Sky's Cost of Capital

Annex 10 to pay TV phase three consultation document

Publication date: 26 June 2009

Contents

Section 1

Summary

1.1 Our approach to determining cost of capital is based on the capital asset pricing model (CAPM), which calculates the return that investors (both debt and equity) expect in return for bearing risk. Although not the only asset pricing model, it is the most widely used, particularly in the regulatory community, and is a model that Ofcom (and Oftel) has consistently used.

1.2 The CAPM expresses cost of capital in terms of an average of the returns expected by debt and equity holders, weighted by value. This is commonly termed a company's WACC (weighted average cost of capital).

1.3 The estimates given here form part of our consultation, and respondents' views are sought on the methodology and the figures in this annex.

1.4 For the purposes of our current review, we use the current forward-looking cost of capital from 2009 as an estimate of the 2004 – 2008 WACC, since Sky's current risk and return profile is substantially the same as it was in 2004. While the market has undoubtedly changed in the last few years, we think that Sky's current risk-return profile is a reasonable estimate of its profile in 2004.

1.5 Figure 1 below shows our estimates of Sky's WACC that we are consulting on:

Figure 1 Changes in Sky's estimated WACC

Period	Estimate	Source
2004 – 2008	~10.3%	Estimate based on forward-looking WACC
2009 onwards	10.3%	Forward-looking WACC

Section 2

Current cost of capital

2.1 In this section we set out our views on Sky's estimated forward-looking cost of capital, which can be used when considering Sky's future profitability.

2.2 International capital markets have been in a state of flux for the last year, with a number of financial institutions failing or receiving substantial state funding, both in the UK and the rest of the world. This process has been accompanied by a global recession.

2.3 The level of uncertainty and volatility in equity and credit markets is very high, and cost of capital inputs have been affected by this volatility. Therefore this is a period in which great care needs to be taken in separating short-term and long-term effects.

2.4 Taking into account all the information available to us at this time, our estimated pre-tax nominal WACC is 10.3% for Sky.

2.5 Our calculations are based on the following range of estimates:

Figure 2 Sky's estimated Cost of Capital

	Sky
Equity Risk Premium	5%
Equity Beta	0.85
Risk-free rate	4.5%
Debt premium	1.5%
Gearing	30%
Pre-tax nominal WACC	**10.3%**

2.6 In arriving at these values, we have, amongst other things, had regard to Section 3(4)(d) of the Communications Act 2003; i.e. to have regard to the desirability of encouraging investment and innovation in relevant markets when exercising our duties.

2.7 Ofcom has a duty to promote efficient investment, and as such should set rates of return at a level that allows a reasonable return on investment and encourages future efficient investment.

Equity Risk Premium ("ERP")

Key parameter in CAPM

2.8 The ERP is a key component of the estimate of a company's WACC. Under the CAPM the ERP represents the extra return that investors require as a reward for investing in equities rather than a risk-free asset. It is market-specific, not company-specific.

2.9 Academics and other users of the CAPM have conducted a large number of investigations into the value of the ERP, using quantitative techniques and surveys. These have produced a range of widely differing estimates, which means that we (and other economic regulators) have to choose a value from within the plausible range implied by these studies.

2.10 Our approach to estimating the ERP can be found in our 2005 Cost of Capital statement entitled "Ofcom's approach to risk in the assessment of cost of capital"[1].

Alternative estimation methods and estimates

2.11 A number of different methods are used to measure the return that investors will require for investing in equity markets. These may be based on historical investment returns (i.e. an ex post approach), or on forward-looking considerations (i.e. an ex ante approach).

2.12 We consider the following estimation methods:

a) Ex-post estimation.

b) Extrapolating observed historical risk premia.

c) Extrapolating adjusted historical risk premia.

d) Ex-ante estimation: (i) using the dividend growth model, and (ii) using surveys of academic and user expectations.

Ex post estimation – extrapolating historical risk premia

2.13 We are relying on work carried out by the London Business School's Dimson, Marsh and Staunton ("DMS")[2], which is regarded as being one of the most authoritative sources of historical estimates. DMS measure total returns over a relatively long period, include a large sample of countries and make adjustments for survivorship bias[3].

2.14 The estimates from DMS suggest it would be appropriate to give weight to historic premia between 4.0% and 5.5%.

2.15 Note that these estimates are calculated using arithmetic means from historic data. Arithmetic means are our preferred measure of the historic premia, and we give more weight to arithmetic means than to geometric means from the same data[4].

2.16 DMS themselves have suggested an arithmetic mean premium for the world index of around 4.5 – 5.0%.[5] They state that "this is our best estimate of the equity risk

[1] http://www.ofcom.org.uk/consult/condocs/cost_capital2/statement/
[2] Dimson, Marsh and Staunton, 2008, "Global Investment Returns Yearbook 2008", ABN AMRO, London Business School, and 2009, "Credit Suisse Global Investment Returns Sourcebook 2009", Credit Suisse
[3] Survivorship bias describes an effect caused by looking at share prices over a long period of time, during which a certain percentage of any starting group would be expected to go into administration or be de-listed. Therefore the only shares that can be tracked over a long period of time are by definition those that have endured, and by implication, have been most successful. Therefore it is necessary to adjust for a natural level of wastage from the opening sample.
[4] See our 2005 Cost of Capital statement for further discussion of this issue: http://www.ofcom.org.uk/consult/condocs/cost_capital2/statement/final.pdf

premium for use in asset allocation, stock valuation, and corporate capital budgeting applications". In addition, for the UK, DMS's estimated premium of equities over bonds (as measured by the arithmetic mean in the period 1900 – 2008) is 5.0%[6].

Ex post estimation – extrapolating adjusted historical risk premia

2.17 Using DMS data implies a range for the adjusted ERP over bonds of 3 to 4.5%.

2.18 We note that the DMS adjustments are fairly subjective, and we would advocate putting only a modest amount of weight on these adjusted returns.

Ex ante estimation – estimates not based on historic returns

2.19 The ERP can be estimated without using historical data.

2.20 The dividend growth method is based on forecasts of future dividend growth. With this method it is possible to calculate an "implied" ERP using current market values and forecasts for earnings/dividends.

