



Europe Economics

Response to PwC Arguments on the Cost of Capital for Q6 *Report for Heathrow*

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Europe Economics
Chancery House
53-64 Chancery Lane
London WC2A 1QU

Tel: (+44) (0) 20 7831 4717
Fax: (+44) (0) 20 7831 4515

www.europe-economics.com



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1 Response to PwC Papers

1.1 Introduction

This document presents our reflections on some methodological aspects of the estimation of the cost of capital for Heathrow as set out in the “Paper on the split cost of capital and skewed returns” and the “Paper on the split cost of capital and skewed returns” prepared by PwC on behalf of the CAA.

PwC envisages two separate cost of capital scenarios. In one, which PwC refers to as “current market approach”, the ERP is 6 per cent, the debt premium is in the region 2.05-2.25, and the risk-free rate falls within the range 0.25-0.75. In the other (“long-term returns approach”), the ERP is lower (5 per cent), the debt premium is 1.1, and the risk-free rate is 1.6. Both scenarios assume a point estimate for the equity beta of 1.03, a debt beta of 0.1, a notional gearing level of 60 per cent, and a tax rate of 20.2 per cent.

Table 1.1: PwC WACC estimates

	Long-term returns approach	Current market approach	
		Low	High
Risk-free rate	1.6	0.25	0.75
ERP	5	6.0	6.0
Debt Premium	1.1	2.05	2.25
Equity beta	1.03	0.9	1.15
Debt beta	0.1	0.1	0.1
Gearing (%)	60	60	60
Tax rate (%)	20.2	20.2	20.2
Pre-tax WACC	5	4.2	5.6

The table below shows a breakdown of the differences between the PwC long-term approach and Europe Economics’ estimate of the cost of capital.

Table 2: Comparison of PwC and Europe Economics WACC estimates

	PwC long-term returns approach	Europe Economics Estimate	Difference to WACC	Percentage of Total Difference
Risk-free rate	1.6	2	0.4	21
ERP	5	5	0.0	0
Debt Premium	1.1	2.6	0.9	44
Equity beta	1.03	1.3	0.7	33
Debt beta	0.1	0.1	0.0	0
Gearing (%)	60	60	0.0	0
Tax rate (%)	20.2	21	0.0	2

Pre-tax WACC	5	7.1	2.1	100
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1.2 Risk-free Rate

PwC suggests two different risk-free rate scenarios. One is based on what PwC refers to as “current market approach” and leads to a risk free rate range of 0.25-0.75 per cent. The second one is referred to as “long-term returns approach” and leads to a range of 1.1-2.0 per cent.

Point of Challenge 1: *PwC states that the risk-free rate is “the rate of return that can be earned on riskless investments i.e. where a fixed investment return is guaranteed with zero probability of variation or default”. This leads PwC in its “current market” approach to estimate the current risk-free rate from gilt yields and then use forward yields to estimate the change in the risk-free rate between now and the middle of the price control period.*

It has been general practice within the CAPM framework to infer the risk-free rate from very low risk assets such as, in the case of the UK, gilts. However, the reason for this is that their very low risk profile has, in the past, made them informative about what is likely to be the level of the risk free rate. In other words, the return on holding gilts was examined because the debt premium on gilts would be approximately equal to zero, and the return on holding them would therefore be approximately equal to the risk-free rate.¹ This does not imply in any way either that the return on government bonds is identically equal to the risk-free rate, or that the return on any riskless asset must equal the risk-free rate in the CAPM.² PwC recognise this point when they state that index-linked gilt yields are a reasonable proxy for the real risk-free rate because they have “negligible default risk and minimal inflation risk”.³

However, we argue that current yields on gilts do not reflect the underlying risk-free rate, because of distortions occurring due to quantitative easing. This is because the Bank of England does not buy gilts through its quantitative easing program in order to achieve a risk-free return. Rather, it buys them to provide a monetary stimulus. This demand for gilts is in addition to the demand that would exist in order to achieve a risk-free return, and pushes up the price of gilts and therefore lowers yields.

This point has been explicitly recognised in recent regulatory determinations, which have set risk-free rates in excess of the gilt yield prevailing at the time.

Indeed, the idea that current yields reflect the underlying risk-free rate is undermined by a basic sense check. The chart on page 49 of the PwC report shows that yields on index-linked gilts are negative even for 15 year gilts at March 2013. There are very good theoretical and empirical reasons to believe that the true risk-free rate is, at the least, highly correlated with the sustainable growth rate over the same period. Given that the yield on the 15 year index-linked gilt is close of zero and negative, this would imply that no growth (or even negative growth) was expected between now and 2028.

Conclusion: *There is no necessary equivalence between zero-risk assets and the risk-free rate in the CAPM. Gilt yields have been examined in past price controls, but this is because their low risk has, in the past, made them good*

¹ To express this more formally, gilt yields were examined to determine the risk-free rate because $r_{UK} = r_f + DP_{UK}$ with $DP_{UK} \approx 0$, and not because $r_{UK} \equiv r_f$ (where r_{UK} is the return on gilts, r_f the risk-free rate and DP_{UK} the UK’s debt premium).

² A simple thought experiment shows that there is no necessary connection between a zero probability of variation or default in returns and the appropriate risk-free rate for the purposes of the capital asset pricing model. Consider a lottery which occurs daily and in which one winning ticket wins all of the revenue from ticket sales, less any administrative costs. Now suppose that one individual were to continually buy all of the tickets for that lottery. The individual would have turned the lottery into an effectively risk-free asset, albeit one with a negative return, but there is absolutely no reason to claim any sort of connection between the return on the lottery and the appropriate risk-free rate for the CAPM.

³ PwC Main Report p48

indicators of the underlying risk-free rate. Because of distortions occurring due to quantitative easing, yields have been depressed by demand for gilts in order to provide a monetary stimulus, rather than to earn a risk-free return.

Point of Challenge 2: For its “current market” approach, PwC uses spot data for real and nominal gilt yields to determine the “current” risk-free rate, and then uses the forward curves to infer an expected increase to 2016, partly reflecting the unwinding of the effects of Quantitative Easing.

Specifically PwC adds a 100 bps adjustment to its estimates of current yields to arrive at an expected risk-free rate for the middle of the next price control, citing the difference between spot and forward yields. PwC notes that this may be because of expectations of Quantitative Easing unwinding. This has the potential to correct for some of the downward distortion in current yields attributable to quantitative easing. However, since forward yields are calculated against the current yield curve, it may be that quantitative easing also has a distorting effect by changing the shape and position of the yield curve. In this way, QE may also have affected implied forward yields.

