Dublin Airport Authority’s Cost of Capital

Report to the Commission for Aviation Regulation

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Executive Summary

1. *This Report estimates the cost of capital for the recently formed Dublin Airport Authority (DAA). To implement the weighted average cost of capital (WACC) approach to estimating DAA's cost of capital, it is necessary to estimate DAA's cost of equity, cost of debt and gearing ratio. The cost of equity is discussed in Section 2 of this Report, the cost of debt is discussed in Section 3, DAA's gearing is discussed in Section 4, and Section 5 brings these together in the WACC calculations to derive the estimate of DAA's cost of capital. Section 6 examines the sensitivity of the WACC estimate to changes in debt levels as a result of possible increases in capital expenditure, and to changes in business risk as reflected in higher asset betas.*
2. *The estimated value for the real risk-free rate is 2.6 percent. The estimated equity risk premium is 6.0 percent. DAA's asset beta is estimated at 0.61 and its equity beta is estimated at 1.1. The resulting estimate of DAA's real cost of equity is 9.2 percent.*
3. *With a real risk-free rate of interest at 2.6 percent, and an estimated debt premium of 1.1 percent, the resulting estimate of DAA's real cost of debt is 3.7 percent.*
4. *DAA's gearing is estimated at 46 percent. The corporate tax rate that applies is 12.5 percent. The resulting estimate of DAA's after-tax WACC is 6.4 percent, and the pre-tax WACC is 7.4 percent.*
5. *The main difference between this estimate and the 6.0 estimated WACC of ART calculated by Hutson and Kearney (2001) is due to a 20 percent higher estimate of the riskiness of DAA, reflected in the rise in the company's estimated asset beta from 0.51 to 0.61. This is due to several factors including the possibility that the Irish economy has become riskier relative to the UK, the fact that the creation of the DAA from ART and the foreshadowed separation of Cork and Shannon airports implies that DAA will eventually be less diversified than its predecessor ART, a greater degree of regulatory risk due to ongoing uncertainty about the timing of the construction and the operation of the new terminal at Dublin airport, and in the aftermath of 9/11 and the recent Asian influenza epidemic there is a greater perception of the possibility of downside shocks in the aviation sector.*
6. *Sensitivity analysis shows that each 0.1 rise in the assumed asset beta for DAA leads to an increase of 0.6 in the overall WACC.*
7. *Sensitivity analysis suggests that with a fixed debt premium, DAA's estimated WACC changes very little with increased gearing, because as the debt-to-assets ratio rises, the equity-to-assets ratio declines, and since equity is the more costly component of the WACC, the higher gearing is offset by a lower weighted cost of equity. When we allow the debt premium to rise by 0.1 (or 0.2) for every €25 million increase in debt, each €100 million extra debt raises the WACC by 0.2 (or 0.4).*

1. Introduction and overview

In the State Airports Act (2004), the government outlined its plans for the de-merging of Aer Rianta (ART) into three separate airports at Dublin, Cork and Shannon. The assets and liabilities of the former ART were transferred to the newly formed Dublin Airport Authority (DAA). After the Cork and Shannon appointed days, due to occur some time after May 2005, the Cork Airport Authority (CAA) and the Shannon Airport Authority (SAA) will manage and operate the assets at these airports. The Act specifies in Section 22 (page 23) that the Commission for Aviation Regulation (CAR) will make a determination specifying the maximum levels of airport charges that may be levied by DAA in respect of Dublin Airport.

The Act also specifies in Section 22 that in making its determination on maximum allowable charges at Dublin Airport, the CAR should have the following objectives.

1. To facilitate the efficient and economic development and operation of Dublin Airport, which meet the requirements of current and prospective users,
2. To protect the reasonable interests of current and prospective users of Dublin Airport, and
3. To enable DAA to operate and develop Dublin Airport in a sustainable and financially viable manner.

[State Airports Act (2004), section 22.4.c, p24].

The Act also instructs the CAR that in making its determination on maximum charges allowable at Dublin Airport, it should have regard to nine issues, including the costs or liabilities for which DAA is responsible. This is particularly relevant insofar as it is envisaged that DAA will be responsible for all of the former ART's liabilities. This raises significant issues for the level of gearing at the newly created DAA, which in turn has implications for DAA's cost of capital.

It is important for the long-term development of Dublin Airport that the DAA is able to earn a reasonable rate of return on its assets, sufficient to attract the necessary funds to maintain and develop its infrastructure. Given the uncertainty that attaches to any estimate of the DAA's 'true' cost of capital, it is preferable that the regulator sets a rate that is more likely to err on the high rather than the low side. This is particularly relevant to the DAA, to the extent that it is operating under current or envisaged future capacity constraints that require infrastructure investment. It is also relevant in light of objective 3 above.

This report builds on the work of Hutson and Kearney (2001), using the same methodology to estimate the WACC, updating all the estimates where appropriate, and reviewing recent contributions to the literature on the components of the WACC, and on policy decisions with regard to cost of capital calculations for regulated utilities. The WACC approach to cost of capital estimation involves estimating the company's cost of debt and cost of equity, and calculating a weighted average of the two relative to the contribution of each source of finance in the company's capital structure. To estimate DAA's cost of capital, it is therefore necessary to estimate its cost of equity, its cost of debt and its gearing ratio. The cost of equity is estimated in Section 2. The cost of debt is estimated in Section 3. DAA's gearing is discussed in Section 4. Section 5 brings these together in the WACC calculations to derive our estimate of DAA's cost of capital. Section 6 examines the sensitivity of the WACC estimate to changes in debt levels as a result of possible increases in capital expenditure, and to changes in business risk as reflected in higher asset betas.

2. <u>The cost of equity</u>

The most widely used model to measure the cost of equity is the capital asset pricing model (CAPM). (See CAA (2001) and Hutson and Kearney (2001) for an overview and its application to estimating the cost of equity for airports.) The CAPM is written in equation form as follows.

$$E(R_i) = r_f + \beta_i [E(R_m) - r_f] \tag{2.1}$$

Here,

$E(R_i)$ is the expected return on stock *i*;

r_f is the risk-free rate of interest;

$E(R_m)$ is the expected return on the market portfolio; and

β_i is the asset's 'beta', representing the systematic risk of stock *i*.

The CAPM measures the return on equity as the sum of the risk free rate, r_f, plus a premium for bearing risk, $\beta_i[E(R_m) - r_f]$. The risk premium is the quantity of risk multiplied by the price of risk. The quantity of risk is measured by the systematic risk of the stock as measured by β_i (the covariance of the stock's return with the return on the market), and the price of risk is measured by the equity risk premium, $[E(R_m) - r_f]$.

2.1 The risk-free rate of interest

The risk-free rate is a theoretical construct defined as the rate of interest that has no variance and no covariance with the market. It is usually proxied by the yield on default risk-free government securities such as treasury bills or bonds. Such nominal rates of interest include both a real and an expected inflation component. Because our task is to estimate DAA's real cost of capital, we need to estimate an appropriate real risk-free rate of interest.

The two components of the risk-free nominal rate of interest are described by the Fisher equation:

$$(1 + r_{nominal}) = (1 + r_{real})(1 + I_{expected}) \tag{2.2}$$

where r denotes the interest rate and I denotes the rate of inflation.

The easiest way to estimate the real risk-free rate of interest is by using the yield on inflation index-linked government bonds (ILGs). These are available for Britain for an extended period of time, as the British government has issued long-term index-linked gilts for many years. Over the 20-year period from 1985 to 2004, the average annual zero-coupon yield on British government 10-year index-linked gilts was 3.2 percent. These real yields have, however, declined over time; the average annual yield over the more recent 10-year period from 1995 to 2004 was a substantially lower 2.6 percent.

In their analysis of the risk free rate for DAA, NERA (2005) provide evidence of ILGs for Australia, for the eurozone area (France, Italy, Austria, and Greece), for the wider European area (Sweden and the UK), and for North America (Canada and the United States). The NERA (2005) approach is to obtain the data on the ILG yields from Bloomberg, and to argue that the most relevant ILGs are:

1. the French 30-year ILG issued in 1999, maturing in 2029, with a yield of 3.0 percent (first-tier evidence in Table 4.4, page 20),

2. the average of two Swedish 15-year ILGs issued in 1995 and 1999, maturing in 2020 and 2015, with yields of 3.4 and 3.2 percent, giving an average of 3.3 percent (Table 4.5 page 21), and the average of three 30-year Canadian ILGs (3.2 percent) and two 30-year United States ILGs (3.0 percent), (Table 4.6, page 22), giving an overall second-tier evidence of 3.2 percent (Table 4.8 page 22), and

3. the average of 7 nominal 30-year German government bonds, at 3.1 percent.

Summarising this evidence in Table 4.10 on page 25, NERA (2005) argue for a real risk free rate of 3.0 percent based on the first-tier eurozone evidence using the French 30-year ILG issued in 1999 and maturing in 2029 with a yield of 3.0 percent (point 1 above) with the second-tier and third-tier evidence backing up the first-tier evidence.

The NERA (2005) approach to estimating the risk free rate by focusing on ILGs is intuitive, but the analysis arrives at an estimated risk free rate on the basis of small and biased sampling of the range of ILGs that is presented. *First*, in their first-tier evidence, NERA focuses on the French 30-year ILG issued in 1999 and maturing in 2029 with a yield of 3.0 percent, without justifying why the exclusive focus should be on this particular ILG. Their Table B1 in Appendix B on page 73 lists a total of 13 eurozone ILGs (excluding Austria for which no yield is presented), for which the average yield is 2.0 percent. *Second*, the average yield of the 8 French ILGs presented in Table B1 is 2.1 percent; the 3.0 percent yield is a clear outlier at the upper end of these yields, and no case is made as to why this should be the representative yield. *Third*, NERA (2005) argues that the 9 UK ILGs are all biased downwards due to strong institutional demand resulting from the Bank of England's minimum funding requirements, and they exclude these from the analysis. It is interesting to note, however, that the average of the yields on the 8 UK ILGs is 2.0 percent, and it would be more intuitive to provide some estimate of the effects of the minimum funding requirement on depressing these yields rather than to simply exclude all the evidence. Such an approach would be consistent with NERA's (2005) argument in Appendix B on page 77 for including United States evidence although there might be once-off supply-side effects keeping yields low. *Fourth*, as with their analysis of the first-tier eurozone evidence, NERA's (2005) sampling of the North American evidence in Table 4.6 on page 22 is also selective, biasing the estimate upwards. Of a total of 20 quoted ILGs in Canada and the United States in Table B3 on page 76, they include only 5 ILGs in their table 4.6, and there is no rationale for this choice. It is clear, however, that they include only the ILGs that have a yield of 3.0 or better. This leads them to include three Canadian ILGs and only two United States ILGs in Table 4.6. This provides an upward bias to the North American evidence, because it overweights the importance of Canada relative to the much more significant United States. A more balanced approach would recognise that the average of the 16 quoted United States ILGs is 2.1 percent, and the average of the 20 Canadian and United States quotes is 2.3 percent. *Fifth*, the inclusion of the average of 7 nominal 30-year German government bonds at 3.1 percent as third-tier evidence is not consistent, because this is a nominal yield and cannot be used to estimate a real risk free rate unless the expected inflation component is subtracted.