2.21 In the 2005 Cost of Capital statement we presented a range of ERP estimates based on this method of estimation with a midpoint of 3.5 to 4%.

2.22 In response to our consultation documents that preceded the 2005 Cost of Capital statement some stakeholders argued that approaches of this type are seriously flawed since they rely on highly subjective input parameters i.e. analyst expectations and an assumption of constant growth rates.

2.23 We agree that approaches of this type require the use of highly subjective parameters. As a result, we place relatively little weight on this type of analysis. This means that the range presented at the time of our 2005 Cost of Capital statement is still relevant.

Ex ante estimation - academic/user surveys

2.24 It is possible to estimate the ERP by using surveys carried out amongst academics and users of the CAPM. Participants are asked to quantify the returns that they expect from the equity market over a particular time horizon.

2.25 The first consultation that we published in January 2005[7] in relation to assessing BT's cost of capital set out the range of views of academics as being from 3 to 7%, while the views of practitioners ranged from 2 to 4%.

2.26 A study of US finance academics, carried out by Ivo Welch, suggested that an estimate of the ERP based on academic views might be around 5% on a geometric mean basis, or 6% on an arithmetic mean basis. This is based on a sample of about 400 finance professors' views on the 30-year geometric equity premium.[8]

[5] DMS 2009, p34
[6] DMS 2009, p146
[7] http://www.ofcom.org.uk/consult/condocs/cost_capital/cost_capital.pdf
[8] http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1084918

2.27 A more recent study from 2008 by Pablo Fernandez[9] suggests that UK finance professors used ERP estimates with an arithmetic mean of 5.5%.

2.28 We would afford this analysis relatively little weight since participant surveys do not provide the same quality of evidence as market-based measures.

Regulatory benchmarks

2.29 The range of ERP estimates adopted by the UK's economic regulators and competition authorities is in the range of 3% to 5%.

Figure 3 Regulatory benchmarks of ERP

Source/Year	ERP	Comment
Ofcom, 2005	4.5% (range of 4.0% to 5.0%)	Our approach to risk in the assessment of the cost of capital, 18 August 2005
Ofwat, 2004	4.0% – 5.0%	For period 2005 – 10. To be reviewed in 2009.
Ofgem, 2006	4.0% - 5.0%[10]	Difference between market return of 6.5% to 7.5% and risk-free rate of 2.5%.
CC/CAA, 2008	3% - 5%[11]	5-yr review of cost of capital for BAA Stansted Airport[12]
FSA, 2006	4.0%[13]	Difference between market return of 8.1% and risk-free rate of 4.1%.

Our objectives in determining the ERP

2.30 In determining an appropriate value for the ERP, we have looked to previous decisions by ourselves, other economic regulators, and the Competition Commission.

[9] Fernandez, Pablo: Market Risk Premium Used in 2008 by Professors: A Survey with 1,400 Answers (April 16, 2009). Available at SSRN: http://ssrn.com/abstract=1344209

[10] http://www.ofgem.gov.uk/Networks/Trans/PriceControls/TPCR4/ConsultationDecisionsResponses/Documents1/16342-20061201_TPCR%20Final%20Proposals_in_v71%206%20Final.pdf

[11] The Competition Commission have a broad range for the ERP as part of their WACC analysis, but end up choosing a point estimate at around the 80th percentile of the overall range. An ERP estimate at the 80th percentile of the above range would give a point estimate of 4.6%.

[12] http://www.caa.co.uk/docs/5/ergdocs/ccstanstedl.pdf
Note that the Competition Commission provide some commentary on the way they approached calculations of the expected market return on pL17-L18.

[13] http://www.fsa.gov.uk/pubs/cp/cp06_03.pdf

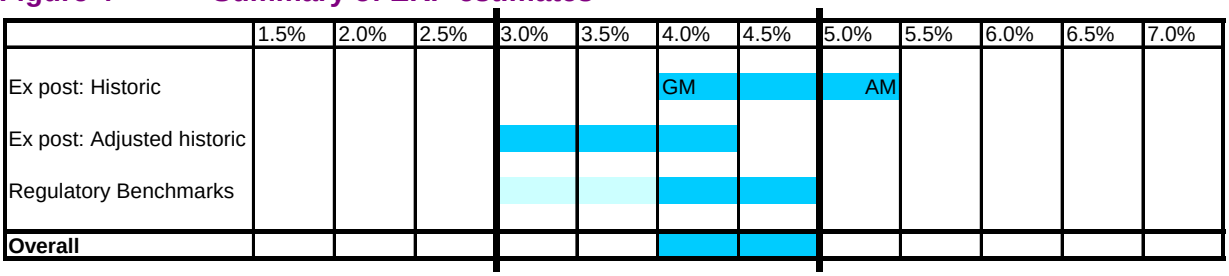
2.31 We have had regard to Section 3(4)(d) of the Communications Act 2003 ("The Act"); i.e. to the desirability of encouraging investment and innovation in relevant markets when exercising our duties.

2.32 While setting rewards too low could lead to discretionary investment being discouraged, setting rewards too high could lead to consumers paying prices that are too high (or investments that are not fully justified by demand).

A range of values for the ERP

2.33 Figure 4 below summarises our ERP estimates.

Figure 4 Summary of ERP estimates



2.34 We believe that our broad range of 4 to 5% reflects a balanced view of the available evidence, but our bias is towards placing more weight on the ex-post historic estimates than other estimates of the ERP.

2.35 We have reviewed evidence from market commentators and the Bank of England, and believe that the prolonged downturn in equity markets and high levels of volatility suggest that the equity risk premium has increased in recent years. Evidence from the US, which has experienced similar equity market volatility to the UK, suggests that the market-wide cost of equity capital has increased by about half a percentage point[14].

2.36 We maintain our belief that the downside of setting an ERP too low is worse than the downside of setting the ERP too high. We therefore tend to favour setting the ERP towards the upper end of the 4 to 5% range.

2.37 Specifically, our point estimate for the ERP is 5.0%, at the top of our range of 4 – 5%.

2.38 Our decision to choose a point estimate at the top of our prior range is in response to increased market volatility and turbulence, which is likely to lead to investors requiring increased returns in exchange for holding equity rather than risk-free assets.