In particular, if we suppose that the effect of QE was to reduce yields at the short end of the curve, but to leave yields at the long end relatively unchanged, this would leave forward yields, at least those towards the long end, relatively unchanged. However, if the effect of QE was to shift the yield curve across all maturities, then this would have a significant effect on the implied level of forward yields. These points are illustrated in the figures below.

Figure 1: Effect of Quantitative Easing on the Yield Curve with minimal effect on forward yields beyond dotted line

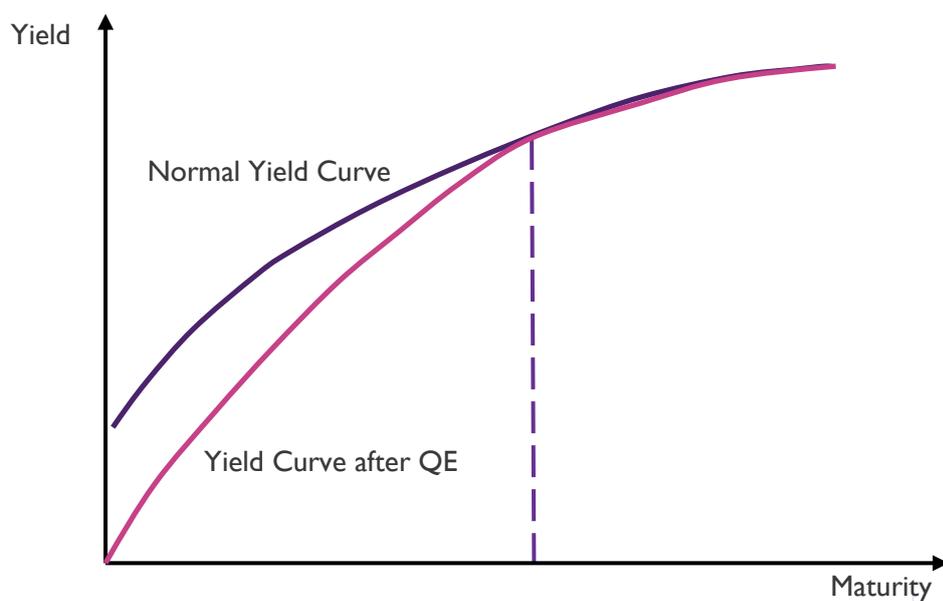
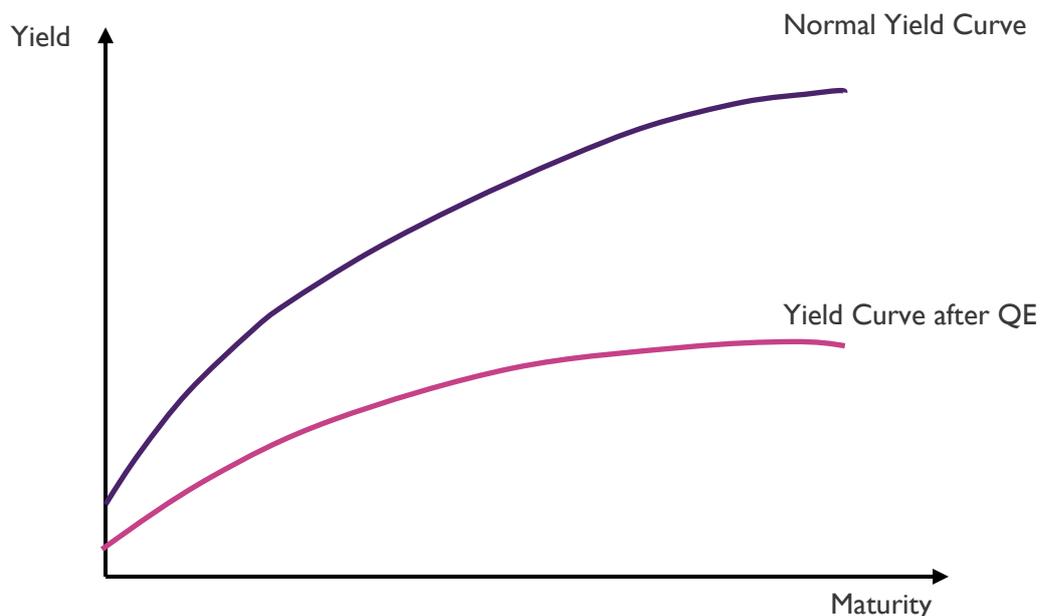


Figure 2: Effect of Quantitative Easing on the Yield Curve with significant effect of forward yields across all maturities



This would mean that the forward yield curve at the time of next control period would be affected by QE even where expectations are that QE would have unwound by then. While it remains the case that the forward curve implies that yields are expected to rise by the middle of the next price control, inferring the amount by which they are expected to rise from the difference between current and forward yields may be problematic.

Conclusion: *PwC's approach of applying an uplift to current yields given the difference between current spot and forward yield curves may prove problematic given that the forward curve is itself calculated on the basis of the spot curve, and distortions caused by QE may have affected the shape and position of the spot curve.*

Point of Challenge 2: *In their "long-term returns" approach, PwC use historical averages to estimate the risk-free rate.*

PwC's approach of using long-term averages for its "long-term returns" approach is in contrast to our approach, which uses established relationships between macroeconomic variables to infer what will be risk-free rate that is relevant for the price control period. More specifically, we appeal to the relationship between the risk-free rate and the economy's sustainable growth rate that is observed both in theory and in statistical analysis, and infer from predictions of future growth what is the most plausible range for the risk-free rate. Put simply, ours is a forecasting approach, whereas PwC uses a combination of "now-casting" (using spot data for its "current market" approach) and "back-casting" (using long-term averages of past values in its "long-term returns" approach). We contend that our approach is more appropriate when setting a risk-free rate that is suitable for the coming price control, given that the sustainable growth rate, and hence the risk-free rate, are expected to rise significantly by the middle of the price control.