In summary, therefore, the NERA (2005) analysis that focuses on ILGs as the best estimates of the risk free rate provides an upwardly biased estimate of 3.0 percent. When this sampling bias is removed, the ILG evidence of an estimated risk free rate is much closer to 2.0 percent. In our view, this would be too low an estimate of the risk free rate, and it explains why the most common approach to estimating the risk free rate in previous regulatory determinations has been to strip the expected inflation component out of the nominal interest rate in equation (2.2) above, rather than relying exclusively on ILGs. The average risk free rate used in five previous Irish determinations from 2000-2004 according to Table 4.1 in NERA (2005) is 2.6 percent, and the average of ten previous United Kingdom determinations from 2000-2004 according to Table 4.2 in NERA (2005) is 2.8 percent.

In analysing the issue of the most appropriate real risk-free rate, we discuss three issues:

- Which government-issued security and which maturity should be used?
- Should current rates or historical averages be used?
- How is the real rate adjusted for the inflation risk premium?

In addressing each of these points, we discuss the recent relevant literature and update the data used in Hutson and Kearney (2001) to estimate the nominal risk-free rate to the end of 2004.

2.1.1 Which government-issued security should be used?

We follow the procedure used in our previous report by using the German government bond rate as a proxy for the nominal risk-free rate. The disadvantage of using a German government bond is that, unlike in the UK, Germany has no government index-linked bonds on issue. The reasons for this choice are still pertinent. It is preferred to a British rate because of Ireland's membership of the eurozone and the UK's absence from it, and it is also preferred to an Irish government rate because many Irish companies and utilities source their financing in the euro-denominated public debt markets. As in Hutson and Kearney (2001), we use the 10-year German bond yield as the appropriate proxy for the nominal risk-free rate. Empirical studies of the cost of equity show that longer-term rates of interest fit the theory better, because longer-term rates are less volatile and less influenced by changes to rates by monetary authorities, and because longer-term rates better match real investment horizons. This is particularly true for estimating the cost of capital for airport infrastructure.

Having determined that this is the most appropriate proxy for the nominal risk-free rate, we must now decide whether current yields should be used or some long-term average. The choice of whether to use current rates or to calculate some historical average is a difficult one, and debate about this is ongoing. The CAA (2001) provides a summary discussion (see paragraphs 2.1-2.4) of the issues and regulatory practices in the UK. Hutson and Kearney (2001) also provides more details. This question is at present particularly pertinent because current long-term (and short-term) interest rates are significantly lower than their long-term historical averages.

2.1.2 Nominal interest rates, inflation, and the real rate of interest

Figure 1 plots nominal interest rates, inflation, and real interest rates in Germany, the UK and the US, from June 1986 to December 2004. The data was obtained from Datastream, and includes the nominal benchmark 10-year bond rates and the consumer price inflation rate for each country. The top and middle parts of the figure show nominal rates and ex-post inflation, while the lower part, labelled *real rates of interest*, is calculated as the nominal rate minus the ex-post inflation rate. The figure is an updated version of Figure 1 from Hutson and Kearney (2001), extending the data by over 3½ years to December 2004.

It is clear that nominal yields on the three countries' government bonds tend to move together. There is considerable variation over time, but a distinct downward trend is visible, from an average of 8–9 percent in the mid-to-late 1980s to between 3½ and 5 percent at the end of 2004. On average, the 10-year benchmark rate was highest in the UK at 7.5 percent. Germany had the lowest rate with just over 6 percent on average, and the US average fell in between with 6.6 percent. It is also clear from the figure that there has been convergence between UK and German 10-year benchmark rates over the period.

The middle graph in Figure 1 depicts the rate of inflation as measured by each country's CPI for the same period. Germany experienced the lowest rate of inflation at just over 1.5 percent on average for the period. UK inflation was more than double this rate – 3.65 percent – and US inflation was on average 3 percent. The reduction in worldwide inflation since the 1980s is clear in the figure. It is also apparent that the co-movement between the three countries' rates of inflation is lower than the co-movement in nominal interest rates, flagging the possibility of very different ex-post real rates of interest.

The lower part of the figure depicts the real rate of interest for each country, in which the inflation rates have been subtracted from the nominal 10-year benchmark yields. These series show considerable variation over time, from around 6 percent at the start of the period in June 1986 to between 0.5 and 2 percent at the end of 2004. This demonstrates that it is probably the best approach to take a long-term average rather than to use current rates. A long-term average is also preferred because real interest rates are at historic lows at present. Further, it is clear from the volatility apparent in the figure that some sort of average is necessary to smooth out short-term fluctuations.

The ex-post real rates of interest calculated here must be interpreted with care. Implied in the current bond yield is the market's estimate of annual inflation over the next 10 years, rather than current inflation rates. The unusually low ex-post real rates of interest at present may therefore reflect the market's assessment that inflation will actually be lower than current inflation in the future. Alternatively, it has been widely discussed in the markets and in the financial press that the current (unusually low) long-term bond yields reflect a very high level of demand for higher yielding securities, because of minuscule yields on short-term deposits and treasury securities. Since the very low levels of nominal interest rates in the early 2000s (particularly in the US, where short-term real rates of interest were negative), demand has shifted further up the benchmark yield curve, and to riskier securities such as high-yield bonds. The result of this is unusually high prices, low yields and relatively small risk premiums for the longer-dated and higher default risk securities.

2.1.3 Previous estimates of the real risk-free rate

Table 1 summarises the findings of recent studies. It is an update of Table 1 in Hutson and Kearney (2001), and includes the findings from the recent study by Dimson, Marsh and Staunton (2002). It presents estimates of the risk-free rate of interest defined over various time periods. The entries under '16 years' are our estimates of the real risk-free rate using 10-year government bond data from the period June 1988 – December 2004 (the calculation is presented in more detail in Table 2 and further discussed in section 2.1.4 below. The entries under '75 years' and under '100 years or more' include long-term estimates using either bills or bonds. It is well known that using bills rather than bonds as the benchmark tends to provide lower estimates of the real risk-free rate. The estimates from long time-series based on bonds include those of Annin and Falaschetti (1998) and Ibbotson and Chen (2001) for the US, and Jenkinson (1999), CSFB (2001) and LBS/ABN Amro (2001) for the UK.

Dimson, Marsh and Staunton's (2002) estimates for Germany, the UK and the US appear in the bottom two rows of the table. This study, published as a book, is extremely comprehensive, and as well as interest rates, examines many other economic issues (such as the equity risk premium) for 17 countries over the period 1900-2000. Their estimates of the real risk-free rate using bills are 0.1, 1.0 and 1.2 percent; and using bonds the estimates are 0.3, 2.3 and 2.1 percent for respectively Germany, the US and the UK. The study also includes data for Ireland, for which real bill and bond returns are 1.4 and 2.4 percent respectively. These considerably higher rates for Ireland probably reflect higher country risk.

2.1.4 Adjusting for the inflation risk premium

While the rates of return on OECD government securities are generally assumed to be default risk-free, they are not free of price risk. This is because actual (ex-post) inflation will seldom equal expected inflation, and investors will be concerned that ex-post inflation may turn out to be more than the anticipated inflation that is reflected in yields, in which case their real return will be eroded. The inflation risk premium is the additional yield required by investors to compensate them for the probability that ex-post inflation is greater than the expected rate impounded in the yield when they purchased the security. Expected inflation can be viewed as a random variable that follows some underlying distribution, and the longer the maturity of the instrument, the greater the dispersion of the distribution. It is intuitive, therefore, that long-term bonds should be associated with a larger inflation prediction premium than short-term bonds or bills.

Table 2 provides the background information for the calculation of the real risk-free interest rate estimates labelled Hutson and Kearney (2005) in Table 1. It tabulates the average nominal 10-year bond interest rates, inflation and real rates for Germany, the UK and the US for the period June 1988 – December, 2004 that are depicted in Figure 1. These figures are presented in the first 3 rows of the table. The fourth row – headed 'the estimated real risk-free rate' deducts our estimate of inflation risk.

In our previous report, we deducted an inflation risk premium from our calculated real risk-free rates of 40 percent. This estimate came from Breedon and Chadha (1997), who came up with this figure for UK interest rates. Dimson, Marsh and Staunton (2002) provide estimates of the inflation risk premiums (they call it 'bond maturity premia') for the 17 countries in their study. The premia are 0.2 percent, 0.9 percent and 1.0 percent for respectively Germany, the UK and the US, and their estimate for Ireland is 0.8 percent. As a proportion of the estimated real risk-free rates derived from bond returns, the inflation risk premiums as calculated by Dimson, Marsh and Staunton (2002) are 67 percent, 39 percent and 48 percent for respectively Germany, the UK and the US, and for Ireland it is 33 percent. Their estimate for the UK at 39 percent is remarkably close to that of Breedon and Chadha (1997) at 40 percent. For this reason we continue to use 40 percent as the inflation risk premium.

Comparing Table 1 (which summarises previous estimates of the real risk-free rate of interest over the very long-term) to Table 2 (which summarises our estimates of the real risk-free rate during the period 1984-2001) shows that our estimates (2.4 percent for Germany, 2.3 percent for the UK, 2.2 percent for the US, and an average of 2.3 percent for all three countries) are considerably higher than the long-term estimates from Table 1. Taking all this into consideration, our recommendation is to leave the estimate of the real risk-free rate at the 2.6 percent we used in Hutson and Kearney (2001). Given the subjective nature of estimating the real risk-free rate of interest, we will err on the high side of the large range of possible estimates discussed above. This figure is the average of previous Irish determinations, and it is within the range of between 2.5 and 2.75 used by the Competition Commission (2002) to estimate the cost of capital for BAA.

2.2 The equity risk premium

The equity risk premium is the return that investors require to induce them to purchase and hold equity rather than risk-free bonds. Given that the CAPM is an expectational model, the equity risk premium is a forward-looking variable that reflects the expectations of investors' future requirements. As such, it cannot be directly observed, and there is continuing research into the determinants of the equity risk premium, how best to estimate it, and what measure is most appropriate for the regulation of public utilities. Kocherlakota

(1996) and Siegel and Thaler (1997) provide reviews of this literature. Given the complexities involved in estimating the equity risk premium, we extrapolate from the most reliable and comprehensive studies to estimate the equity risk premium for the cost of equity figure. Six percent has become the norm for an estimate of the equity risk premium – in academic circles, in the financial services industry, and in regulatory rulings. More recently, researchers have argued that this may be too high; this is discussed in section 2.2.2 below.

2.2.1 The preferred estimation method

The equity risk premium can be estimated in three ways. The *first* method uses historical time series data to calculate the difference between the long-run return on a stock market index, and the long-run return on risk-free bills or bonds. The *second* method uses models that incorporate fundamental information such as earnings, dividends or economic productivity (see, for example, Diermeier, Ibbotson and Siegel (1984), Shiller (2000) and Fama and French (2001)). The *third* method uses surveys of the views of professional financial analysts (see, for example, Welch (2000) and NERA (2001)). In this report, we use the first method, which is the most common approach. The second method, as discussed in Hutson and Kearney (2001), is complex and often difficult to implement in practice. The estimates of the equity risk premium coming out of such studies, however, tend to be lower than market-based studies. Claus and Thomas (2001), for example, estimated the discount rate that equated US stock market valuations with the present value of prevailing forecasts of cash flows, and found that the equity premium may be as low as 3 percent. The third approach – surveying analysts – was derided by Dimson, Marsh and Staunton (2002) for being highly biased to fads and trends. Investor surveys, they argue,

> *"mostly …. provide a source of amusement rather than useful information. Private investors' opinions appear to reflect what has happened in the recent past, or even sheer fantasy. Professional money managers seem (at best) to provide answers that reproduce, with some noise, the evidence from long-run historical studies. That approach is unlikely to inform us about the market's expectations."*
>
> [Dimson, Marsh and Staunton (2002), p179].