2.39 In selecting a point estimate of 5.0% for the ERP, we have taken account of many factors, including recent market volatility, the longer-term outlook, and the views of market participants such as the Bank of England and other independent commentators.

[14] McKinsey Quarterly December 2008, p2: http://www.mckinseyquarterly.com/Why_the_crisis_hasnt_shaken_the_cost_of_capital_2269

Sky's equity beta

2.40 The value of a company's equity beta reflects movements in returns to shareholders (as measured by the sum of dividends and capital appreciation) from its shares relative to movements in the return from the equity market as a whole.

2.41 We estimate Sky's equity beta to be 0.85, based on a report we commissioned from the Brattle Group[15], which measured the daily correlation between Sky's share price movements and the FTSE Allshare and FTSE Allworld indices.

2.42 Brattle concluded that Sky's equity beta lies in the range 0.75 – 0.95, with a mid-point of 0.85. It also concluded that Sky's equity beta does not appear to have moved as a result of the small movements in Sky's gearing level, which has been between 12 and 22% for the last two years. In addition, none of the beta estimates is biased, and they pass several statistical tests. In this sense, the results can be seen as robust.

2.43 Based on Brattle's report, we estimate Sky's equity beta to be 0.85, the mid-point of Brattle's range.

Gearing levels

2.44 Our approach to gearing is to assume an optimal level of gearing, which is that at which the cost of capital is minimised and the value of the firm is maximised. Since the cost of debt is lower than the cost of equity, this suggests that the optimal rate would favour debt financing. However, if the level of debt gets too high the risk of financial distress increases very quickly, and equity investors recognise that their claim on the assets of a firm in financial distress comes after the claims of debt holders. Therefore, equity holders will be wary of high levels of gearing, particularly in firms where there are limited fixed assets (which could be liquidated in the event of distress).

2.45 So we would expect investors of Sky, which would have relatively few assets to sell in the event of financial distress, to want lower levels of gearing than those of a company like BT, where substantial valuable fixed asset investments might help to insulate investors from the risk of losing their investment. As a point of reference, we assume the optimal gearing rate to be 35% for BT Group, which was based on BT's long-run average gearing up until the last few years.

2.46 On the basis that investors should want a gearing rate that maximises the benefit from cheaper debt financing, but without jeopardising the financial viability of the firm, we assume an optimal gearing level of 30% for Sky.

Debt markets

Introduction

2.47 Our WACC calculations require two further inputs in addition to those already set out:

a) The risk-free rate.

b) Sky's debt premium.

[15] See p18 of this annex.

2.48 Since the latter half of 2007 there has been increased uncertainty and volatility in world credit markets, and we have been mindful of this when considering our estimates of debt parameter values.

2.49 In 2008 we noted two effects, which are partially offsetting for the purposes of our calculations:

- As volatility and uncertainty in credit and property markets increased, central bank interest rates fell and the risk-free rate also dropped.
- The demand for corporate debt diminished and the required spreads on corporate debt issues increased, pushing up corporate debt premia.

2.50 In this period, nominal gilt yields first increased and then fell back more recently, as investors' desire for low-risk assets, such as government gilts, drove up demand, pushing prices up and yields down. In addition, declines in expected inflation have pushed nominal gilt yields down. As part of the same preference for low-risk assets, spreads on corporate bonds (which are more risky than government gilts) increased, and continue to be at relatively high levels.

2.51 In 2009 corporate debt yields have reduced somewhat but are still at historically high levels. Sky's most recently issued debt currently trades at around 2% above equivalent government gilts, which reflects its Baa1/BBB credit rating.

2.52 In 2009 a number of macroeconomic factors have become apparent:

- Partially as a result of global efforts to tackle the worldwide recession, the UK government's level of borrowing has increased markedly in the last year, which has resulted in the supply of government gilts being increased. While investor demand for gilts remains strong, the increased supply has reduced prices and increased yields over the last month or so. Given the high level of expected debt issuance by the UK government over the next few years, we expect this effect to continue, and the comparatively low current yields seen today are unlikely to endure.
- As part of the Bank of England's monetary stimulus package, it has embarked on a policy of quantitative easing, which has included the central bank purchasing selected corporate bonds. This effect, while relatively minor, may help to increase prices for the corporate bonds in question, which will in turn reduce yields and spreads over gilts.

2.53 Given the factors set out above, our expectation is that the current levels of corporate bond spreads are unlikely to remain at such elevated levels for the next 10 years.

The risk-free rate

2.54 The risk-free rate of interest is an input into both the calculations of the cost of debt and the cost of equity.

2.55 For a UK company, a proxy for the nominal risk-free rate is the yield to maturity on gilts, or government strips[16], while the real risk-free rate can be proxied by the yield

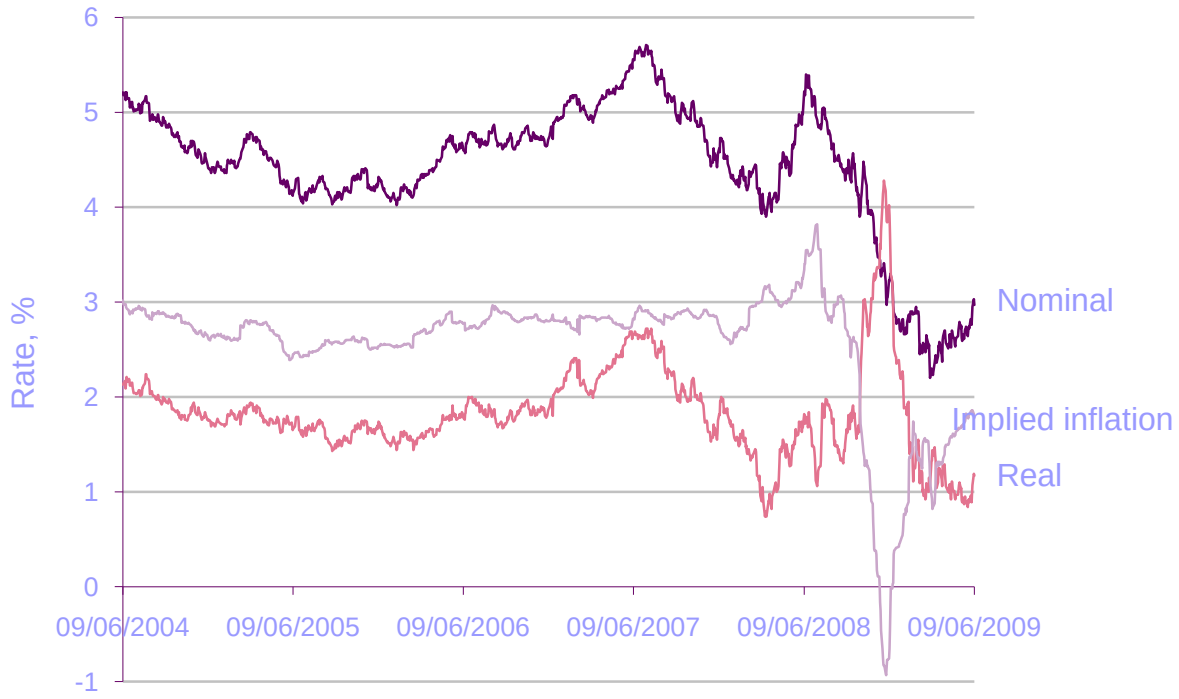
[16] STRIPS = Separate trading of registered interest and principal securities - fixed-income securities sold at a significant discount to face value which offer no interest payments because they mature at par.