Conclusion: *In contrast to PwC's approach, Europe Economics' approach allows for expectations of future growth rates to provide a forecast of the risk-free rate.*

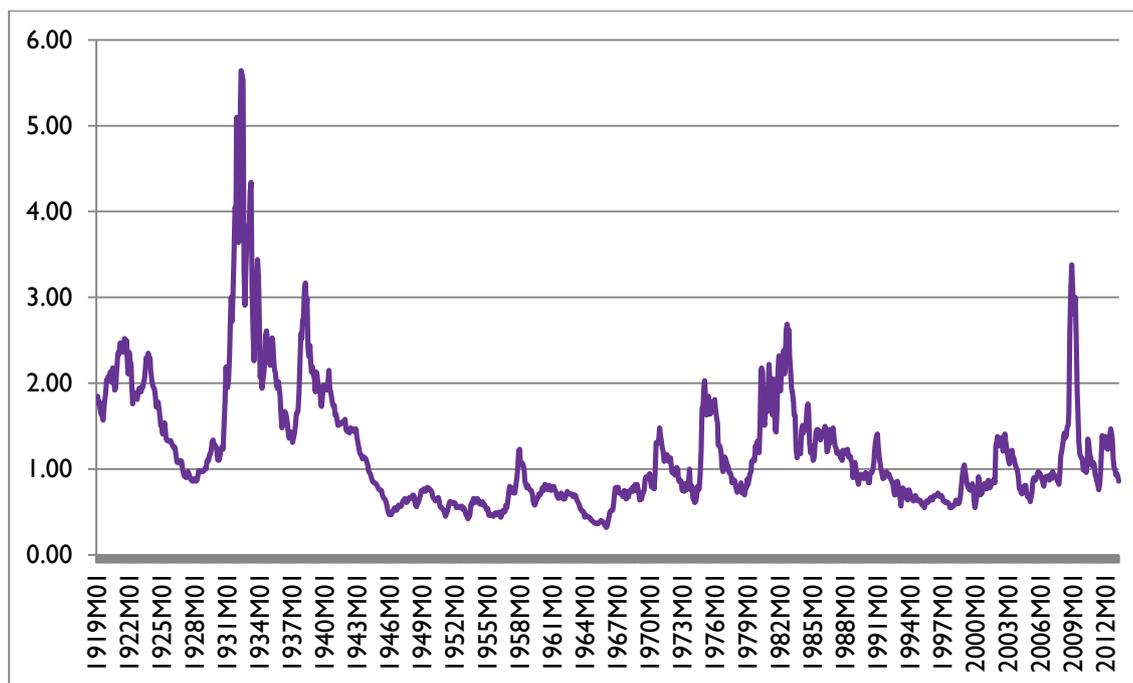
1.3 Debt Premium

Point of Challenge: *The debt premium in PwC's "long-term" scenario of 110 bps is almost identical to the 105 bps debt premium determined in the Q5 price review. Assuming a debt premium of this magnitude therefore*

implies that the low levels of debt premium seen before 2007 were sustainable in the long term, which is in contrast to the generally accepted view that risk was under-priced in the period leading up to the financial crisis.

To test the proposition that the pre-crisis debt premium level is appropriate for the Q6 determination, we examine historical data to test whether post-crisis debt premiums tend to return to their pre-crisis level. The chart below shows monthly data on the spread between US Corporate Baa and Aaa bonds since 1919. There are notable spikes in spreads after 1929, during the period of the Great Depression, again during the 1938 recession, and a series of spikes during the 1970s and early 1980s. The most recent financial crisis is clearly evident with a significant increase in yields after late 2007.

Figure 3: US Corporate Bond spreads, 1919-2013



Source: US Federal Reserve

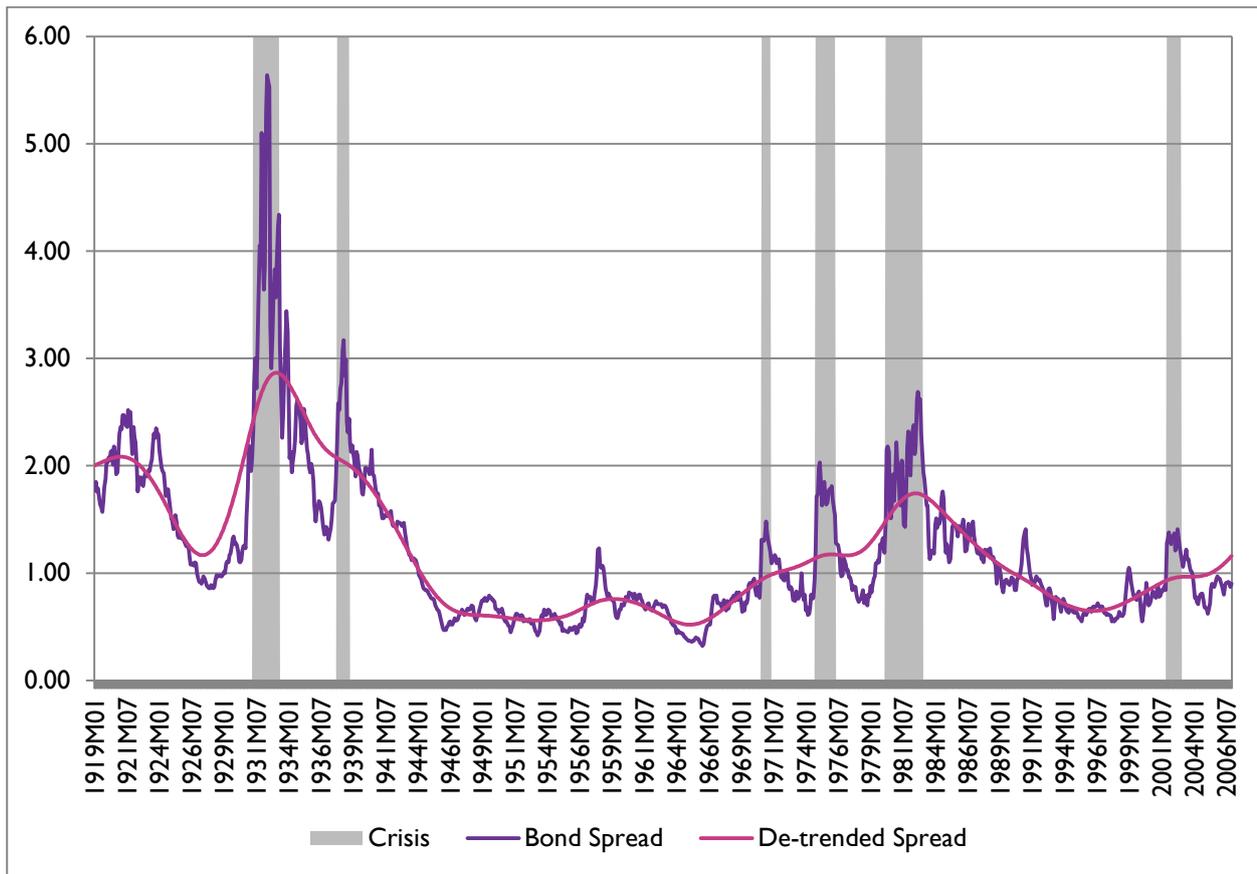
To identify periods of crisis, we first smoothed the series using the Hodrick-Prescott filter in order to remove “short-term” fluctuations, setting lambda equal to 129,600 as recommended by Ravn and Uhlig (2002) for monthly time series data.⁴ We then selected “crisis” periods using the following rules:

- We identified the start of a crisis period by identifying months in which month-on-month increases in spreads were outside the 90 per cent confidence interval around the mean.
- We determined the persistence of each crisis by counting months in which the standard deviation of the spread remained more than 20 per cent above its trend level. Where the spread returned to within 20 per cent of its trend level only to go back above within three months, we counted this as a continuation of the crisis.