It is widely accepted that expected equity returns are best approximated by actual (ex-post) equity returns over very long periods of time. Equity markets are well known to move in a cyclical fashion, and to lead the business cycle. Long periods of bull market conditions are common, and are often followed by bear market conditions. Care must be taken to include data from both types of periods. For example, data drawn from a bear market only could result in a negative equity premium, while data from only a bull market will produce overestimates of the equity risk premium.

Figure 2 depicts the levels, percentage returns and standard deviations for the stock markets in Germany, the UK and the US over the period from 1986 to the end of 2004. From the first graph in the series, which depicts the stock market levels (with all three indexes re-stated so that they equal 100 at the start of the series) it is clear that although the markets diverge in the short-term, all three stock markets tend to move together over time. This graph also shows the strong upward trend during the 1990s, the stock market 'bust' from early-mid 2000, and the partial recovery in recent months. The second graph in Figure 2 depicts the returns over the period. This graph gives some indication of varying volatility;

particularly apparent is the heightened volatility associated with the post-2000 bear market. The third graph is the 5-year rolling standard deviation, which shows the increase in volatility during the late 1990s (particularly evident for Germany post-2000), which persisted until quite recently when volatility appears to have fallen off.

2.2.2 Estimates from academic and practitioner studies

Table 3 summarises the estimates of the equity risk premium from a selection of previous studies. The table is an updated version of Table 3 in Hutson and Kearney (2001). It presents the studies by time horizon of the data used, starting with our estimate over 19 years, followed by studies with at least 75 years of data, and concluding with those studies using 100 or more data years. The figures using 19 years of data from 1986 to 2004 in the first row of the table demonstrate the danger of using short horizon data for estimating the equity risk premium. This period includes the stock market crash of 1987, the bull market of the late 1990s, and the sustained bear market of the early 2000s. The estimated equity risk premium is negative (-1 percent) for Germany, and 5.1 percent for the US. The UK lies in between at 1.8 percent. The very low premium for Germany probably reflects its stock market's poor performance since early 2000 that is clearly visible in Figure 2, and the fact that it underperformed both the UK and US markets throughout the period. The relatively high premium calculated for the US reflects its superior performance. During the bear years of the early 2000s, the decline in the stock market index would have been offset to some extent by the unusually low rates of interest.

Dimson, Marsh and Staunton's (2002) estimates are the most recent, and in many ways the most rigorous to date. These researchers have produced the definitive work on estimating the equity risk premium, using data for 16 countries for the period 1900-2001. They claim that looking at 16 markets around the world – as opposed to the common approach that tends to use only well-established markets such as the US and the UK as benchmarks – addresses the serious problem of survivorship bias. Ignoring other markets that have been less successful or have weathered more economic volatility than others, they argue, leads to the overestimation of the equity risk premium.

By extending the data set back to 1900, in some cases requiring the hand collection of data from archives, Dimson, Marsh and Staunton (2002) also claim to overcome so-called 'easy data' bias, which

> *"… arises from researchers' preference for data that are not obfuscated by 'unusual' events such as war or government default, are based on good quality price and income information, do not suffer from trading halts, and are produced on a continuing basis. Easy data preferences explain why (until the publication of the research for this book) the standard publication on long-term stock market returns in the UK started at the end of 1918, in the Netherlands in 1947, in Germany in 1952, and in Japan in 1971."*
>
> [Dimson, Marsh and Staunton (2002), p142].

That being said, because they find that the US and the UK fall in the middle of the distribution of equity risk premium estimates, this mitigates their potential survivorship bias to some extent. Another common bias that Dimson, Marsh and Staunton (2002) attempt to overcome is 'success bias' in stock market indices. Stock market indices – particularly those with a small number of constituent stocks such as the Dow Jones in the US – are subject to success bias because the stocks are retained in the index only if they are a certain size by market capitalisation. They attempt to overcome success bias by ensuring that their indices are compiled from a very large number of underlying stocks.

Dimson, Marsh and Staunton (2002) make two equity risk premium calculations: one relative to bills as the risk-free rate, than then relative to long-term government bonds. The equity premiums for Germany, the UK, the US and their world index appear in the last two rows of Table 3. The figures for the equity risk premium are greater when measured relative to bills relative to bonds because of the higher yield on bonds vis-à-vis bills. Although Dimson, Marsh and Staunton (2002) argue in a subsequent chapter that the equity risk premium may currently be lower than their historical estimates, mainly because price variability has fallen over time and the required risk premium has declined, we argue that their market-based estimates provide an appropriate ball-park for the equity risk premium to be used in estimating DAA's cost of equity.

Our assessment of the recent evidence suggests that the appropriate figure for the equity risk premium remains at 6.0 percent.

2.3 Beta

In order to estimate the equity beta (β) of a stock, we need to obtain historical returns data for the stock and for the overall market, and estimate the following time series regression:

$$R_{i,t} = \alpha_i + \beta_i R_{m,t} + \varepsilon_i \tag{2.3}$$

where $R_{i,t}$ is the return on stock *i* at time period *t*, and
$R_{m,t}$ is the return on the overall market at time period *t*.

The slope of the resulting regression line is the stock's beta. This slope has the expression

$$\beta_i = \frac{cov(R_i, R_m)}{var(R_m)} \tag{2.4}$$

In this report, we follow our prior approach in estimating rolling 5-year regressions on monthly data, using the BAA as the comparator airport, and using the FTSE 100 index to estimate BAA's beta. Unlike in our previous report, we have not used the Dow Jones European index in our calculations, because this index continues to demonstrate significantly lower estimates of beta than are obtained using the FTSE 100 index, and we are keen to err on the higher rather than the lower side of estimating the WACC.

As before, using BAA as the appropriate comparator company for estimating DAA's equity beta requires us to follow three steps.

1. The estimated equity beta for BAA is 'de-geared', producing an *asset beta*, which is the beta for an equivalent company that has no debt in its capital structure.

2. The asset beta for BAA is adjusted for any differences in business risk between BAA and the unlisted company, in this case DAA. This produces an estimate of the asset beta for DAA.

3. DAA's asset beta is 're-geared' according to DAA's capital structure. This produces an estimate of DAA's equity beta, which is used in the CAPM estimate of the required return on equity.

The estimation of risk for any firm is fraught with difficulty, and this is particularly true for the airport sector at present. Before implementing the beta estimation procedure described above, we address the critical issue of changing risks in this sector.

2.3.1 The risk and distributional characteristics of airport stocks

Some economists and commentators have argued that the airport business has become riskier over time, with catastrophic events such as the terrorist attacks of 9/11 and the possibility of future global pandemics such as an influenza outbreak. Using the stock prices and returns to 5 comparator quoted airport companies, we examine two related issues. *First*, has the airport business become riskier over time, particularly in the wake of 9/11? *Second*, has the possibility of large negative shocks led to asymmetric risk; that is, do airport stocks experience large negative return realisations resulting in significant negative skewness? If so, it would be appropriate that the cost of equity is increased to reflect this additional risk, as skewness is not taken into account in traditional risk measures (including beta).

We examine the price volatility and the distributional properties of daily returns to five quoted airport companies: Auckland, BAA, Florence, Frankfurt and Vienna. These airports were floated on the stock market at different times, so the data periods vary considerably. The data for Auckland begins on 28th July 1998. For BAA it is 5th July 1988; for Florence the data period begins 11th July 2000; for Frankfurt airport the start date is 11th June 2001; and data is available for Vienna airport from 15th June 1992.

Summary statistics for the daily returns to these five airport stocks are presented in Table 4. Panel A provides summary statistics for the entire sample period, and Panel B provides summary statistics from 11th June 2001 to 31st December 2004, which is the period for which data are available for all 5 airport stocks. (This coincides with the data availability for the airport with the least available data, which is Frankfurt. The statistics in Panels A and B are therefore the same for Frankfurt.) The mean returns obviously vary from one airport to another, with both Florence and Frankfurt exhibiting negative mean returns for the full period. The riskiness of the airports varies considerably, with Florence and Frankfurt displaying the greatest standard deviations, while Auckland, BAA and Vienna exhibit lower levels of volatility.

Figure 3 plots the quoted stock prices over the period from the start of the most recent flotation, which was Frankfurt Airport, from 16th June 2001, to 31st December, 2004. This period also encompasses the large declines associated with the 9/11 attacks in September 2001, and these are clearly visible in the diagram. Although the 9/11 attacks are visible, however, it is interesting to note that in all cases, except for Florence and Frankfurt (which are the two airports with overall negative mean returns) the stock price had recovered to their pre-9/11 values within about 8 months.

The largest daily percentage decline in price for each stock was 12.25 percent for Auckland, 19.21 percent for BAA, 25.60 percent for Florence, 15.04 percent for Frankfurt, and 16.24 percent for Vienna. It is interesting to compare the largest declines for the full period versus the abbreviated period of Panel B. While the largest decline for Auckland was as a result of 9/11, this is not the case for BAA, Florence and Vienna, whose largest declines occurred before 9/11. In the case of BAA, its largest decline of 19.21 percent exceeds the one-day decline on 9/11 of 17.94 percent. The largest decline for Florence airport, at 25.60 percent, is almost double the decline associated with 9/11 of 12.88 percent. The same applies to the Vienna airport, for which the largest decline of 16.24 percent, exceeds the decline associated with 9/11 of 8.83 percent.

Figure 4 presents the standard deviations for the 5 airport stocks from 16th July 2001 to 31st December, 2004, based on rolling 25-day windows. It is clear from this figure that both Florence and Frankfurt exhibit the greatest volatility, and this is consistent with the standard deviations presented in Table 4. The figure shows that the second moments of the distributions of airport stock prices exhibit strong tendencies for the volatilities to be time-varying. Also apparent is a decline in volatility since the shock of 9/11. Given that we have a much longer time series data set for two of the comparator airports; namely BAA and Vienna, Figure 5 plots the same rolling standard deviations for these two airports for at least 10 years before the 9/11 terrorist attacks. This figure shows that, in the case of BAA, the late 1990s and early 2000s were a period of high volatility, and that this volatility has reverted to historical norms in the past couple of years. In the case of Vienna airport, no such trend emerged during the late 1990s and early 2000s.

Overall, therefore, our analysis suggests that the airport business suffered a significant decline in stock price in the wake of the 9/11 terrorist attacks; that this was accompanied by a temporary increase in volatility and hence perceived risk; that the effect of 9/11 was not the biggest downside shock to have happened to the airport stocks in most cases; and that prices recovered fairly quickly and volatilities have reverted to their historical averages. This tends to suggest that the 9/11 terrorist attacks have neither caused nor are particularly symptomatic of the existence of asymmetric risk associated with large negative shocks. This is a potentially interesting finding, because it begs the question concerning the perceived negative skewness of equity markets in general, and the airport business in particular.

It is apparent from Table 4 that the skewness statistics, although significant at standard levels, are rather small, and certainly not all negative. Those that show negative skewness have skewness statistics not smaller than -3, and Florence and Frankfurt airports show positive skewness. As pointed out by Peiró (1999, 2002) and Kearney and Lynch (2004), however, the standard skewness statistic – that is, the third moment of the return distribution – can lead to erroneous inferences about the true nature of the underlying distribution. In addition, Kim and White (2004) demonstrate that the skewness statistic can be highly misleading in the presence of a single outlier.