on index-linked gilts of appropriate maturity. The difference between the two provides an estimate of forecast inflation.

2.56 We can track the nominal, real and implied forecast inflation rates over time, using Bank of England data on five-year duration gilts, as shown by Figure 5 below.

2.57 From Figure 5 we can see that the nominal yield peaked at around 5.8% in July 2007 but in 2009 has been below 3%, primarily due to very sharp falls in inflation expectations. At the same time, real gilt yields peaked at a high of over 4%, but are now closer to 1%.

Figure 5 Five year gilt yields – Nominal, Real & Implied Inflation



Source: Bank of England data

2.58 The average nominal yield for five-year zero coupon gilts has fallen over the last year. While we would generally tend to give more weight to more recent nominal rates than averages over past years, we are mindful that we do not wish to estimate the rate based on a period of unprecedented market turbulence.

2.59 Given the likelihood of increasing nominal yields, we give more weight to the one, two, three and five year averages than recent very low rates.

Figure 6 Historic averages of Nominal, Real and Inflation five year rates (9/6/09)

Averaging period	Nominal	Real	Implied Inflation
Spot (9 Jun 09)	3.0	1.2	1.8
3 month	2.6	1.1	1.5
6 month	2.7	1.4	1.3
1 year	3.5	1.8	1.7
2 year	4.2	1.8	2.3
3 year	4.4	1.9	2.5
5 year	4.4	1.8	2.5

Source: Bank of England data

2.60 Using values from Figure 6, our broad range for the real risk-free rate is 1.8 to 2.1%. This range includes the average yields over a one year, two year, three year and five year periods, and can be viewed as a prudent range on which to base our real risk-free rate.

2.61 The nominal risk-free rate will then be given by the real risk-free rate plus an inflation assumption.

Inflation in our risk-free rate assumption

2.62 In the current environment, where the UK inflation rate (as measured by the RPI) has turned negative for the first time since 1960, we think it prudent to be explicit in our inflation assumptions (and hence our real and nominal risk-free rates).

2.63 Despite the recent volatility in observed real risk-free rates, we note that the average real gilt yield over the last one year, two years, three years and five years all lie within a narrow range of 1.8 – 2.1%. We therefore propose to use a forward-looking real risk-free rate of 2%[17].

2.64 We propose to use a long-term inflation assumption of 2.5%.

2.65 Bringing together our inflation assumptions with a real risk-free rate of 2.0%, gives us a nominal risk-free rate of 4.5%.

Sky's debt premium

2.66 Sky's current credit rating is Baa1 (Moody's) and BBB (S&P).

2.67 Sky's most recent debt issue was on 17th November 2008, when it issued $600m of 10-year bonds at more than 500 basis points above the equivalent US government

[17] This is also consistent with the CC in its Stansted paper (see table 12 on pL27 of http://www.competition-commission.org.uk/rep_pub/reports/2008/fulltext/539al.pdf)

bond rate. We note that this was around the high point of corporate debt spreads, and the current market price implies a yield of around 210 basis points.

2.68 Recent Bank of England data suggests that UK investment grade corporate debt spreads went up considerably after September 2008 (when Lehman Brothers went into administration).

2.69 The latest Bank of England Quarterly Bulletin[18] suggests that in the first quarter of 2009, investment-grade non-financial corporate bond spreads have narrowed from January 2009. However, the Bank notes that:

> "it seems unlikely that the compensation required by investors in corporate bonds to cover credit risk…would have fallen recently. Instead, contact reported a pickup in investor demand for exposure to corporate bonds which could have reduced the required liquidity premia embedded in secondary market corporate bond spreads."

2.70 The Bank's reference to embedded liquidity premia in corporate bond spreads hints at one of the problems with interpreting corporate bond spreads in the last year, i.e. trading volumes in corporate bonds have been thinner as investors focus on risk-free assets, such as government gilts.

2.71 In addition we note that the current high levels of corporate debt spreads are unlikely to endure for the long term, and we are comfortable with an estimated debt premium for Sky below this level.

Gearing and the debt premium

2.72 Sky's gearing level at the time of its most recent issue of debt was around 22%, above its current gearing level of around 17%. The slightly higher level of debt premium at the time of issuance may help to explain why Sky had to offer such a high yield on its debt, but it is more likely to be due to the level of market volatility following the collapse of Lehman Brothers, which resulted in a short-term spike in corporate bond rates.

2.73 We believe that a long term debt premium for Sky would sit in the range 1 – 2%, although the top end of this range would only apply in periods of relatively high market uncertainty and volatility, such as the conditions that prevail at present.

2.74 On a longer term view, we think that the debt premium for a mature, well-established and well-funded market operator may well tend towards the lower end of the range. At this stage, where we have relatively little visibility about the future state of credit markets and the effects of a global recession, we consider it appropriate to select an estimate of the long-term debt premium for Sky at the mid-point of our range, or 1.5%.