The chart below shows the crisis periods that were identified using this method. We note that the periods selected by this criterion coincide with narrative expectations of economic crises.

⁴ Ravn, M.O. and Uhlig, H., “On Adjusting the Hodrick-Prescott Filter for the Frequency of Observations”, *The Review of Economics and Statistics*, May 2002, 84(2): 371–380

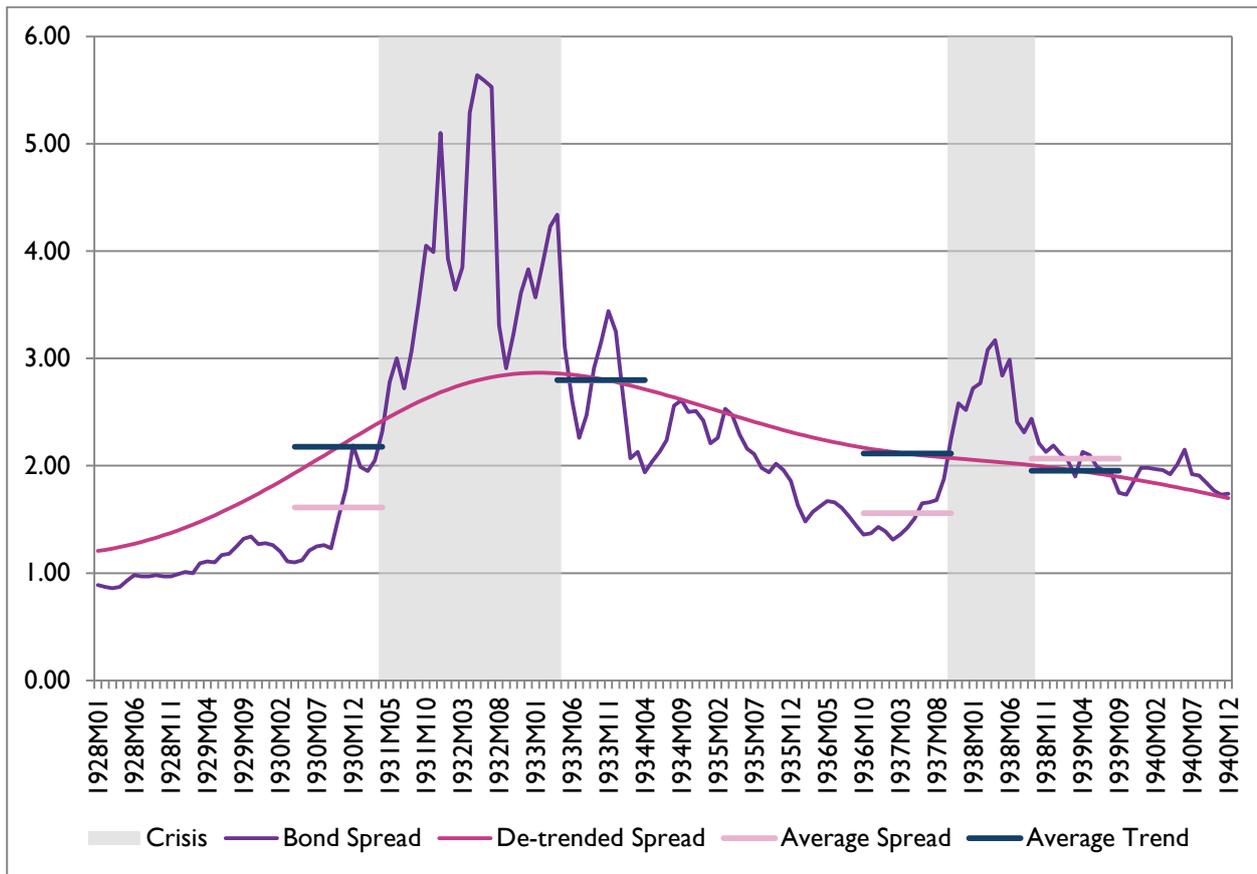
Figure 4: Smoothed (underlying) US corporate bond spread series and “crisis” periods, 1919-2006



Source: US Federal Reserve and Europe Economics calculations

To see more closely what this shows, the chart below focuses on the crises that occurred during the period from 1928 to 1940. It shows the raw and smoothed spread series, alongside average values of the smoothed spread series and the spread series in the year periods before and after each crisis. The underlying series is significantly higher post-crisis than pre-crisis in the case of the spike coinciding with the Great Depression. The smoothed series is, however, lower post-crisis than pre-crisis for the spike coinciding with the 1938 recession. However, in both cases spreads were higher, on average, after each crisis.