Figure 6 presents an analysis of the distributions of stock returns for the 5 airports. The figure depicts the number of observations in the tails of the distributions, defined as beyond 2 standard deviations either side of the mean. The tails are further divided into the following intervals: 2 to 2½, 2½ to 3, 3 to 3 ½, 3½ to 4, 4 to 5, 5 to 6, and greater than 6 standard deviations from the mean. The evidence here is clear. There is virtually no case in which the tails exhibit more negative rather than positive returns relative to the mean. It seems that neither the terrorist attacks of 9/11, nor other large negative shocks have induced negative skewness in the tails of the distribution of airport stock returns. Rather, these events seem to be incorporated within the data in an unremarkable way that is consistent with the overall distributional patterns of returns.

2.3.2 BAA's historical equity beta

Figure 7 presents rolling beta values estimated for BAA using ordinary least squares (OLS) regression, with data updated to December 2004. The estimate of beta clearly varies over time, demonstrating the importance of taking care with its estimation. BAA's beta declined dramatically from around 1 in 1997 to approximately 0.4 at the end of 2001, using the *FTSE 100* index as a proxy for the overall market. This is consistent with the trend of declining betas more generally across regulated utilities in the UK during the late 1990s and early 2000s. The Utilities Journal (2002) points to this trend, and suggests that it could partly result from the world's declining stock markets together with greater equity market volatility during this period, which would account for the low correlations between the returns to utilities and the overall market returns.

Our estimate of BAA's beta in Hutson and Kearney (2001) was clearly made at a low point for BAA's systematic risk, and the Figure shows that BAA's beta has since risen from a low of 0.4 in August 2001 to 0.7 in December 2004. The average of BAA's monthly rolling equity betas is 0.57 for the most recent 5-year period from January 2000 to January 2004, and it is 0.74 for the full period from September 1988 to December 2004. Although the more recently calculated betas are below the long term average, they seem to be rising, and we consequently recommend use of the higher long term average of 0.74. This is very similar to the beta of 0.73 recommended in Hutson and Kearney (2001), which was partly based on the premise that the calculated beta in 2001 might well rise over time, and this has been shown to be the case.

2.3.3 BAA's asset beta

Having estimated BAA's equity beta, we follow the procedure in Hutson and Kearney (2001) to 'de-gear' it in order to produce an *asset beta*, which is the beta for an equivalent company that has no debt in its capital structure. The established approach to de-gearing an equity beta to obtain an asset beta from equation (2.5),

$$\beta_{asset} = \frac{\beta_{equity}}{1+(1-T_c)\frac{D}{E}} \quad (2.5)$$

where T_c is the corporate tax rate, D is the company's total debt and E is the company's total equity. (See Copeland and Weston (1988) for a derivation of equation 2.5.) This equation defines the equity beta as the asset beta adjusted for gearing as defined by the debt-to-equity ratio adjusted for the tax benefit of debt. The British corporate tax rate is 30 percent. The debt-to-equity ratios for BAA and DAA appear in Table 5 and are discussed further in section 4 of this report. Applying these to (2.5) gives the following.

$$\beta_{asset\ (BAA)} = 0.74/(1+(1-.30)0.67) = 0.51 \quad (2.6)$$

Our recommended asset beta for BAA is 0.51. This is very close to the asset beta of 0.50 calculated for BAA in Hutson and Kearney (2001)

2.3.4 DAA's asset beta

In Hutson and Kearney (2001), ART's operational and business risks were assessed as insufficiently different from BAA's to warrant significant adjustment to BAA's asset beta. Both operated in a strong competitive position in their respective markets, had similar passenger profiles, and were committed to major capital expenditure projects in the short to medium term. These similarities remain; and in addition the two companies have a high proportion of non-aeronautical revenues, part ownership of other airports, and extensive interests in duty free.

In commenting on uncertainties in the process of estimating the cost of capital for BAA, the Competition Commission (2002) makes the following point in paragraph 4.40:

> *'Inputs to the CAPM are continually changing, not only as a result of movements in financial markets, but also as a result of continuing work by financial and academic analysts on new data and on the reinterpretation of existing data. In addition, there can be considerable uncertainty over the appropriate level for some inputs, and a degree of judgment is therefore required. This can result in changes over time to the WACC of an individual company and, in the case of airport companies, from one quinquennial review to another.'*
> [Competition commission (2002), p. 171]

The issue of DAA's business risk is critical to the estimation of it cost of equity, and hence its WACC. In examining the current and medium-term risk of the DAA, we believe it is approximately 20 percent more risky than BAA. Both ART and BAA were similarly rated in 2001. Since then, however, the former ART was downgraded in July 2003 by Standard and Poor's from A+/Stable/A-1 to A/negative/A-1. As BAA is currently A+/Stable/A-1+, DAA now has a lower credit rating than BAA.

This additional risk reflects a number of possible explanatory factors. *First*, DAA is probably more susceptible to shocks in the Irish economy than is BAA to shocks in the British economy, and DAA is also likely to be sensitive to shocks in the British economy. Moreover, the Irish economy itself is generally understood to be riskier than the British economy. This, however, is difficult to measure, because many of the multinational companies located in Ireland are not listed on the Irish stock market. Comparing the Irish stock market to the British stock market, therefore, does not give an accurate reflection of the relative riskiness of the two economies. *Second*, in the aftermath of 9/11 and the recent Asian influenza epidemic, there is a greater perceived possibility of downside shocks in the aviation sector. Although our analysis in section 2.3.1 demonstrated that there does not appear to be unusually negative skewness in the historical distribution of airport stock returns, it is possible that such global shocks to the travel and aviation business may have a greater effect in the future. *Third*, although the government has recently announced that DAA will build the second terminal at Dublin Airport and that it will be operational by 2009, there remains a degree of uncertainty about the timing of the completion due to the possibility of legal challenge, and about who will operate it when the construction is completed. *Fourth*, creation of the DAA from ART and the foreshadowed separation of Cork and Shannon airports implies that DAA will eventually be less diversified than its predecessor ART.

Our recommended asset beta for DAA is consequently a 20 percent increase (from 0.51 to 0.61) on the calculation applied in Hutson and Kearney (2001).

We note that the estimate supplied by NERA (2005) for DAA's asset beta is 0.7. This estimate, however, results from two adjustments that have the effect of scaling up the estimate. *First*, NERA (2005) exclude the data from February 1999 – February 2002 in calculating their equity betas. On page 51, they argue that during this period, BAA's equity price 'decoupled' from the market price due to a number of events including the abolition of intra-EU duty free, the uncertainty due to forthcoming regulatory review, and events (including, presumabely 9/11) that made BAA more susceptible to world events. It is clear from Table D1 on page 79 that excluding this period has the effect of raising the estimate of BAA's equity beta by 0.9 percent, from 0.76 percent to 0.85 percent for the 10-year rolling estimate. As this Table, and Table 5.6 on page 51 also show, this has the effect of scaling up the estimate of BAA's asset beta by 0.07 percent, from 0.55 percent to 0.62 percent. *Second*, NERA (2005) scale up their estimated equity beta by an 'ad hoc' factor of two thirds the estimated value and one third of unity (see equation (5.2) on page 28. This is to allow for the tendency for betas to move towards unity over time.

We do not agree with these adjustments. The first adjustment amounts to data-mining, because it excludes the period of time when BAA's equity beta was at its lowest over the available period. Beta is supposed to measure the riskiness of a company relative to the market over time, and this will move up and down depending on a number of factors that influence the risk behaviour of the company and the market. We do not accept the legitimacy of NERA's (2005) 'decoupling' argument for excluding this period. Rather, this period is representative of the risks faced by the company and the market, and should be included in the dataset from which an average value of beta is estimated.

The second adjustment is redundant because the estimates of beta have been updated using the most recently available data. To include this adjustment would therefore amount to a kind of double counting that has the effect of biasing upwards the estimate of beta. In Table D1 on page 79, NERA (2005) provide their preferred estimate of the equity beta for BAA of 0.85, and the footnote to the Table indicates that this includes the adjustment in equation (5.2) on page 28. We can calculate the NERA (2005) estimate of BAA's equity beta without this adjustment by solving equation (5.2) for the raw equity beta, and it is equal to 0.78. This adjustment, therefore, also scales up NERA's (2005) estimate of BAA's equity beta by 0.07 percent.

The two adjustments combined add approximately 0.14 percent to NERA's (2005) estimate of BAA's equity beta. If this amount is subtracted, the NERA (2005) estimate of BAA's equity beta would be 0.71 rather than 0.85. Our preferred estimate is 0.74, which is below NERA's (2005) preferred estimate of 0.85, but which can be interpreted as including a proportion of the NERA (2005) adjustments.

2.3.5 DAA's equity beta

In order to determine DAA's equity beta from its asset beta, we need the appropriate corporate tax rate. The tax rate for Ireland is 12.5 percent. This is different from the average tax rate that existed at the time of the prior determination in 2001, which averaged 13.2 percent over the 5-year period. The debt-to-assets ratio for DAA is calculated in Table 5 as 0.46, and the debt-to-equity ratio is 0.86. The resulting update for DAA's equity beta is

$$\beta_{equity} = \beta_{asset}\left(1 + (1 - T_c)\frac{D}{E}\right) \tag{2.7}$$

$$\beta_{equity} = 0.61(1+(1-.125).86) = 1.1$$

Our recommended equity beta for DAA is consequently 1.1. This is an 18 percent increase on the value of 0.93 calculated previously for ART, and reflects the combination of the 20 percent rise in the asset beta, offset by a small change to DAA's gearing and a slight reduction in Ireland's corporate tax rate.

[3] The cost of debt

While the cost of equity is not observable and must be estimated by some economic model, the cost of debt for most companies is readily available. If the company in question has outstanding debt, its real cost of debt can be measured as the risk free rate plus the debt premium, the latter being obtained as the spread over benchmark of the debt.

In 2001, ART conducted its first public issue in the euro-denominated bond market of €250 million. Being market-determined, the best estimate of DAA's debt premium is therefore the quoted yield spread over the benchmark rate. An added advantage of using the spread over benchmark on this eurobond issue is that it has a 10-year maturity, which matches the maturity of the reference rate chosen for the risk-free rate in our CAPM calculation. Further, the benchmark rate used in the Eurobond market is the 10-year Bund (German government bond) rate, which matches our choice of the risk-free rate.

The CAA (2001) suggested that the debt premium of BAA is 140 to 145 basis points and Manchester Airport is 80 basis points. The average of the mid-point of the BAA range and the estimate for Manchester Airport is 111 basis points. This could arguably be used as a starting point for estimating a debt premium for DAA. In this case, assessments of the business and financial risk of DAA relative to the two British airports could be used to argue whether the appropriately estimated debt premium for DAA should be above or below 1.1%.

As discussed above, Standard & Poor's originally assessed DAA's debt as A+/Stable/A-1, but it was downgraded to A/negative/A-1 in 2003. The yield on their euro-denominated bond was 6.002% as at 30th July 2001, representing a spread over the benchmark rate (the 10-year German government bond yield) of 113 basis points. This spread corresponded closely to the average debt premium of 111 basis points calculated from the CAA's (2001) estimated debt premiums for BAA and Manchester airports. In estimating the cost of debt for BAA, the Competition Commission (2002) noted that the corporate spread for a typical company with an AA-rating in the transportation sector ranged between 69 basis points (for one-year debt) up to 165 basis points (for 30-year debt). In making their calculations on the debt premium, the Competition Commission (2002) assumed that BAA's total debt would be spread over a range of maturities. They consequently assumed a debt premium of between 0.9 and 1.2 percent. The midpoint of this is 1.05 percent, and it is similar to the premium previously estimated of 113 basis points.