Parameter assumptions for CAPM

2.75 Figure 7 sets out our WACC estimates for Sky based on the estimates outlined in the sections above.

[18] http://www.bankofengland.co.uk/publications/quarterlybulletin/qb0901.pdf, p10

Figure 7 Pre-tax nominal WACC for Sky

WACC Component	June 09
Risk-free rate, %	4.5
Equity Risk Premium, %	5
Equity Beta	0.85
Cost of equity (post tax)	8.8
Debt premium, %	1.5
Corporate tax rate, %	28%
Cost of debt (post tax)	6.0
Gearing, %	30%
WACC (post tax)	7.4
WACC (pre-tax)	10.3

Section 4

Brattle Report into Sky's equity beta

ESTIMATE OF

BSB'S EQUITY BETA

MAY 2009

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1 Introduction

Ofcom has asked us to estimate BSkyB's equity beta, using similar methodology to that which we have previously used to estimate BT's equity beta in reports for Ofcom.[1] We have estimated BSkyB's equity beta by regressing daily returns against both the FTSE Allshare and Allworld indices. This report uses market data up to and including March 10th 2009.

In chapter 2 we present our results, and in chapter 3 we show some statistical tests of the reliability of our estimates.

In previous work[2] for Ofcom we discussed estimation methods and, in particular, whether to use daily or monthly returns in estimating equity betas. Here we follow the conclusions of that work, using daily returns because trading in BSkyB is highly liquid. The stock's liquidity prevents the emergence of any significant problems with using daily data.

[1] See, for example, *Updated Estimate of BT's Equity Beta*, October 2008.

[2] See *Issues in beta estimation for UK mobile operators*, July 2002.

2 Equity beta estimates

2.1 Current estimates

We have estimated BSkyB's equity beta by regressing daily returns on BSkyB equity against the daily returns on the market index. We use both the FTSE Allshare and the FTSE Allworld indices, and we use data up to March 10th 2009. Table 1 shows our results.

Table 1: current equity beta estimates

	Allshare		Allworld	
	1-year	2-year	1-year	2-year
Beta	0.92	0.88	0.82	0.83
Standard error	0.06	0.04	0.08	0.06

Notes
Using data to March 10th 2009.

2.2 Comparison with earlier estimates

Financial markets during the last 18 months or so have seen unusual volatility. Many stock prices and indices have fallen dramatically in connection with the "credit crunch" and the financial distress of several major financial institutions. It is prudent to consider whether these unusual conditions might affect equity betas. We therefore compare the estimates in Table 1 with the results of other regressions. One set of regressions uses data before the onset of the crisis. The data window ends in August 2007 prior to Northern Rock's receipt of liquidity support from the Bank of England. Another set of regressions uses data ending in August 2008 before Lehman Brothers entered Chapter 11 bankruptcy proceedings. Table 2 shows the results.[3]

Table 2: equity beta estimates at various points in time

	Allshare		Allworld	
End date	1-year	2-year	1-year	2-year
31/08/2007	0.53	0.61	0.62	0.71
31/08/2008	0.98	0.85	1.14	0.99
10/03/2009	0.92	0.88	0.82	0.83

Notes
The standard errors of these estimates are very similar to those in Table 1.

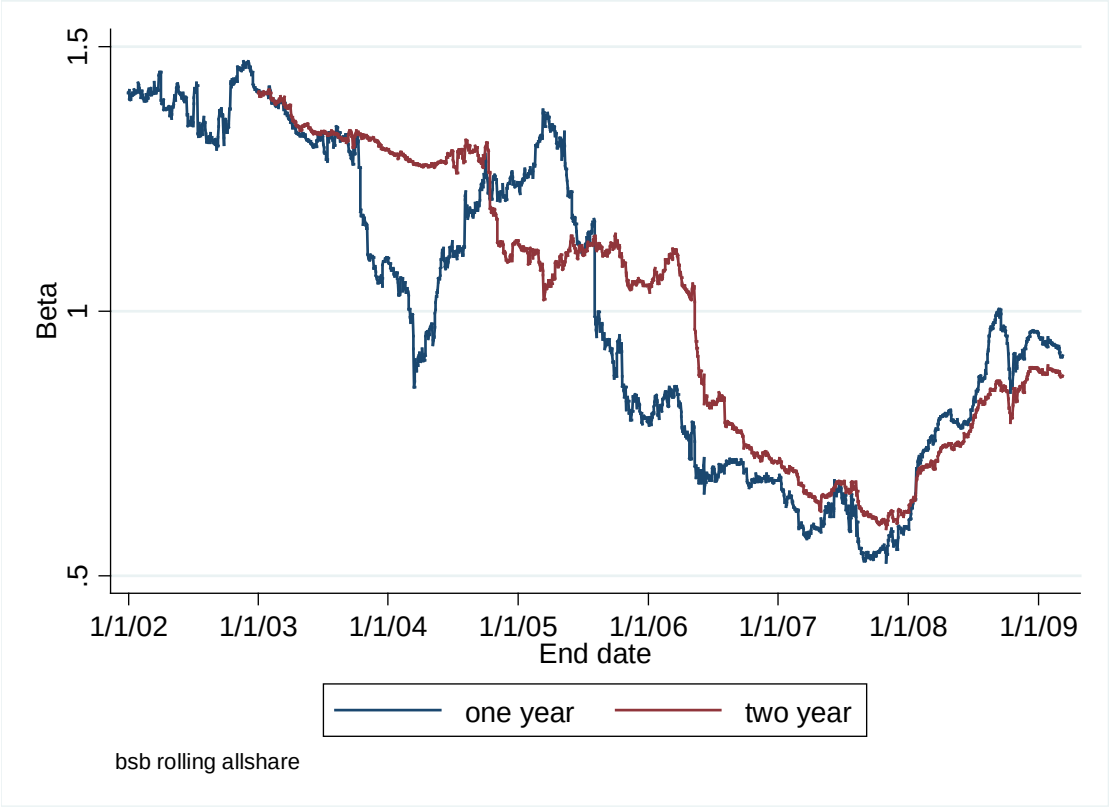
Table 2 shows that the chosen timeframe is important. There are around six standard errors between the Allshare August 2007 and March 2009 estimates, and around two for the Allworld. The underlying "true" equity beta may be changing. Chapter 3 shows the