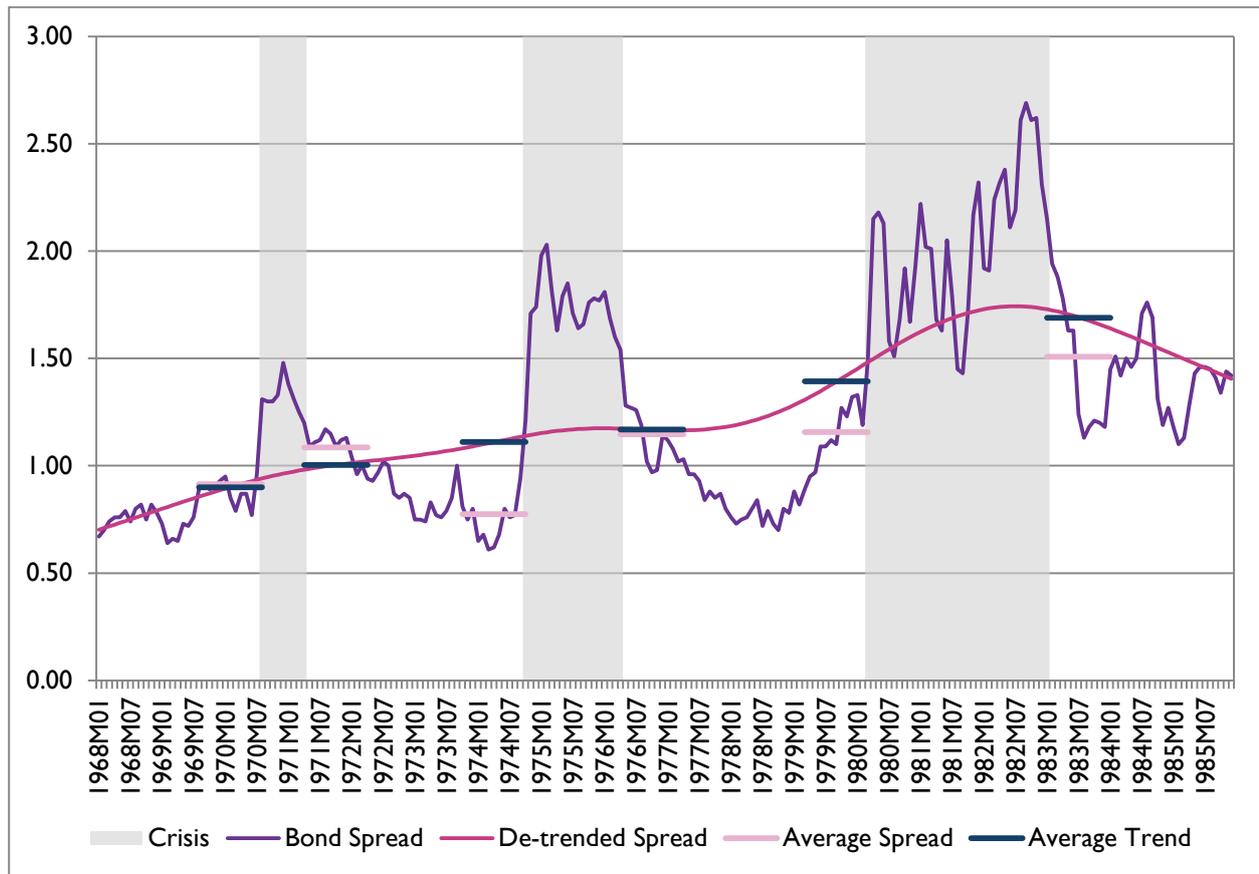
Figure 5: US corporate bond spread series, 1928-1940



Source: US Federal Reserve and Europe Economics calculations

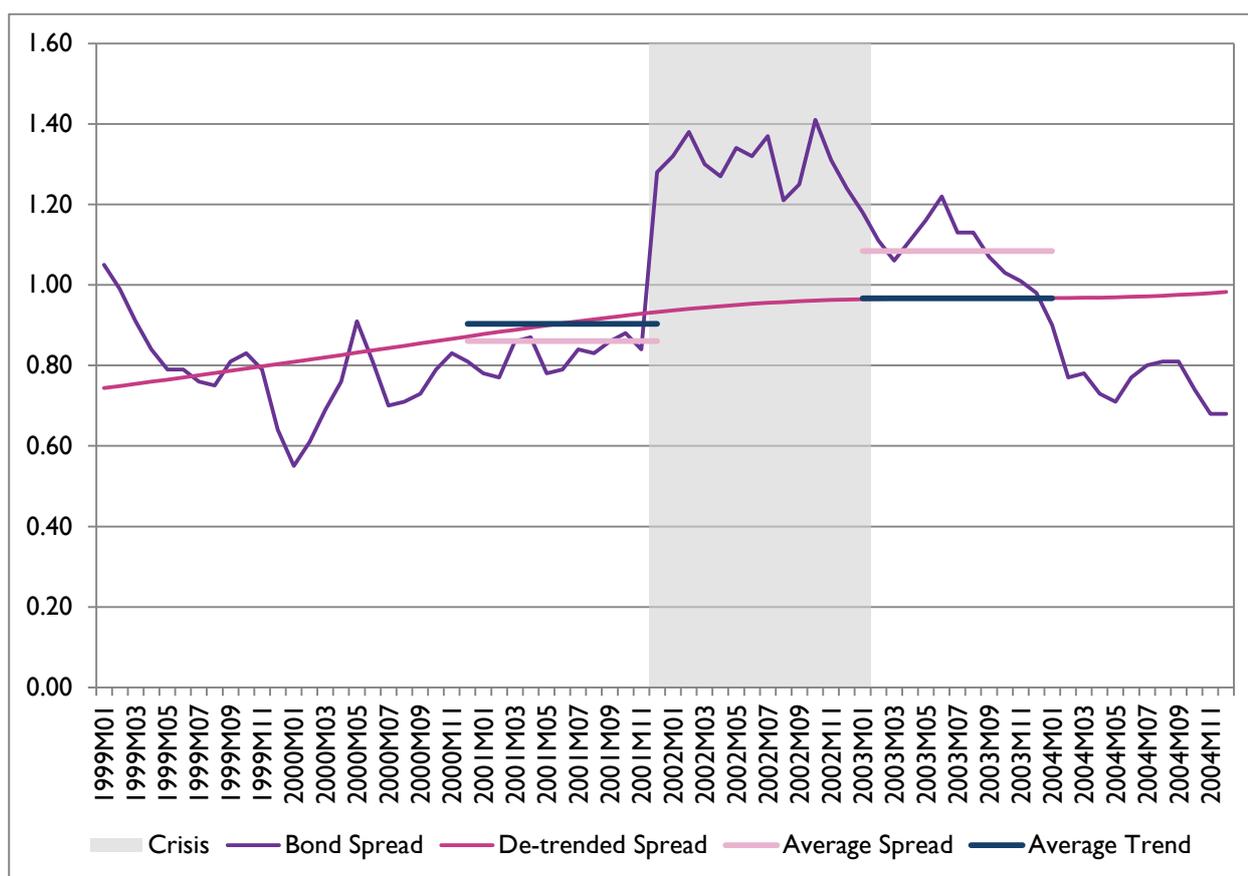
The chart below shows spreads the crises that occurred during the period between 1968 and 1985. In each case, the underlying series is higher post-crisis than pre-crisis. In other words, although spreads fell as the crises came to an end, the level to which they returned was higher than was the case pre-crisis. The same is true of average spreads before and after the crisis.

Figure 6: US corporate bond spread series, 1968-1985



Source: US Federal Reserve and Europe Economics calculations

Finally, the chart below shows spreads during the crisis that occurred during the period from 1998 to 2004. Again, spread series itself and the smoothed spread series are, in each case, higher post-crisis than was the case pre-crisis.