Following the discussion in NERA (2005) on page 68 and in footnotes 34 and 36, we add an estimate of 10 basis points for issuance costs of debt. Our estimate of the debt premium is therefore 1.1. In summary, therefore, we estimate DAA's real cost of debt as our risk-free rate estimate of 2.6 percent plus 120 basis points for the debt premium. The resulting real cost of debt estimate for DAA is 3.7 percent. This is the same rate as applied in Hutson and Kearney (2001) to calculating ART's cost of capital, and it is equal to the midpoint of the range (3.4-3.95) applied by the Competition Commission (2002) for BAA's cost of capital.

[4] <u>Gearing</u>

The 'optimal' capital structure of a privately owned firm is based on the fact that, as interest payments on debt are tax deductible, raising the quantity of debt adds to company value. The 'optimal' capital structure gives a level of debt at which the tax benefits of debt begin to be outweighed by the costs of financial distress caused by difficulties associated with servicing high debt obligations. The problem with the concept, however, is that the 'optimal' capital structure difficult to determine, and there is no guiding theory as to how to estimate it. In addition, in countries like Ireland with a low corporate tax rate, or where a dividend imputation system reduces the tax benefit of debt, the concept of an 'optimal' capital structure is less important to company value. As Hart (1995) points out, however, for publicly owned companies, the government's objective function might not be clear to all stakeholders, and its commitment to property rights might also be less than totally reliable. These factors render it even more difficult to determine the optimal capital structure for publicly owned firms. What does seem clear, however, is that a significant degree of debt in the capital structure of publicly owned firms acts as an efficiency incentive for management to the extent that it replaces the discipline of the stock market. For DAA, therefore, our preferred approach to estimating gearing for the WACC calculation is to use its actual current gearing or its expected average gearing for the forecast period. This is also the preferred approach of the CAA (2001).

Table 5 summarises the current capital structure of DAA. The table includes comparable ratios for BAA, as these were needed to de-gear BAA's equity beta. The data have been obtained from DAA's balance sheet as at 31 December 2004. For the purposes of comparison, the gearing for BAA and DAA for 2000 is also included. In 2004, the net debt of DAA was €375 million, and total equity amounted to €432 million. This gives a debt-to-equity ratio of 86 percent, and a gearing of 46 percent. In Hutson and Kearney (2001), a gearing ratio of 50 percent was adopted for the purpose of calculating the cost of capital for ART. The current calculation of 46 percent reflects the actual gearing of the company in December 2004.

It is accepted, however, that DAA's gearing will inevitably rise to some extent over the regulatory period. The extent to which this will happen depends on a number of factors, such as the possible construction of a new runway, a new pier, and a new terminal. There exists considerable uncertainty about which of these investments will take place, and when. In the case of the new terminal, although the government has announced that DAA will construct it, and that it will be completed by 2009, there remains uncertainty due to the possibility of legal challenge. In order to shed light on the implications of some of these developments for our calculation of the cost of capital for DAA, we conduct sensitivity analysis by varying the company's gearing, and tracing through its implications for the cost of capital. This is presented in section 6.

[5] The weighted average cost of capital

A summary of our findings for the WACC and its components can be found in Table 6. In the final cost of capital estimation, we follow the methodology adopted by the CAA (2001). The CAA uses estimates of the real cost of equity and the real cost of debt in the following equations for the after-tax and pre-tax WACC.

After-tax WACC:

$$WACC_{post-tax} = \frac{D}{D+E}\left(r_f + \rho\right)\left(1 - t_c\right) + \frac{E}{D+E}\left(r_f + \left[ERP\right]\beta\right) \qquad (5.1)$$

Pre-tax WACC:

$$WACC_{pre-tax} = \frac{D}{D+E}\left(r_f + \rho\right) + \frac{\frac{E}{D+E}\left(r_f + [ERP]\beta\right)}{(1-t_c)} \qquad (5.2)$$

where D = total debt
E = total equity
r_f = the real risk-free rate of interest
ρ = the debt premium
t_c = the corporate tax rate
ERP = the equity risk premium
β = equity beta

The expression $(r_f + \rho)$ is the company's real return on debt, and $(r_f + [ERP]\ \beta)$ is the company's real return on equity using the CAPM.

Inserting our estimates of the inputs to the WACC calculations provides our estimates of Aer Rianta's cost of capital follows:

After-tax WACC:

$$WACC_{post-tax} = \frac{D}{D+E}\left(r_f + \rho\right)\left(1-t_c\right) + \frac{E}{D+E}\left(r_f + [ERP]\beta\right) \qquad (5.1)$$

$$= 0.46\left(2.6 + 1.1\right)\left(1 - .125\right) + 0.54\left(2.6 + [6]1.1\right)$$

$$= 6.4$$

Pre-tax WACC:

$$WACC_{pre-tax} = \frac{D}{D+E}\left(r_f + \rho\right) + \frac{\frac{E}{D+E}\left(r_f + [ERP]\beta\right)}{(1-t_c)} \qquad (5.2)$$

$$= 0.46\left(2.6 + 1.1\right) + \frac{0.54\left(2.6 + [6]1.1\right)}{1 - .125}$$

$$= 7.4$$

Our resulting estimate of DAA's after-tax WACC is 6.4 percent. This lies within the range (5.67 to 8.76) for the WACC calculated by the Competition Commission (2002) for BAA's cost of capital. The pre-tax WACC is 7.4 percent.

[6] Sensitivity analysis

In interpreting the State Airports Act (2004), the CAR in its CP9 2004 has indicated that in making its determination on maximum charges allowable at Dublin Airport, it should have regard to a number of issues including the costs or liabilities for which DAA is responsible and the level of gearing at the newly created DAA, and that it should ensure the long-term development of Dublin Airport by allowing the DAA to earn a reasonable rate of return on its assets, sufficient to attract the necessary funds to maintain and develop its infrastructure. Given the uncertainty that attaches to any estimate of the DAA's 'true' cost of capital, it is preferable that the regulator sets a rate that is more likely to err on the high rather than the low side. In the previous section, we estimated DAA's after-tax cost of capital at 6.4 percent, and we arrived at this estimate by tending towards the high rather than the low end of estimates.

It is, however, also useful to conduct sensitivity analysis around our baseline estimate. In this section we conduct two sensitivity analysis exercises.

- We first examine the implications for the WACC of successively increasing the DAA's capital expenditure programme in increments of €25 million, up to a total of €250 million additional capital expenditure.
- We then examine the implications of increasing the assumed riskiness of DAA's business by considering eight different measures of DAA's asset beta, increasing it by increments of .05, from 0.41 to 0.81.

6.1 Sensitivity to increased capital expenditure

Table 7 illustrates the effects of an increase in DAA's capital expenditure programme (capex) on the cost of capital (WACC). The first row of the table under the headings begins the sensitivity analysis with zero additional capex, and with the baseline data used in previous sections to calculate DAA's WACC, which appears as 6.34 in column [11]. The next 10 rows sequentially raise the capex programme by €25 million, up to an extra €250 million, assuming that the extra expenditure is financed entirely by new debt. The calculations assume that the debt premium remains constant at 1.1. We will relax this assumption in table 8. With equity fixed in column 3, column 4 gives total assets as the sum of net debt plus equity. Columns 5 and 6 give the ratio of debt to assets and equity to assets, and column 7 gives the debt-to-equity ratio. Column 8 shows the increasing equity beta as leverage rises. Column 9 shows how the weighted cost of debt rises with gearing, and column 10 shows that the weighted cost of equity declines. The final column shows the resulting WACC under the different levels of leverage. It is clear that the overall WACC changes very little with increased gearing. The reason for this is that as the debt-to-assets ratio rises, the equity-to-assets ratio declines. As equity is the more costly component of the WACC, increasing gearing is offset by a decreasing weighted cost of equity.

As already noted, the analysis in Table 7 assumes that the cost of debt remains unchanged as leverage rises. This is probably unrealistic, as debtholders are likely to demand a higher risk premium with increasing levels of debt. This is also likely to be reflected in the ratings agencies' assessments – who may well reduce DAA's credit rating – which in turn pushes up the required debt premium. In Table 8, we allow for the debt premium to rise as gearing rises in response to variations in the capex programme. The table considers two scenarios. In scenario 1, the debt premium rises from the base case of 1.1 with zero additional capex, by 0.1 for every €25 million increase in debt. In scenario 2, we consider the effects of allowing the debt premium to increase by 0.2 for every €25 million increase in debt. In the first case, each €100 million extra debt raises the debt premium by 0.4; this increases the cost of debt by almost 0.4, and lead to an increase in the WACC of 0.2. In scenario 2, a €100 million increase in debt raises the debt premium by 0.8. This raises the cost of debt by almost 0.6 (56 basis points), which causes the WACC to rise by almost 0.4.

The bottom row of the table shows that an additional €250 million in debt raises the debt premium by 2.1 percent in scenario 1, and by 3.1 percent in scenario 2, leading to an increase in the WACC by 0.5 and 1.1 in scenario 1 and 2 respectively.

6.2 Sensitivity to increased asset beta

In section 2.3.4, we estimated the asset beta for DAA at 0.61. Our discussion in that section justified a 20 percent increase in our estimate of the asset beta relative to the figure of 0.51 used in Hutson and Kearney (2001) to estimate the cost of capital for ART. Given the degree of uncertainty that pervades estimates of the risk facing airports in particular, and companies in general, it is useful for the regulator to have some feel for the sensitivity of estimates of the WACC to variations in the regulated firm's asset beta. Table 9 does this for DAA. The first column varies the assumed asset beta by 8 increments of 0.5, from a minimum of 0.41 to a maximum of 0.81. The midpoint of this range is where the asset beta is 0.61, which is our estimate of asset beta for DAA's cost of capital. The table can therefore be interpreted as examining the implications for DAA's estimated WACC of a 30 percent rise or fall in business risk, as measured by asset beta.

The central estimate of 0.61 yields the equity beta of 1.07, and a cost of equity of 4.84, which when added to the constant cost of debt of 1.50, gives our central estimate of DAA's WACC of 6.34. The table shows that each 0.1 rise in the assumed asset beta leads to an increase of 0.6 in the overall WACC. In other words, starting with our assumed asset beta of 0.61, a rise in the asset beta to 0.71 would increase the estimated WACC to 6.91, and a rise in the asset beta to 0.81 would increase the WACC to 7.47.

7. Conclusion

Our estimate of DAA's pre-tax WACC is 7.4 percent, and our estimate of its post-tax WACC is 6.4 percent. As Table 6 shows, in addition to small changes in the gearing of BAA and DAA, and to the change in Ireland's corporate tax rate, our estimate of DAA's WACC differs from Hutson and Kearney's estimate of Aer Rianta's WACC due mainly to a 20 percent higher asset beta of DAA because of an upward revision to business risk.