[3] These dates were chosen to represent "pre credit crunch" and "mid credit crunch".

results of some statistical tests which do not suggest that any of the results in Table 1 and Table 2 are likely to be biased.[4]

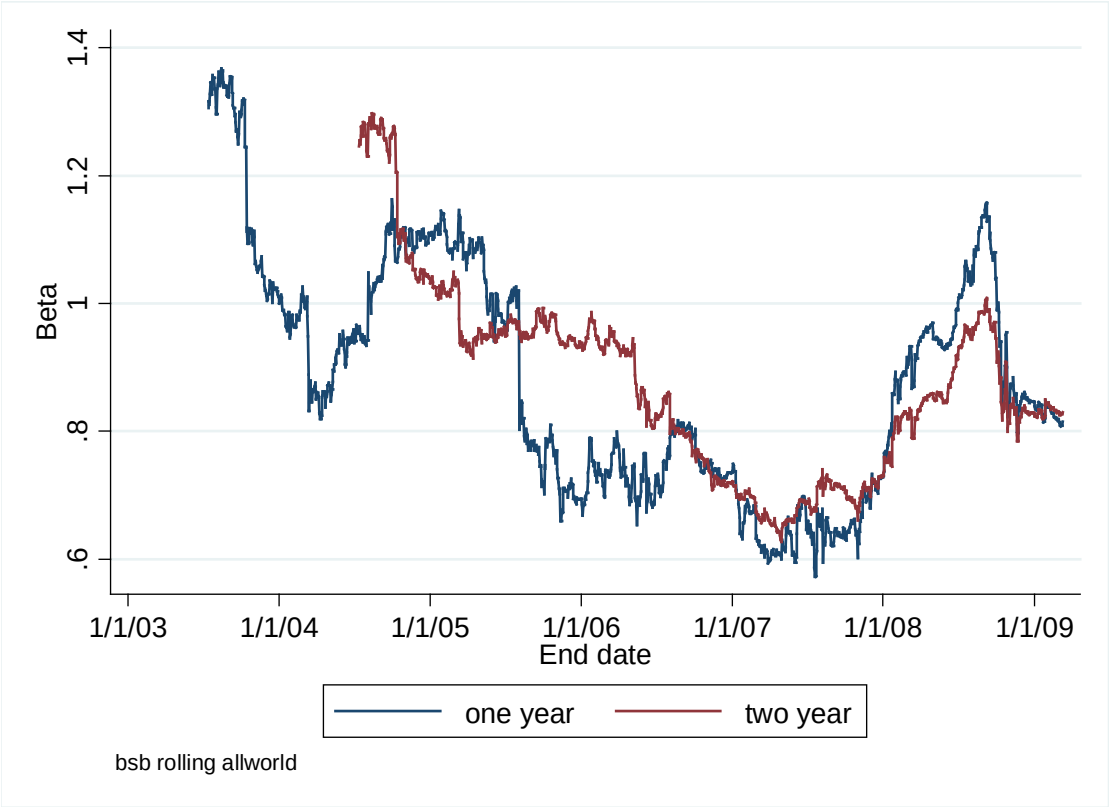
Figure 1 and Figure 2 plot a "rolling" estimate of the beta, which keeps the estimation window constant in length but shifts it back in time.

Figure 1: "rolling" beta estimates against the Allshare index



[4] As discussed below, the most recent Allworld regressions show evidence of auto-correlation, which implies that the regression results may be less certain than suggested by the standard errors. However, auto-correlation does not lead to bias.

Figure 2: "rolling beta estimates against the Allworld index



Note that the declines in the results and the subsequent increase do not necessarily mean that the beta has changed. Beta may be constant even as the data changes. Only the estimate may be changing. More statistical tests would be necessary to detect whether the underlying beta is changing. The standard regression approach of "ordinary least squares" assumes that the beta is constant throughout the particular time window examined. We discuss these results further in section 2.4

2.3 Gearing

Other things equal, we would expect equity beta to change if financial gearing changes. However, BSkyB's gearing has been reasonably constant over the past few years. Table 3 shows the relevant gearing estimates. Since these changes are relatively small, we would not expect large changes in equity beta to result (for example, if equity beta is 0.61 at 10% gearing, it would rise to 0.65 if re-levered[5] to 16% gearing, assuming a debt beta of zero). We therefore conclude that changes in gearing are not changing BSkyB's equity beta over time.

Table 3: BSkyB gearing

Date	Gearing at end of window	Gearing 1-year average	Gearing 2-year average
10/03/2009	22%	19%	16%
31/12/2008	21%		
30/09/2008	16%	15%	15%
30/06/2008	16%		
31/03/2008	14%		
31/12/2007	14%		
28/09/2007	12%	15%	10%
29/06/2007	12%		
30/03/2007	17%		
29/12/2006	17%		
29/09/2006	5%		
30/06/2006	5%		
31/03/2006	4%		
30/12/2005	4%		

Notes
Gearing defined as net debt divided by (net debt + market capitalisation).
The March 2009 figure is estimated (based on December 2008 net debt).

2.4 Discussion

The increase in beta estimates is not due to a significant increase in gearing. In chapter 3 we demonstrate that none of the estimates are biased, and they pass several statistical tests. However, chapter 3 does not rule out the possibility that our estimates may simply be mid-points within relatively wide ranges, because the standard errors may understate the total uncertainty of the estimates. Another possibility is that BSkyB's equity has changed over the past few years for other reasons than gearing.

If equity beta is in fact changing over time, the estimates we present here are much less certain than the standard errors of the regressions would suggest. The "Kalman filter" is a standard technique for estimating parameters that are changing over time, and this has

[5] We use a standard relevering formula (see *Principles of Corporate Finance* (8th edition), Brealey Myers and Allen, p. 518).

been applied to the estimation of equity betas.[6] Such techniques might be applied in this case, though we note that they typically produce estimates with rather wide confidence intervals.