Figure 7: US corporate bond spread series, 1999-2004

Source: US Federal Reserve and Europe Economics calculations

The table below summarises our findings on the behaviour of bond spreads pre-and post- crisis. In all but one case, the smoothed spread series was higher post-crisis than pre-crisis, and in all cases the raw spread series was on average higher post-crisis than pre-crisis. Moreover, after more serious crises – the Great Depression, in particular – the percentage difference pre- and post-crisis was larger. The conclusion that crises are associated with changes in investors’ perceptions of risks is not surprising.

Table 3: Summary of pre- and post-crisis corporate bond spreads, 1919-2013

	Pre-crisis	Post-crisis	Change	Percentage Difference
<i>Spread</i>				
1931-1933	1.613	2.795	+1.182	+73%
1937-1938	1.559	2.067	+0.508	+33%
1974-1976	0.915	1.086	+0.172	+19%
1970-1971	0.775	1.146	+0.371	+48%
1980-1983	1.157	1.508	+0.351	+30%
2001-2003	0.861	1.084	+0.223	+26%
<i>Trend</i>				
1931-1933	2.177	2.800	+0.623	+29%
1937-1938	2.115	1.954	-0.161	-8%
1974-1976	0.900	1.003	+0.103	+11%
1970-1971	1.110	1.168	+0.058	+5%

1980-1983	1.393	1.689	+0.296	+21%
2001-2003	0.904	0.967	+0.063	+7%

Source: US Federal Reserve and Europe Economics calculations

Conclusion: *Following a spike, spreads typically do not return to the levels observed pre-crisis. In all but one case, although spreads settled down after the crisis had passed, they did so at levels that were in excess of the levels seen pre-crisis. This suggests that there is little historical justification for believing that debt premiums ought to return to the levels they were at prior to the financial crisis.*

1.4 Beta

Point of challenge: *PwC does not appear to attach weight to the level of beta estimates for Frankfurt and Paris, which show a materially higher beta than was determined for Heathrow in Q5 (0.47-0.58 for Frankfurt and Paris versus 0.42-0.52 for Q5). This may be due to the fact that the Fraport and Aéroports de Paris groups also have activities outside of pure aviation.*

PwC suggests using in Q6 the same beta assumption for Heathrow that was used in Q5. The proposed asset beta for Heathrow is therefore 0.47 (with a range 0.42-0.52), which implies an equity beta of 1.03 (with a range 0.90-1.15) at the 60 per cent notional gearing level. This choice is justified by PwC on the ground that, with a lack of direct market data for Heathrow, there would need to be strong evidence suggesting a change in the systematic risk of the airport sector in order to move away from the Q5 figures. To this end PwC has conducted an analysis of the evolution of asset beta for a number of comparator airports and concluded that there is no evidence suggesting a change in the systematic risk in the airport sector since Q5.

In its comparator analysis PwC finds that the spot asset beta and six month average asset beta for Frankfurt Airport and Aéroports de Paris are respectively 0.48 and 0.47 (for Frankfurt Airport), and 0.58 and 0.55 (for Aéroports de Paris). These values lead to a range of 0.47-0.58 which is materially higher than the 0.42-0.52 range proposed for Heathrow. It appears that PwC does not give any weight to the level of beta estimates of Frankfurt Airport and Aéroports de Paris despite acknowledging that, among the comparators considered, these are the most relevant to Heathrow. Indeed, we note that, given the lack of data for Paris during Q5, one cannot observe whether or not Paris's beta has since increased.

We note that one problem with using Frankfurt and Paris betas to infer the level of Heathrow's beta is that these airports may have a different mix of activities, with different risk levels, to Heathrow. We have therefore used disaggregation techniques to reconstruct appropriate beta estimates for Heathrow, using data on Frankfurt and Paris, but adjusting for Heathrow's mix of activities. We disaggregated ADP's and Fraport's group asset betas using data on their operating activities using the following relationship:

$$\beta_{\text{GROUP}} = \sum_i w_i \beta_i$$

where β_{GROUP} is the asset beta of the whole group, β_i is the asset beta of the i^{th} operating segment and w_i is the proportion of total assets segment i . We used this to estimate asset betas for the aviation segments of Frankfurt and Paris's businesses, and then

To estimate the asset betas of the non-aviation segments of ADP and Fraport, we used returns data from a number of Bloomberg industry sector indices from European companies to calculate equity betas. To convert these to asset betas, we constructed market capitalisation-weighted averages of the gearing levels of the companies comprising the indices. So as to be consistent with PwC's preferred methodology, we used equity betas calculated on five years of returns data. As the companies comprising these indices come from a number of European countries, we use a Europe-wide equity market index. To calculate asset betas from these, we estimated gearing using the ratio of net debt to the sum of net debt and market capitalisation and assumed zero debt betas. Throughout this exercise we also assume debt betas of 0.1 for the purposes of calculating asset betas and re-levering equity betas. As a range of possible asset betas

matched the description of the activities, we constructed ranges for Fraport's and Paris's aviation asset betas by using the highest and lowest sector asset betas that matched the descriptions of Fraport's and Paris's segments.

Fraport

We estimated Fraport's five-year asset beta, assuming a debt beta of 0.1, to be 0.56. To disaggregate this, we made use of the following data on Fraport's assets.

Table 4: Disaggregation of Fraport Group's Assets

Segment	Description	Assets (€ million)	Proportion of Total
Aviation	Airside and Terminal Management, Corporate Safety and Security; Airport Security Management.	4023.2	43.61%
Ground Handling	Ground Services	705.9	7.65%
Retail & Real Estate	Retail and Properties	2483.1	26.92%
External Activities & services	Global Investments and Management; Information and Telecommunications; Facility Management; Corporate Infrastructure Management	1928.2	20.90%

Source: Fraport Annual Report 2011

For the purpose of our analysis, we amalgamated the aviation and ground handling segments into one category. As retail and real estate combine two areas, we estimated an asset beta range. To estimate a real estate asset beta we used the Bloomberg 500 Real Estate index, while for retail we used a market-capitalisation weighted average of returns on the Bloomberg 500 Retail and Food Retail indices. For External Activities we also used the Bloomberg 500 Commercial Services and Telecommunications Services indices as part of our range estimate.