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Figure 1
Nominal Interest Rates, Inflation and Real Interest Rates in Germany, the United Kingdom and the United States
Monthly, June 1988 – December, 2004

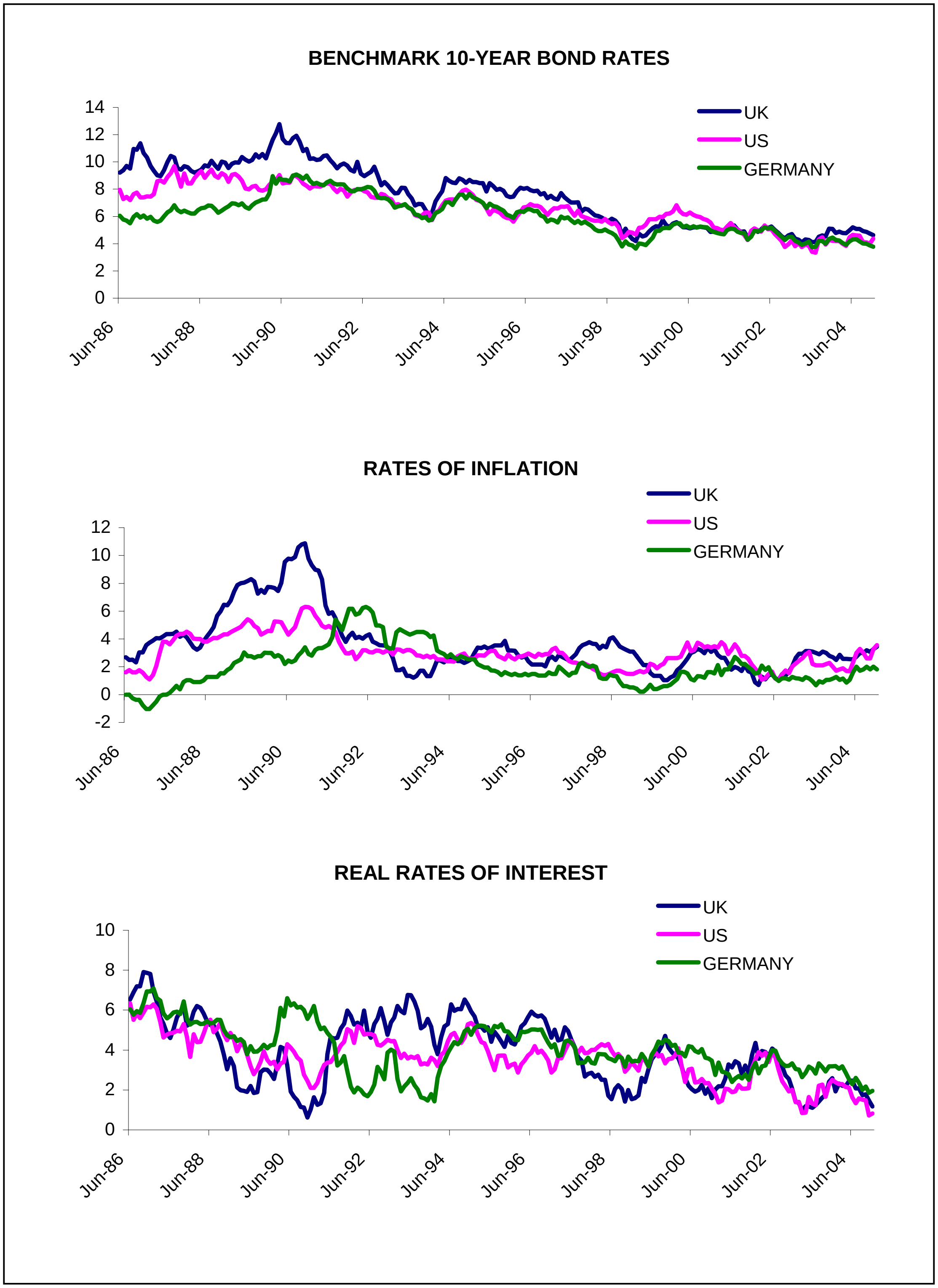


Table 1
Estimates of the real risk-free rate using historical data

Data and Study	*Period*	*Bills / Bonds*	*Germany*	*UK*	*US*	*Average*
				Country		
16 Years						
Hutson and Kearney (2005)	1986-2004	Bonds	2.6	2.6	2.7	2.6
75 Years						
Siegel (1992)	1926-1995	Bills			0.7	
Annin and Falaschetti (1998)	1926-1996	Bonds			2.0	
Jenkinson (1999)	1919-1998	Bonds		2.1		
Ibbotsen and Chen (2001)	1926-2000	Bonds			2.0	
100 years or more						
CSFB (2001)	1869-2000	Bonds		1.8		
LBS/ABN AMRO (2001)	1900-2000	Bonds		1.0		
Mehra and Prescott (1985)	1889-1978	Bills			1.0	
Dimson *et al* (2002)	1900-2000	Bills	0.1	1.2	1.0	
		Bonds	0.3	2.3	2.1	

Notes. Dimson *et al*'s (2002) estimate for Germany excludes data during the hyperinflation years 1922-23.

Table 2
Nominal interest rates, inflation, real interest rates and the real risk-free rate in Germany, the United Kingdom and the United States

Average monthly 10-year bond rates, June 1988 – December 2004

	Germany	UK	US	Average
(1) Nominal Interest Rates				
	6.0	7.5	6.6	6.7
(2) Ex-post Inflation				
	2.0	3.7	3.0	2.9
(3) Real Interest Rates				
	4.0	3.9	3.6	3.8
(4) The Estimated Real Risk-Free Rate				
	2.4	2.3	2.2	2.3

Notes. All data is sourced from Datastream. Observations are taken at the beginning of each month. Estimates of the real risk-free rate are obtained by subtracting the ex-post inflation rates (2) from the nominal rates (1) giving the preliminary real rate (3). The final estimate (4) results from deducting an inflation prediction premium of 40 percent, as estimated for the UK by Breedon and Chadha (1997) and Dimson, Marsh and Staunton (2002).

Figure 2
Stock Market Levels, Returns and Standard Deviations
In Germany, the United Kingdom and the United States
Monthly, June 1988 – December, 2004

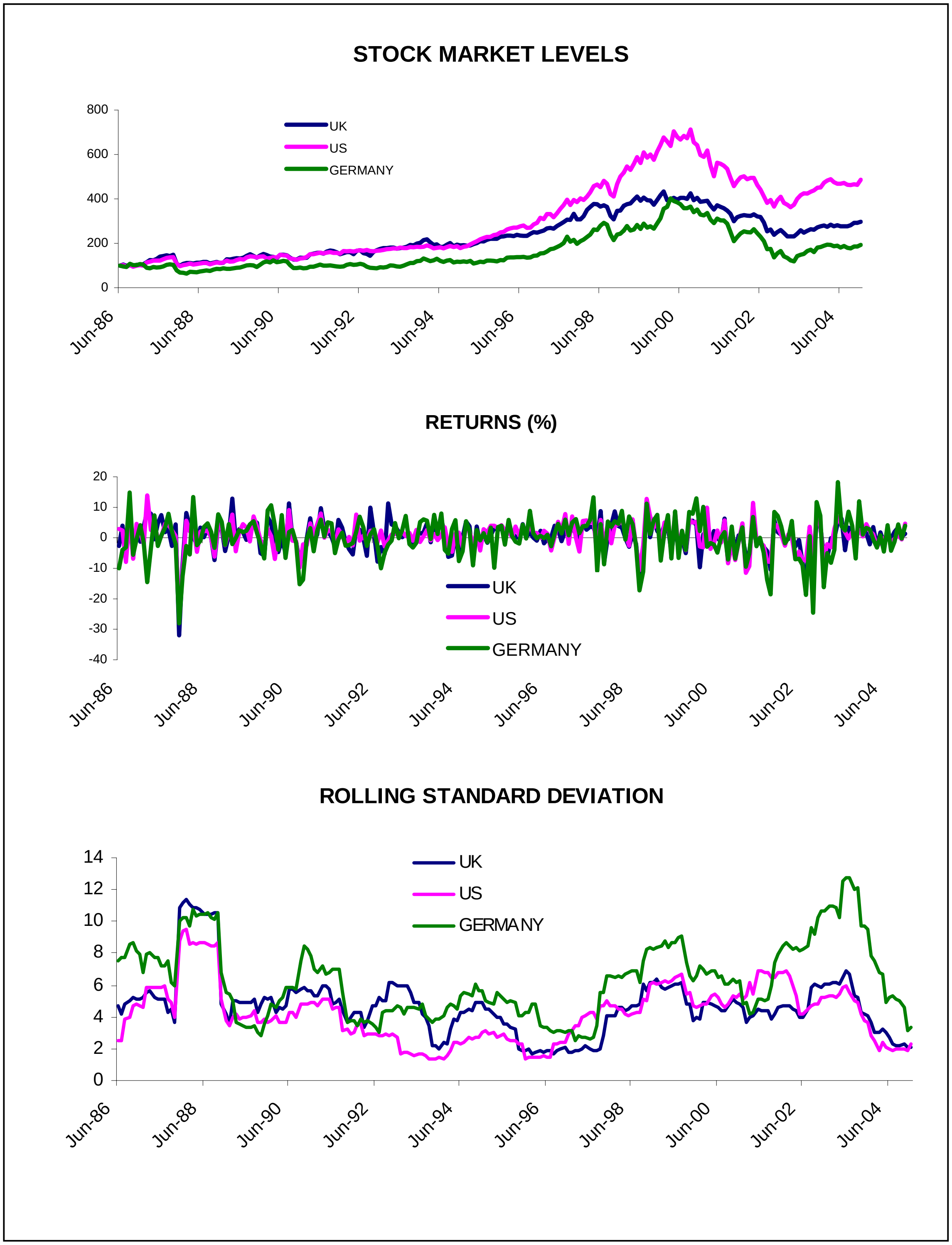


Table 3
Estimates of the Equity Risk Premium
Using Historical Data

Data and study	Period	Relative to bills or bonds?	Country: Germany	UK	US	World / Average
19 Years						
Hutson and Kearney (2005)	1986-2004	Bonds	-1.0	1.8	5.1	
75 Years						
Annin and Falaschetti (1998)	1926-1996	Bonds			7.3	
Cornell (1999)	1926-1997	Bonds			4.5	
Ibbotsen and Chen (2001)	1926-2000	Bonds			6.0	
100 years or more						
Mehra and Prescott (1985)	1889-1978	Bills			6.0	
Siegel (1992)	1802-1990	Bills			5.3	
LBS/ABN AMRO (2001)	1901-2000	Bonds	9.9	5.6	6.9	6.7
Dimson *et al* (2002)	1900-2000	Bills	10.3	6.5	7.7	6.2
		Bonds	9.9	5.6	7.0	5.6