To know with confidence whether and why the equity beta of a share changes over time would require some additional investigation into possible reasons for the change. The research should screen for company-specific events such as changes in investment plans, or for market-related events such as the technology boom around 2000.

The alternative possibilities prompt us to urge caution in interpreting our current beta estimates for BSkyB. The estimates might be less certain than implied by the standard errors of the regressions. Furthermore, the current estimates could reflect unusual and temporary market conditions.

The best current estimate for BSkyB's equity beta is 0.85, the average of the estimates shown in Table 1. We would normally recommend a range of +/- approximately two standard deviations around this mid-point figure—ie, a range of 0.75–0.95 in this case. However, in light of the discussion above, we would also recommend further analysis before discounting the possibility that BSkyB's equity beta might lie outside this range.

[6] See, for example, *Report on the cost of capital*, Smithers & Co., September 2006.

3 Statistical reliability

The use of daily returns data in regressions to estimate equity beta can risk introducing statistical problems, for example in relation to thin trading. These problems were discussed in earlier papers for Ofcom.[7] We have carried out a number of statistical tests of the regressions in this report to check for potential problems.

3.1 Dimson adjustment

To test for possible bias relating to the liquidity of trading, we make the "Dimson" adjustment to the estimated beta by including a one period lag and a one period lead in the regressions. In no case was the Dimson adjustment significantly different from zero.

Table 4: Dimson adjustments

End date	Beta	Dimson beta	Beta	Dimson beta
	Allshare - 1 year		Allshare - 2 years	
31/08/2007	0.53	0.64	0.61	0.59
31/08/2008	0.98	0.96	0.85	0.85
10/03/2009	0.92	0.80	0.88	0.80
	Allworld - 1 year		Allworld - 2 years	
31/08/2007	0.62	0.76	0.71	0.61
31/08/2008	1.14	0.93	0.99	0.89
10/03/2009	0.82	0.89	0.83	0.87

Notes
In no case is the Dimson adjustment significant at the 10% level.

3.2 Tests for heteroscedasticity and auto-correlation

One set of concerns about statistical reliability relates to the "standard assumptions" that underlie classic regression, specifically that the error term in the regression follows a normal distribution and does not suffer from heteroscedasticity or auto-correlation. Failure to meet these conditions does not invalidate the regression estimates (ie, the beta estimate), but it does have the following consequences:

1. Although OLS is still an unbiased procedure in the presence of heteroscedasticity and/or autocorrelation, it is no longer the best (least variance) estimator.

2. In the presence of heteroscedasticity and/or autocorrelation, the standard error may understate the uncertainty of the beta estimate.

3. Heteroscedasticity and/or auto-correlation may also indicate that the underlying regression is mis-specified.

[7] See *Issues in beta estimation for UK mobile operators*, July 2002.

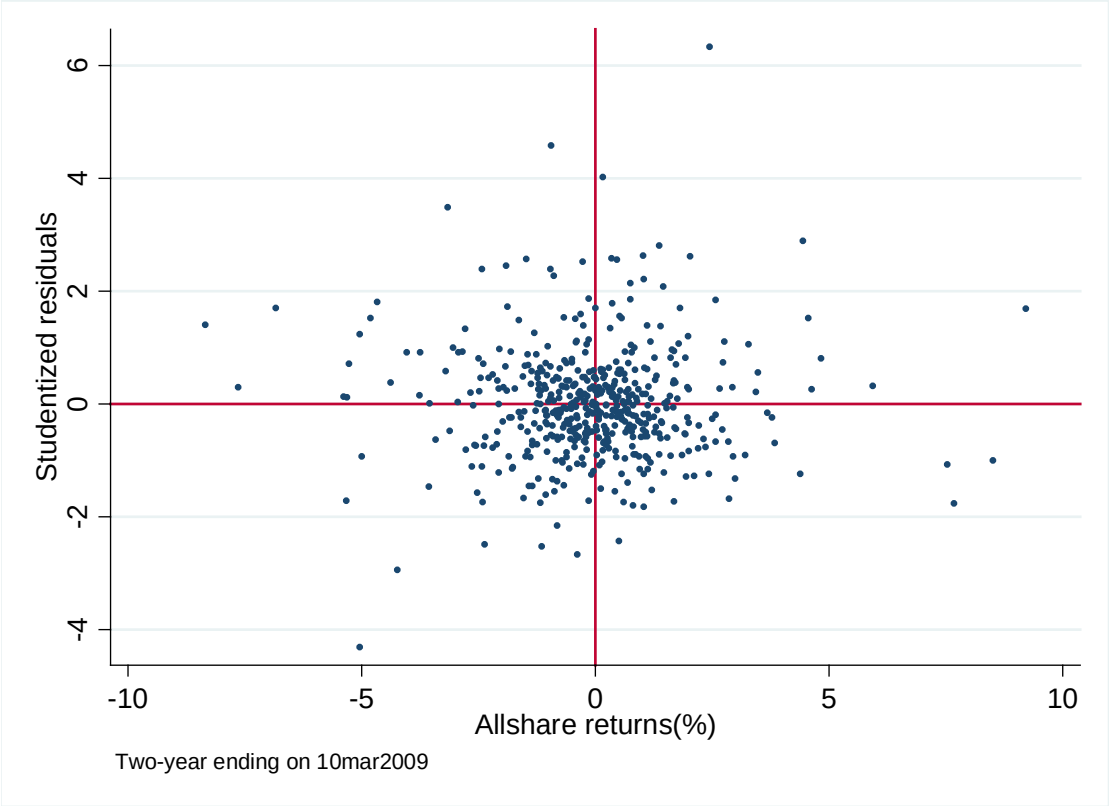
4. Failure of normality does not *per se* undermine the validity of OLS, but the presence of outliers raises difficult questions about the robustness of the estimates.

We have therefore carried out a number of standard diagnostic tests.