Table 5: Disaggregation exercise for Fraport Aviation and Ground Handling equity and asset betas

Segment	Proportion of Assets	Asset Betas	
		Lower	Upper
Group Total	100.0%	0.561	0.561
Retail & Real Estate	27.2%	0.808	0.421
External Activities & services	21.1%	0.610	0.511
Aviation & Ground Handling	51.7%	0.412	0.655

Source: Bloomberg and Europe Economics Calculations

Paris

We estimated Paris's five year asset beta, assuming a debt beta of 0.1, to be 0.71. To disaggregate this, we made use of the following data on Paris's revenues.

Table 6: Disaggregation of Aéroports de Paris' Revenues

Segment	Description	Revenue (€ million)	Proportion of Total
Aviation	Aeronautical fees; ancillary fees; airport security tax; other revenue.	1505	53.0%
Retail and services	Commercial activities (shops, bars and restaurants, car parks, rentals within terminals); commercial distribution joint ventures; advertising activities.	841	29.6%
Real estate	Aeronautical real estate; diversification real estate.	241	8.5%
Other activities	Security services; airport management or design; telephony.	255	9.0%

Source: Aéroports de Paris Annual Report 2011

As retail and real estate are separated in Paris's accounts, we were able to use the Bloomberg 500 Real Estate index and the composite of the Retail and Food Retail for these segments. To produce a range, for Other Activities we used asset betas calculated using the Bloomberg Commercial Services and Telecoms Services indices. The results of the disaggregation exercise are shown below.

Table 7: Disaggregation exercise for Paris aviation equity and asset betas

Segment	Proportion of Assets	Asset Beta	
		Lower	Upper
Group Total	100.0%	0.706	0.706
Retail and Services	29.6%	0.808	0.808
Real Estate	8.5%	0.421	0.421
Other Activities	9.0%	0.610	0.511
Aviation	53.0%	0.710	0.727

Source: Bloomberg and Europe Economics Calculations

Heathrow

Finally, in order to construct a beta appropriate for Heathrow, we combined the implied range of aviation asset betas for Paris and Fraport with data on the apportionment of Heathrow's revenue between different segments in order to reconstruct an asset and equity beta range for Heathrow. The table below shows data on the makeup of Heathrow's revenues.

Table 8: Disaggregation of Heathrow's Revenues

Segment	Revenue (£ million)	Proportion of Total
Aeronautical income	1297.7	58.1%
Retail income	460.1	20.6%
Operational facilities and utilities income	162.9	7.3%
Property rental income	102.5	4.6%
Rail income	116.0	5.2%
Other income	95.4	4.3%

Source: Heathrow

Given this revenue apportionment, we construct an asset and equity beta range, using appropriate asset betas for Heathrow's revenue segments. The results of this analysis are shown in the table below.

Table 9: Reconstruction of Heathrow equity beta on the basis of Fraport and Paris aviation

		Fraport		Paris	
		Low	High	Low	High
Aviation	58%	0.412	0.655	0.710	0.727
Retail income	21%	0.673	0.673	0.673	0.673
Operational facilities and utilities income	7%	0.506	0.506	0.506	0.506
Property rental income	5%	0.421	0.421	0.421	0.421
Rail income	5%	0.771	0.771	0.771	0.771
Other income	4%	0.610	0.610	0.610	0.610
Asset Beta		0.500	0.641	0.673	0.683
Equity Beta at 60 per cent gearing		1.100	1.454	1.533	1.558

Disaggregating the Fraport and Paris betas and then applying this to Heathrow's revenue sources therefore gives an implied equity beta range for Heathrow of 1.10 to 1.46. This gives a mid-point estimate of 1.33, which is almost identical to Europe Economics' point estimate of Heathrow's equity beta of 1.3.

Conclusion: *The results of the disaggregation exercise produce results that confirm Europe Economics' recommended estimate for Heathrow's equity beta, giving an equity beta of around 1.3 at 60 per cent gearing.*

1.5 Skewness and the airport sector

In their "Paper on the split cost of capital and skewed returns" prepared by PwC for the CAA, PwC acknowledges that there is empirical evidence suggesting that, in the long run, market returns are negatively skewed. Their analysis on the FTSE All Share indicates a skewness of -0.33 for the UK market since 1992. This result is similar to the one we found in our "Heathrow Cost of Capital" paper. After reviewing the literature on skewness premium, PwC endorses the idea that investors require higher rates in compensation for negatively skewed assets, and acknowledges that, in principle, there is a sound theoretical basis for attempting to incorporate skewness in the cost of capital.

Point of Challenge 1: *PwC argues that evidence of co-skewness for BAA until it was delisted is mixed. PwC analysis (which is based on estimation of Harvey and Siddique conditional co-skewness) finds evidence of negative co-skewness for BAA in the recent past (2001-2006), but a positive co-skewness over the long-run (1987-2006).*

We note that PwC find that Heathrow is positively co-skewed over the long run (1987 to 2006), but they find that co-skewness falls steadily across this period, changing from being positive in the periods 1987-1991 and 1991-1996 to being negative in the periods 1996-2001 and 2001-2006. This suggests that Heathrow has become increasingly negatively co-skewed over time. In particular, since 2006 (i.e. since the data window used for the Q5 analysis, upon which PwC's equity beta conclusion is based), the co-skewness of airports in general, and Heathrow in particular, has **changed** so that holding their equity contributes to the negative skewness of an investor's portfolio, and therefore **increases** the cost of equity.

PwC notes that the gammas that Europe Economics estimated for BAA from mid-2003 to the end of 2005 were positive, being 0.57 regardless of which index was used. This can be seen in Table 6.15 of our report. We note that these gammas were calculated using the Kraus and Litzenberger methodology, and their interpretation requires an understanding of the skewness of the market as a whole. As can be seen in Table 6.14 of the same report, the UK, Europe and World equity indices we used in calculating these gammas were negatively skewed for the period under consideration. Since the Kraus and Litzenberger gamma showed that BAA was positively co-skewed with the market, this means that BAA was contributing to the negative skewness of the market, albeit less than the average firm.

To repeat: we are not contending that the evidence suggests significant co-skewness meant that the cost of equity for Heathrow implied by the standard CAPM model was an under-estimate up to 2006. Rather, we contend that the co-skewness of airports in general, and Heathrow in particular, has risen since the last price control, and that rise in co-skewness is regarded by investors as unattractive.

This point can be seen in Figure 8.

Figure 8: Co-skewness for the European Airport and Utilities sectors

Note: Co-skewness defined by the Harvey and Siddique (HS) gammas, on a 5 year rolling basis. A positive (negative) HS-gamma implies that an asset is more positively (negatively) skewed relative to the market (irrespective of the underlying market-wide skewness), and a HS-gamma value of zero implies that an asset is as skewed at the market average.