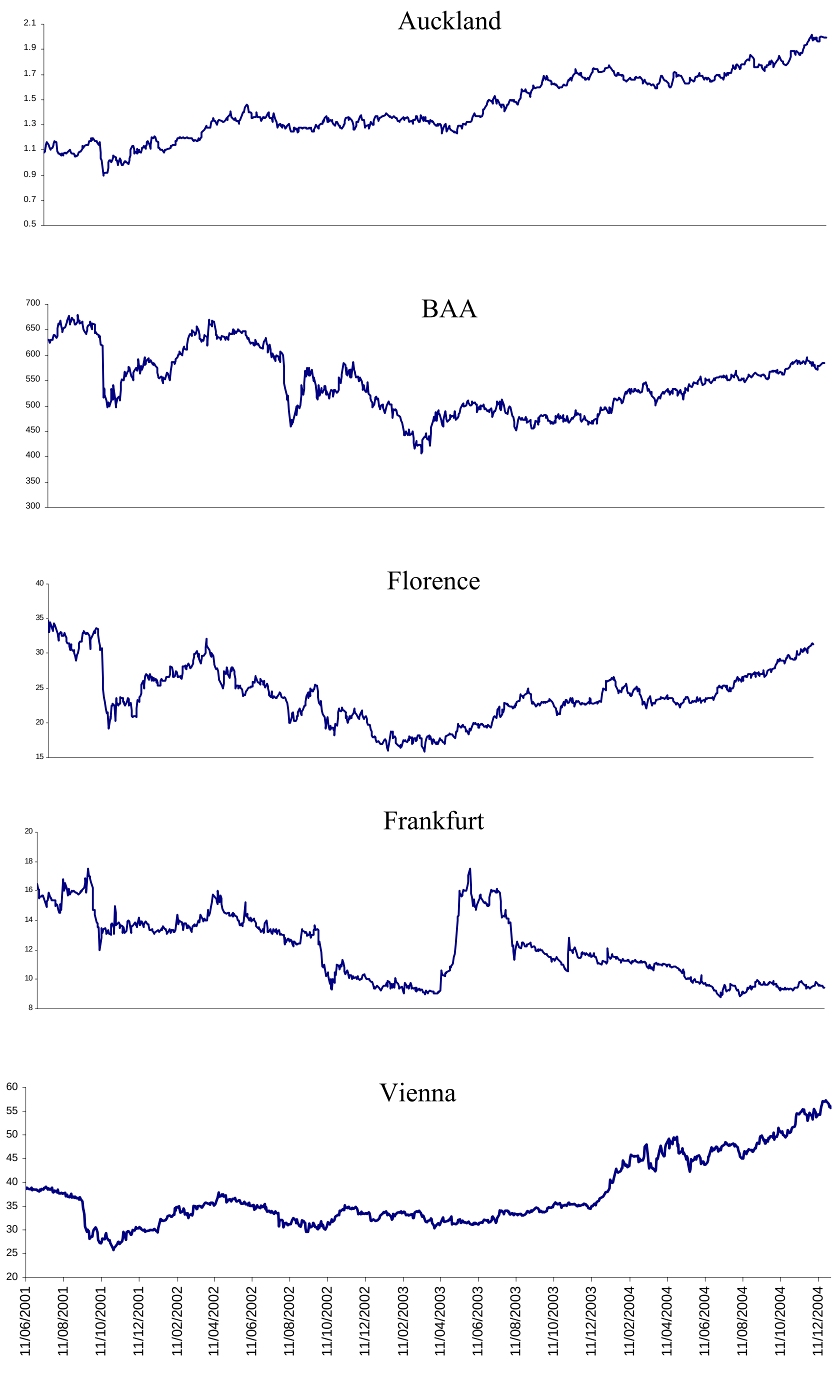
Notes. Dimson *et al*'s (2002) estimate for Germany excludes data during the hyperinflation years 1922-23.

Table 4 Summary statistics for comparator airports

	Auckland	BAA	Florence	Frankfurt	Vienna
Panel A: full data set					
Start date	July 28, 1998	July 5, 1988	July 11, 2000	June 11, 2001	June 15, 1992
Number of observations	1617	4167	1130	904	3094
Mean	0.07	0.03	-0.01	-0.01	0.02
Median	0.00	0.00	-0.21	0.00	0.00
Standard Deviation	1.53	1.50	3.03	2.22	1.56
Kurtosis	4.45	15.56	19.57	6.25	7.82
Skewness	-0.25	-0.58	1.37	0.17	-0.45
Range	19.42	34.08	49.46	29.67	25.76
Largest decline	-12.52	-19.21	-25.60	-15.04	-16.24
Largest rise	6.90	14.87	23.86	14.64	9.52
Panel B: data from 11th June, 2001					
Number of observations	896	904	899	904	882
Mean	0.07	-0.01	-0.06	-0.01	0.04
Median	0.00	0.00	-0.14	0.00	0.09
Standard Deviation	1.35	1.59	2.27	2.22	1.44
Kurtosis	9.96	18.76	9.02	6.25	4.24
Skewness	-1.19	-1.53	0.89	0.17	-0.43
Range	16.81	23.71	26.65	29.67	14.34
Largest decline	-12.52	-17.94	-12.88	-15.04	-8.83
Largest rise	4.29	5.77	13.77	14.64	5.51

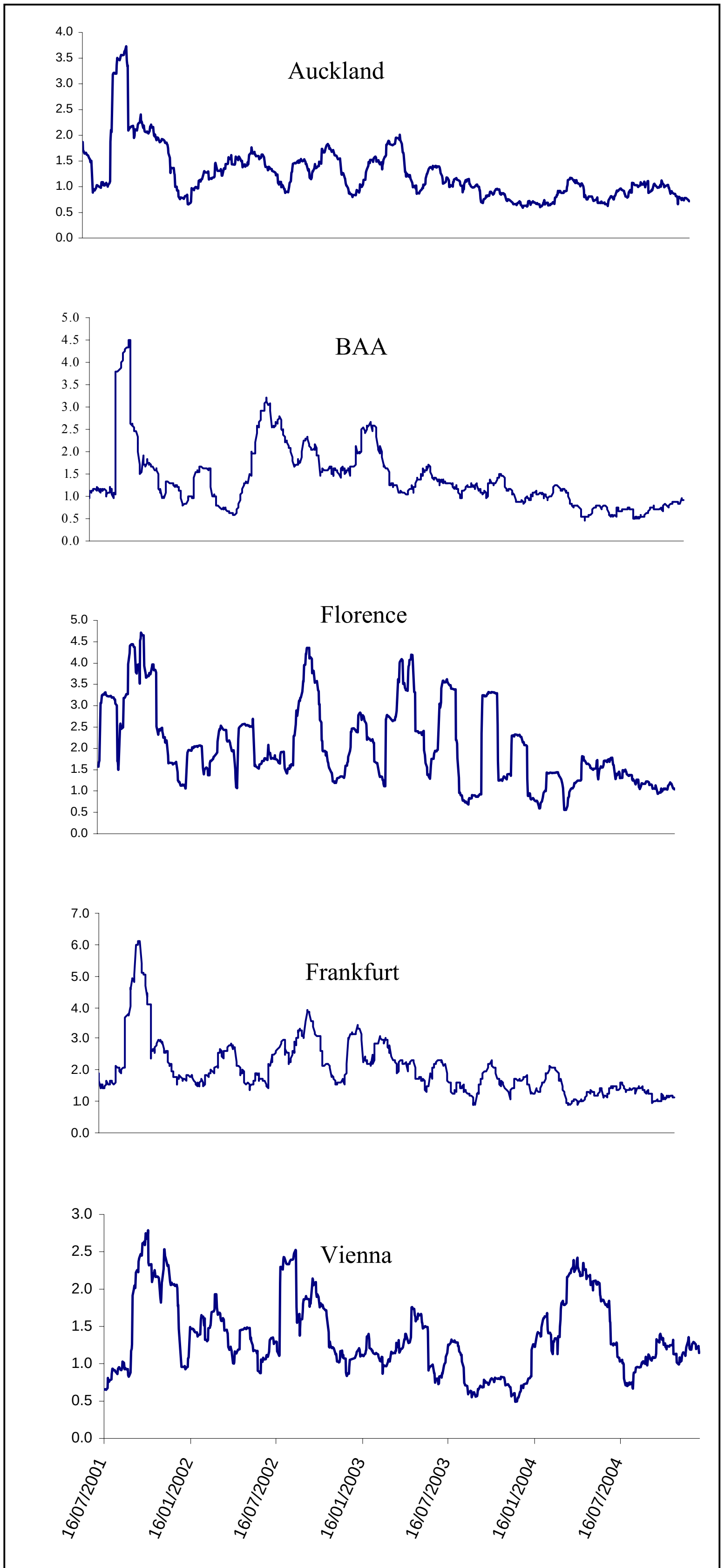
Notes. This table presents the summary statistics using daily data for the 5 comparator airport companies: Auckland, BAA, Florence, Frankfurt and Vienna. Panel A shows the summary information for the full daily price data set for each firm since listing until the end of 2004. Panel B presents summary statistics for truncated data for Auckland, BAA, Florence and Vienna, to correspond with the airport firm that has the shortest listing history, Frankfurt, beginning 11th June, 2001. (This explains why the statistics are the same in Panels A and B for Frankfurt). The number of observations in Panel B differ slightly due to different numbers of public holidays in each country. All kurtosis and skewness statistics are significant at least the 5 percent level.

Figure 3
Stock price of the 5 comparator airport companies



Notes. This figure shows the stock price of the 5 name airport companies for the period 16th June, 2001 to December 31st, 2004.

Figure 4 Rolling standard deviation of airport companies



Notes. This figure shows the rolling 25-day standard deviation for the 5 comparator airport companies, for the period 16th July 2001 to December 31st, 2004.

