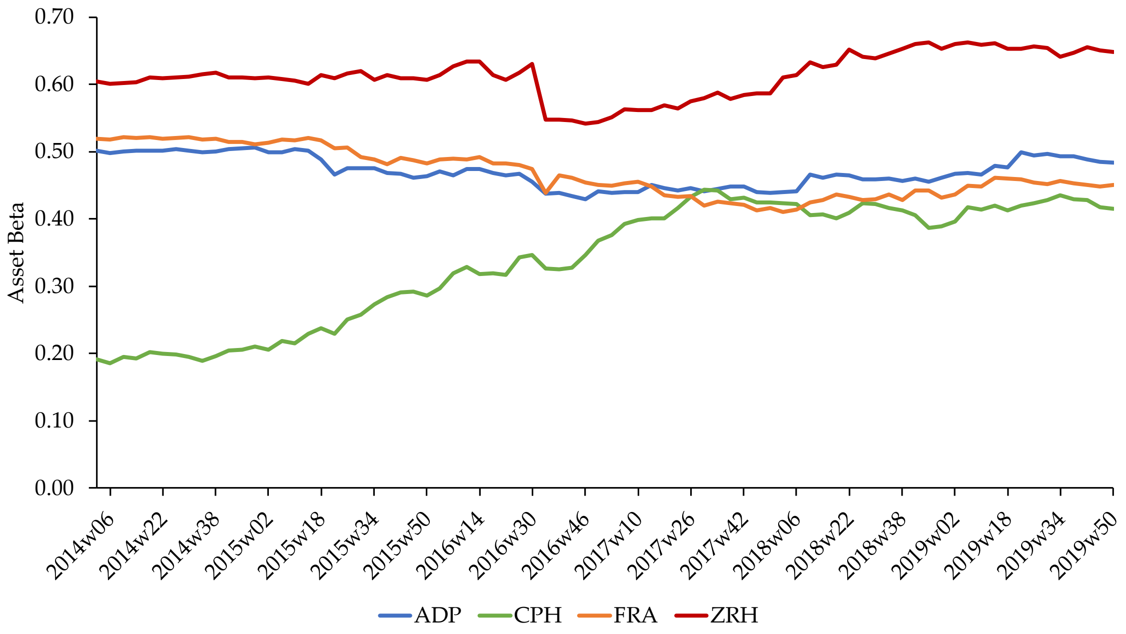
Figure 1: Risk Score vs Beta estimates



Notes: Asset Beta estimates are based on 5-year/weekly data, Hamada de-levering, and the indices discussed in Table 7.
Source: Swiss Economics.

Figure 2 displays 5-year rolling Asset Betas of the exchange-listed comparator airports. Apart from Copenhagen Airport, comparator airports' Asset Beta have remained rather stable over the time-horizon shown.

Figure 2: 5-year rolling Asset Betas for comparator airports



Notes: Asset Beta estimates are based on 5-year, weekly data. Correspondingly, values for leverage and tax rate are based on 5-year averages as well. Leverage is defined as net debt to market capitalisation. No rolling Betas are shown for AENA Aeropuertos since no stock data is available before 2015.

Source: Swiss Economics.

5 Group Results

Using the Beta estimates shown in Table 11 and applying the weighting matrix that is introduced in Section 2, we obtain Asset Beta point estimates of 0.44 for group 1, 0.49 for group 2, and 0.53 for group 3. The corresponding ranges are based on various sensitivity analyses we conducted. **Table 12** reports the Asset Beta estimates for the various risk groups.

Table 12: Group Asset Betas

Group	Asset Beta (point estimate)	Asset Beta (Range)
1	0.44	0.39 – 0.49
2	0.49	0.44 – 0.53
3	0.53	0.49 – 0.58

Source: Swiss Economics.

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A Sensitivity Analysis

A.1 Varying the estimation methodology

Table 13 shows the results of a sensitivity analysis comparing the estimated Betas with Betas estimated using MSCI national indices. MSCI national indices are constructed in order to cover approximately 85 percent of a country's free float-adjusted market capitalization. Again, total return indices are used.