In this diagram we contrast two periods. In the period affecting the calculation of equity beta for the Q5 price control, we can identify two important features of the data:

- a) Co-skewness for airports was becoming more negative, from being only slightly negative;
- b) Co-skewness for airports and utilities was similar, with utilities having been more negatively skewed at the start of the data window period for which airports data is available.

By contrast, in the Q5 period itself (2008 on) we see a “new normal”, characterised by two key features:

- a) Co-skewness for airports and utilities have become very dissimilar — whereas utilities have exhibited markedly positively skewed returns during Q5 (of benefit to investors with standard risk aversion), airports returns have been markedly negatively skewed (imposing a cost on investors with standard risk aversion);
- b) Co-skewness for airports has been continuously negative, typically at around the peak negative skewness seen at the end of the Q5 analysis data window (i.e. the start of 2006) and often more so than that.

This implies that co-skewness for the European airports sector has become materially more negative since the Q5 data window and that this is not a characteristic shared with other regulated entities such as utilities. Hence if, as PwC implies, co-skewness for Heathrow was already negative in the period up to 2006, then even if it had been typical of other European airports (noting that we contend that, being more capacity constrained, its negative skewness has increased, in recent years, by more than most airports), it should now be expected to be materially more negatively co-skewed.

Conclusion: Evidence suggests that the negative co-skewness of Heathrow and airports in general has increased since the last price control, and that this has implications for the cost of equity. In particular, it implies that the data

window used in the Q5 price control cannot be regarded as reflective of the current investor risk assessment for Heathrow.

Point of Challenge 2: PwC argues that analysis of recent co-skewness produced by Heathrow based on operational data is not considered robust because volumes of passengers do not represent a good proxy for equity returns.

The skewness analysis conducted by Heathrow based on its operational data should then be interpreted as a cross-check which confirms the idea that negative co-skewness in the airport sector has become a material issue in recent years, and more so for Heathrow.

Conclusion: Operational data should be considered as a cross-check, not an end in itself.

Point of Challenge 3: PwC argues that co-skewness coefficients (gammas) are particularly volatile, and that the allocation of a skewness adjustment to Heathrow would be complex and arbitrary.

We agree with PwC that the gamma parameters are typically more volatile than other CAPM components. We also appreciate that the lack of recent market data imposes further challenges to an analysis aimed at assessing the appropriate skewness premium for Heathrow. However, these challenges should not prevent the CAA from reflecting upon the potential implications that asymmetric down-side risk might have for Heathrow cost of equity. The analysis reported above suggests that, whilst before 2008 the symmetric properties of airport returns were largely comparable to that of other utilities, airport assets are now characterised by a larger down-side risks compared to other utilities (although Heathrow's own asymmetry may pre-date this), we believe it would be inappropriate ignoring altogether any skewness adjustment for Heathrow in Q6. Whether the skewness effect is estimated directly through a third moment CAPM approach, or it is assumed to be embedded in the beta coefficient of standard CAPM model, market evidence suggests that an uplift in the cost of equity of Heathrow to reflect the negatively skewness nature of its returns would be required.

Conclusion: There are strong reasons to believe that skewness has increased the cost of equity since 2006, and acknowledging this can be done by uplifting the cost of equity. Combining the strong evidence of increasingly negative co-skewness with the higher equity betas suggested by Heathrow's most appropriate comparators suggests a higher equity beta than was appropriate for Q5.

1.6 Conclusions

The table below summarises the PwC arguments that we seek to challenge and our response.

Table 10: PwC points of challenge and Europe Economics' responses

WACC Component	Point of Challenge	Europe Economics' Response
Risk-free rate	PwC states that the risk-free rate is "the rate of return that can be earned on riskless investments" and therefore infers the risk-free rate from gilt yields.	It is not the case that the return on a risk-free asset is necessarily the risk-free rate in the CAPM. The risk-free rate and the yield on gilts are therefore not synonymous.
Risk-free rate	For its "current market" approach, PwC uses spot data for real and nominal gilt	This may prove problematic given that the forward curve is itself calculated on

WACC Component	Point of Challenge	Europe Economics' Response
	yields to determine the “current” risk-free rate, and then uses the forward curves to infer an expected increase to 2016, partly reflecting the unwinding of the effects of Quantitative Easing.	the basis of the spot curve, and distortions caused by QE may have affected the shape and position of the spot curve.
Risk-free rate	In their “long-term returns” approach, PwC use historical averages to estimate the risk-free rate.	There are good theoretical and empirical reasons to believe that the risk-free rate will rise in line with the sustainable growth rate. A forecasting approach is therefore available.
Debt Premium	The debt premium in PwC’s “long-term” scenario of 110 bps is almost identical to the 105 bps debt premium determined in the Q5 price review.	This implies that the low levels of debt premium seen before 2007 were sustainable in the long term, which is in contrast to the generally accepted view that risk was under-priced in the period leading up to the financial crisis.
Equity Beta	PwC does not appear to attach weight to beta estimates for Frankfurt and Paris, which show a materially higher beta than was determined for Heathrow in Q5, despite acknowledging that Paris and Frankfurt are Heathrow’s most appropriate comparators.	Europe Economics has conducted a disaggregation analysis which supports a higher equity beta range than was determined in Q5.
Equity Beta/Skewness	PwC argues that evidence of co-skewness for BAA until it was delisted is mixed. PwC analysis finds evidence of negative co-skewness for BAA in the recent past, but a positive co-skewness over the long-run.	Europe Economics’ argument is not that Heathrow’s returns have always been negatively co-skewed (in the Harvey and Siddique sense), but that since the last price control they have become so in such a ways as to increase the required return on Heathrow’s equity.
Equity Beta/Skewness	PwC argues that analysis of recent co-skewness produced by Heathrow based on operational data is not considered robust because volumes of passengers do not represent a good proxy for equity returns.	The use of operational data is viewed as a cross-check, and the establishment of skewness in returns for Heathrow is not dependent on this point. It remains the case that both returns and operational data are negatively co-skewed in the Harvey and Siddique sense.
Equity Beta/Skewness	PwC argues that co-skewness coefficients (gammas) are particularly volatile, and that the allocation of a skewness adjustment to Heathrow would be complex and arbitrary.	As it has been established both that skewness matters for investors and that Heathrow is negatively co-skewed (in the Harvey and Siddique sense), this should be reflected in the cost of equity. This can be done by either adding an additional term to the CAPM, or

WACC Component	Point of Challenge	Europe Economics' Response
		embedding an adjustment in the estimated equity beta.