Figure 5 Rolling standard deviation of BAA and Vienna airport

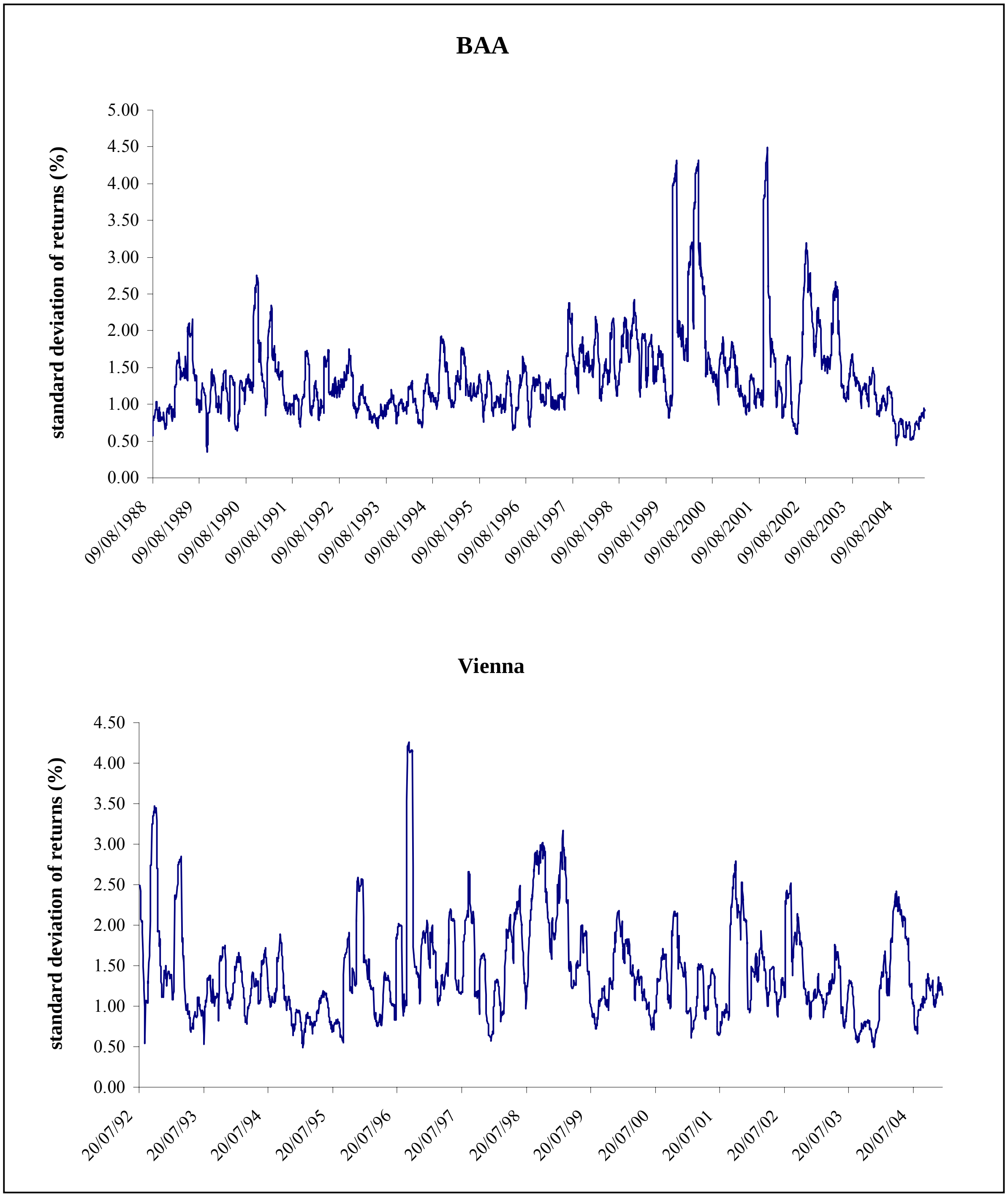
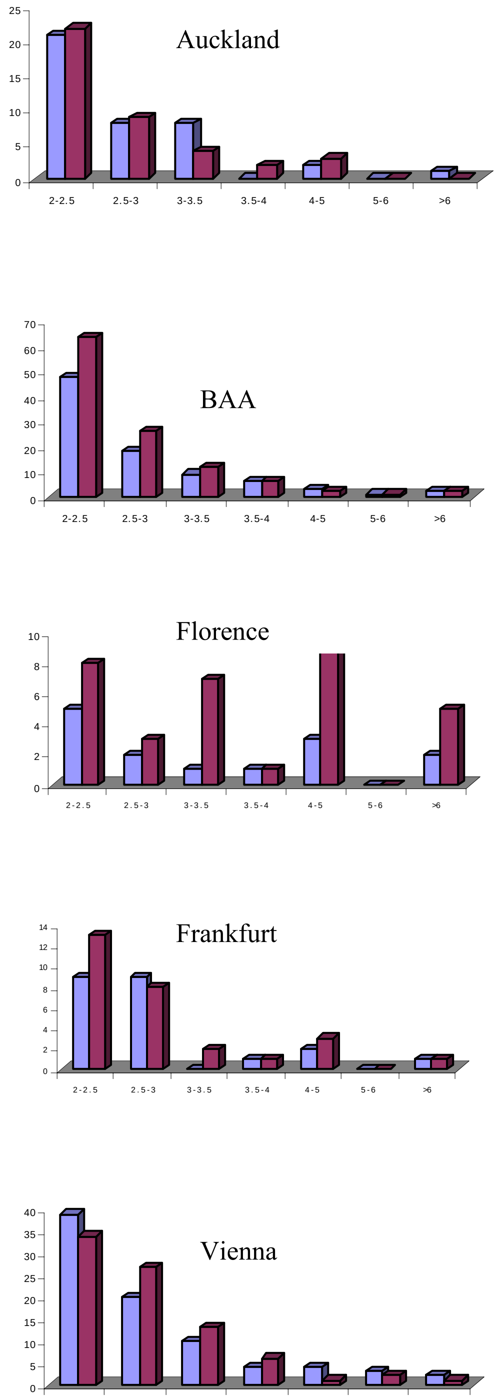


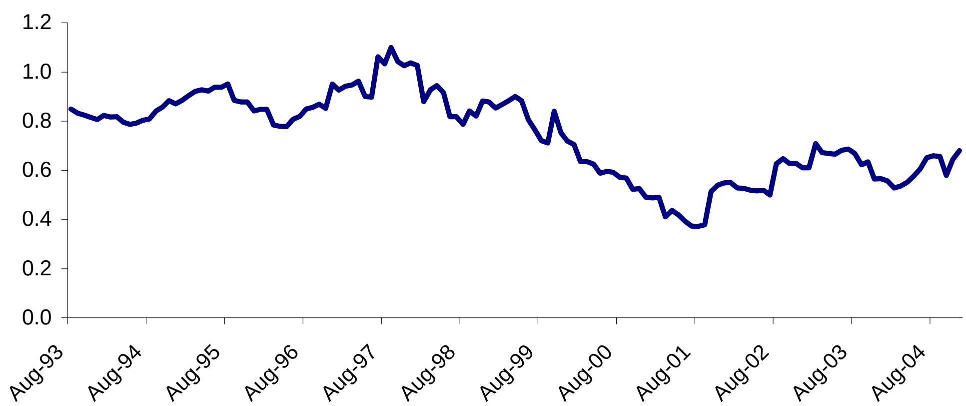
Figure 6 Tail behaviour of comparator airport companies



Notes. This figure depicts the number of observations in the tails of the distribution; that is, beyond 2 standard deviations either side of the mean. The tails are divided into the following intervals: 2-2½, 2½-3, 3–3½, 3½-4, 4-5, 5-6 and greater than 6 standard deviations from the mean.

Figure 7
Estimated equity beta for BAA

Calculated over 5 years of rolling monthly data for the FTSE 100 index for the period 1988-2004



Notes. This figure shows the evolution in BAA's monthly equity beta, using data from BAA's equity price and the FTSE 100 index from September 1988 to December 2004. The data were obtained from *Datastream International Ltd*. The betas are 5-yearly rolling estimates, using ordinary least squares, so the first calculated beta is for August 1993.

Table 5
Gearing ratios of BAA and DAA 2000 and 2004

	net debt	equity	D/(D+E)	D/E
BAA (2000) £	2704	4565	37%	59%
BAA (2004) £	3359	5018	40%	67%
ART (2000) £	324	280	54%	116%
DAA (2004) €	375	432	46%	86%

Note. The figures for BAA (2000) and BAA (2004) are in UK sterling. The figures for ART (2000) are in IR£ and for DAA (2004) are in euro. The figures for net debt, equity, and the debt-to-equity ratios for both BAA (2000) and ART (2000) are reproduced from Hutson and Kearney (2001). The figures for BAA (2004) and for DAA (2004) are taken from the annual reports of the companies.

Table 6
Estimates of WACC

	DAA 05	ART 01	Reasons for change
1. Risk-free rate	2.6	2.6	No change
2. Equity risk premium	6.0	6.0	No change
3. Equity beta for BAA	.74	.73	Updated data
4. Gearing ratio of BAA	.40	.37	Actual data.
5. Asset beta of BAA	.51	.50	Updated data
6. Asset beta of DAA	.61	.51	Higher perceived risks in aviation
6. Gearing ratio of DAA	.46	.54	Updated data
7. Ireland's corporate tax rate	.125	.135	Updated data
8. Equity beta of DAA	1.1	.93	18% rise: • Less diversified • Potential competition • Pandemic risks • Riskier than BAA
9. Cost of equity for DAA	9.2	8.1	Increase due to higher estimated beta.
10. Debt premium	1.1	1.1	No change
11. Cost of debt	3.7	3.7	No change
12. Post-tax real WACC	6.4	6.0	Increase due to higher estimated cost of equity.
13 Pre-tax real WACC	7.4	7.0	As above.

Notes. This table summarises the changes from our WACC report for ART ('ART 01' refers to Hutson and Kearney (2001)), to the current estimates ('DAA 05'). 'BAA 02' refers to the Competition Commission's (2002) estimates of the WACC for BAA.

Table 7
Sensitivity analysis for increasing capex (debt-financed)

[1] Additional capex (€m)	[2] Net debt (€m)	[3] Equity (€m)	[4] Assets (€m)	[5] D/(D+E)	[6] E/(D+E)	[7] D/E	[8] Beta	[9] Cost of debt	[10] Cost of equity	[11] WACC
0	375	432	807	0.46	0.54	0.87	1.07	1.50	4.84	6.34
25	400	432	832	0.48	0.52	0.93	1.10	1.56	4.79	6.35
50	425	432	857	0.50	0.50	0.98	1.14	1.61	4.74	6.35
75	450	432	882	0.51	0.49	1.04	1.17	1.65	4.70	6.35
100	475	432	907	0.52	0.48	1.10	1.20	1.70	4.66	6.35
125	500	432	932	0.54	0.46	1.16	1.23	1.74	4.62	6.36
150	525	432	957	0.55	0.45	1.22	1.26	1.78	4.58	6.36
175	550	432	982	0.56	0.44	1.27	1.29	1.81	4.55	6.36
200	575	432	1007	0.57	0.43	1.33	1.32	1.85	4.51	6.36
225	600	432	1032	0.58	0.42	1.39	1.35	1.88	4.48	6.36
250	625	432	1057	0.59	0.41	1.45	1.38	1.91	4.45	6.37

Notes. This table illustrates the effects of an increase in DAA's capital expenditure programme (capex) on the cost of capital (WACC). These calculations assume that the debt premium remains constant at 1.1 (Table 8 recalculates assuming an increasing debt premium.) Column 1 portrays the effect of increasing the capex programme in 10 steps of €25 million, and we assume (column 2) that this additional capex is financed by debt. With equity fixed in column 3, column 4 gives total assets as a sum of net debt plus equity; columns 5 and 6 give the ratio of debt to assets and equity to assets, and column 7 gives the debt-to-equity ratio. Column 8 shows the effect on equity beta as leverage rises, and columns 9 and 10 show the effect on the weighted cost of debt and equity respectively. The final column shows the changing WACC.

Table 8
Sensitivity analysis for increasing capex assuming increasing debt premium

		[1] Debt premium increases by 0.1			[2] Debt premium increases by 0.2		
Additional capex (€m)	**Net debt (€m)**	debt premium	cost of debt	WACC	debt premium	cost of debt	WACC
0	375	1.1	1.50	6.34	1.1	1.50	6.34
25	400	1.2	1.60	6.39	1.3	1.64	6.43
50	425	1.3	1.69	6.44	1.5	1.78	6.52
75	450	1.4	1.79	6.49	1.7	1.92	6.62
100	475	1.5	1.88	6.54	1.9	2.06	6.72
125	500	1.6	1.97	6.59	2.1	2.21	6.83
150	525	1.7	2.06	6.65	2.3	2.35	6.93
175	550	1.8	2.16	6.70	2.5	2.50	7.05
200	575	1.9	2.25	6.76	2.7	2.65	7.16
225	600	2.0	2.34	6.82	2.9	2.80	7.28
250	625	2.1	2.43	6.88	3.1	2.95	7.40

Notes. This table extends the analysis in Table 7 to assume an increasing cost of debt as gearing rises. We first assume an increasing debt premium from its base of 1.1 of 0.1 (10 basis points) for each additional €25 million increase in net debt [1] and we then assume an increasing debt premium in steps of 0.2 (20 basis points) [2].

Table 9
Sensitivity analysis for increasing asset beta

[1] Assumed asset beta	[2] Equity beta	[3] Cost of debt	[4] Cost of equity	[5] WACC
0.41	0.72	1.50	3.71	5.21
0.46	0.81	1.50	3.99	5.50
0.51	0.90	1.50	4.27	5.78
0.56	0.99	1.50	4.56	6.06
0.61	1.07	1.50	4.84	6.34
0.66	1.16	1.50	5.12	6.63
0.71	1.25	1.50	5.40	6.91
0.76	1.34	1.50	5.69	7.19
0.81	1.43	1.50	5.97	7.47

Notes. This table illustrates the effect of an increasing asset beta [1] on DAA's WACC. Asset beta is assumed to increase to a high of 0.81 in increments of 0.05. All other inputs to the WACC calculation are held constant.