Table 13: Sensitivity analysis regarding alternative indices

Airport	Asset Beta Wide national indices	Asset Beta MSCI national indices
AENA Aeropuertos	0.46	0.43
Aeroporti di Roma	0.57	0.57
Aéroports de Paris (Group)	0.48	0.48
Amsterdam Schiphol Airport	0.43	0.43
Copenhagen Airport	0.42	0.32
Dublin Airport	0.50	0.50
Fraport (Frankfurt)	0.45	0.43
London Gatwick Airport	0.56	0.56
London Heathrow Airport	0.50	0.50
Zurich Airport	0.64	0.67
Group 1	**0.44**	**0.43**
Group 2	**0.49**	**0.46**
Group 3	**0.53**	**0.53**

Notes: Asset Beta estimates are based on 5-year/weekly data and Hamada de-levering. Airport Asset Betas from regulatory decisions remain constant across the various methodologies.

Source: Swiss Economics based on Refinitiv data.

The results confirm the relative stability of the Beta estimates. Using MSCI indices only slightly decreases the Asset Beta for group 1 (from 0.44 to 0.43) and for group 2 (from 0.49 to 0.46). The Asset Beta for group 3 remains constant. MSCI national indices cover a smaller share of a country's market capitalization than the wide national indices we used and, hence, it is not recommended to use such indices for the estimation of Betas.

Due to the risk of reflecting liquidity constraints in Beta estimates, and due to the risk caused by short-term correlations that dissipate over longer periods (e.g. Brotherson et al., 2013), we do not recommend estimating Beta values exclusively on daily data. For weekly data, a time horizon of 5-years increases the sample size considerably compared with a 2-year or even 1-year time horizon. Time horizons of more than 5 years risk representing data variation which is no longer relevant and diluting the impact of recent risks which are more relevant for Beta values (e.g. Wright et al., 2018).

A.2 Additional robustness tests

A.2.1 GARCH

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 conduct sensitivity analyses using GARCH models. The GARCH models estimated here 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.

Table 14 represents the results of the sensitivity analysis. The difference between group Betas estimated by OLS and by GARCH is minimal.

Table 14: Sensitivity analysis regarding GARCH methodology

Airport	Asset Beta OLS	Asset Beta GARCH
AENA Aeropuertos	0.46	0.50
Aeroporti di Roma	0.57	0.57
Aéroports de Paris (Group)	0.48	0.49
Amsterdam Schiphol Airport	0.43	0.43
Copenhagen Airport	0.42	0.42
Dublin Airport	0.50	0.50
Fraport (Frankfurt)	0.45	0.44
London Gatwick Airport	0.56	0.56
London Heathrow Airport	0.50	0.50
Zurich Airport	0.64	0.65
Group 1	**0.44**	**0.43**
Group 2	**0.49**	**0.49**
Group 3	**0.53**	**0.54**

Notes: Asset Beta estimates are based on 5-year/weekly data, Hamada de-levering, and the indices discussed in Table 7. Airport Asset Betas from regulatory decisions remain constant across the various methodologies. Copenhagen airport Beta remains constant across the methodologies due to non-convergence of the GARCH model.

Source: Swiss Economics based on Refinitiv data.

A.2.2 Blume's and Vasicek's adjustments

A 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. The occurrence of reversion to the mean has been considered by Blume and others through the following formula:

$$\beta_{Blume\ adjusted} = \frac{2}{3} * \beta_{raw} + \frac{1}{3} * \beta_{market} \qquad (2)$$

where

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

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. A common formula of Vasicek's adjustment is the following:

$$\beta_{Vasicek\ adjusted} = \frac{\sigma^2[\beta_{raw}]}{\sigma^2[\beta_{market}] + \sigma^2[\beta_{raw}]} * \beta_{market} + \frac{\sigma^2[\beta_{market}]}{\sigma^2[\beta_{market}] + \sigma^2[\beta_{raw}]} * \beta_{raw} \tag{3}$$

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.

Contemporary empirical research however advises against the use of Beta adjustments (e.g. Echterling & Eierle, 2015).

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[6]. 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. However, this approach is certain to reduce the validity of Vasicek's adjustment.

[6] In addition, in a regulatory context, we deem it inappropriate to consider a reversion to 1. A reversion to the mean Beta of a regulated portfolio (lower than 1) would be more appropriate.

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