Tests for heteroscedasticity

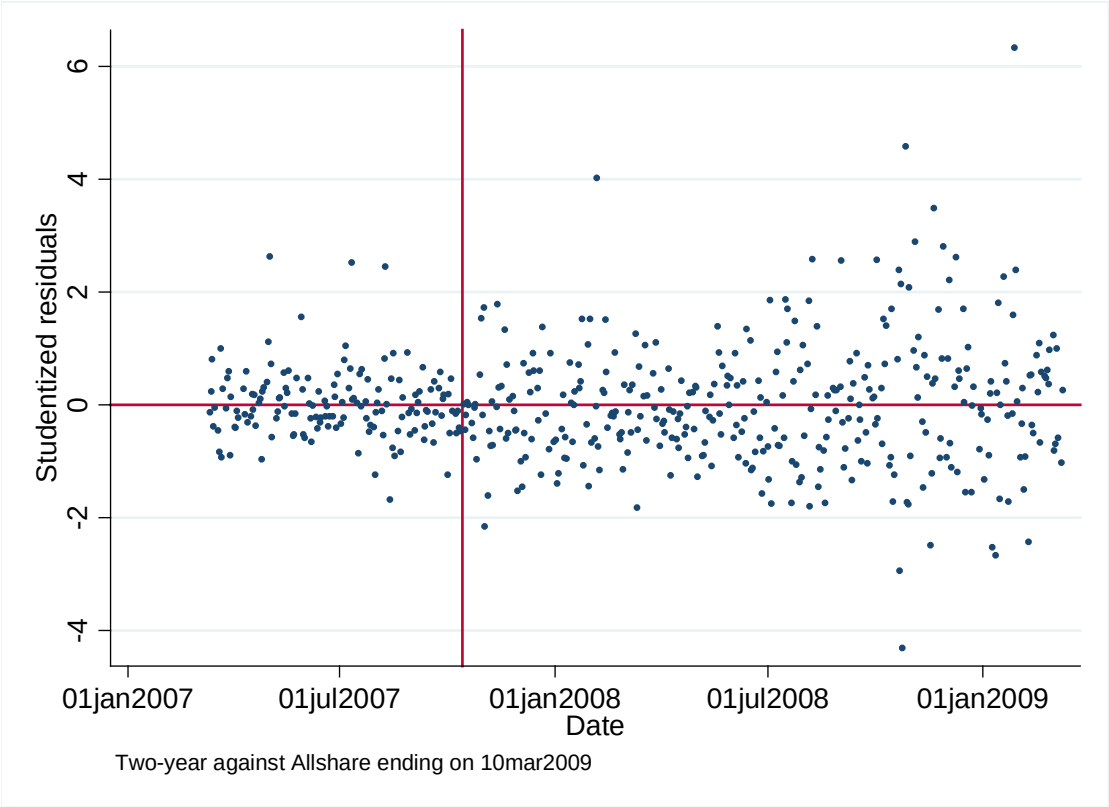
Figure 3 shows a scatterplot of the residuals against the market index returns, for the two-year FTSE Allshare regression. Visual inspection does not reveal any clear pattern—the "vertical spread" does not appear to change in any systematic way as we move horizontally across the graph, as would be the case under some sources of heteroscedasticity. However, there are clearly a number of outliers. We discuss the issue of outliers below.

Figure 3: scatter plot of residuals against index returns



We can also check whether there is change in the pattern of residuals over time. Figure 4 shows an apparent increase in the magnitude of the residuals over time. This may be a result of recent market turmoil, and extreme volatility of share prices.

Figure 4: scatter plot of residuals against time



Since simple inspection suggests that there may be some heteroscedasticity, we also applied a formal test (the White test), shown in Table 5.

Table 5: White test for heteroscedasticity

End date	White statistic	White p-value	White statistic	White p-value
	Allshare - 1 year		Allshare - 2 years	
31/08/2007	1.38	0.50	1.09	0.58
31/08/2008	0.16	0.92	3.84	0.15
10/03/2009	2.40	0.30	6.92	0.03
	Allworld - 1 year		Allworld - 2 years	
31/08/2007	2.52	0.28	2.16	0.34
31/08/2008	1.47	0.48	8.78	0.01
10/03/2009	15.11	0.00	38.12	0.00

As expected from Figure 4, Table 5 shows that the two-year regressions fail the White test. Nevertheless, we do not think that heteroscedasticity is a significant problem because the “robust” standards errors of the regressions are small and close to the “normal” standard errors (see Table 6 and Table 7).

Table 6: Robust standard errors for one-year regressions

End date	Beta	S.E.	Robust S.E.
	Allshare - 1 year		
31/08/2007	0.53	0.07	0.08
31/08/2008	0.98	0.07	0.07
10/03/2009	0.92	0.06	0.07
	Allworld - 1 year		
31/08/2007	0.62	0.10	0.12
31/08/2008	1.14	0.10	0.12
10/03/2009	0.82	0.08	0.11

Table 7: Robust standard errors for two-year regressions

End date	Beta	S.E.	Robust S.E.
	Allshare - 2 years		
31/08/2007	0.61	0.06	0.06
31/08/2008	0.85	0.05	0.06
10/03/2009	0.88	0.04	0.05
	Allworld - 2 years		
31/08/2007	0.71	0.08	0.09
31/08/2008	0.99	0.07	0.09
10/03/2009	0.83	0.06	0.09

Auto-correlation

We have performed a formal test (the Durbin-Watson test) for auto-correlation, reported in below in Table 8. This test indicates a degree of autocorrelation in the most recent Allworld regressions. The effect of this is that standard (or "robust") errors will over-estimate the precision of the regression.

Table 8: Durbin–Watson test for autocorrelation

	D-W statistic	D-W statistic
End date	Allshare - 1 year	Allshare - 2 years
31/08/2007	1.83	1.86
31/08/2008	2.10	2.03
10/03/2009	2.10	2.09
	Allworld - 1 year	Allworld - 2 years
31/08/2007	1.86	1.90
31/08/2008	2.25	2.16
10/03/2009	2.40	2.36

3.3 Normality and outliers

To test for normality of the residuals we have plotted histograms of the "studentised residuals", shown in (Figure 5 to Figure 8). The curve superimposed on the histograms is a standard normal distribution. If the error terms follow a normal distribution then the studentised residuals should follow the t-distribution, which for our sample size is practically indistinguishable from the standard normal distribution. The histogram looks like a normal distribution except for the outliers: there are a few too many points a large number of standard deviations away from zero.

Figure 5: Studentized residuals from the two-year Allshare regression

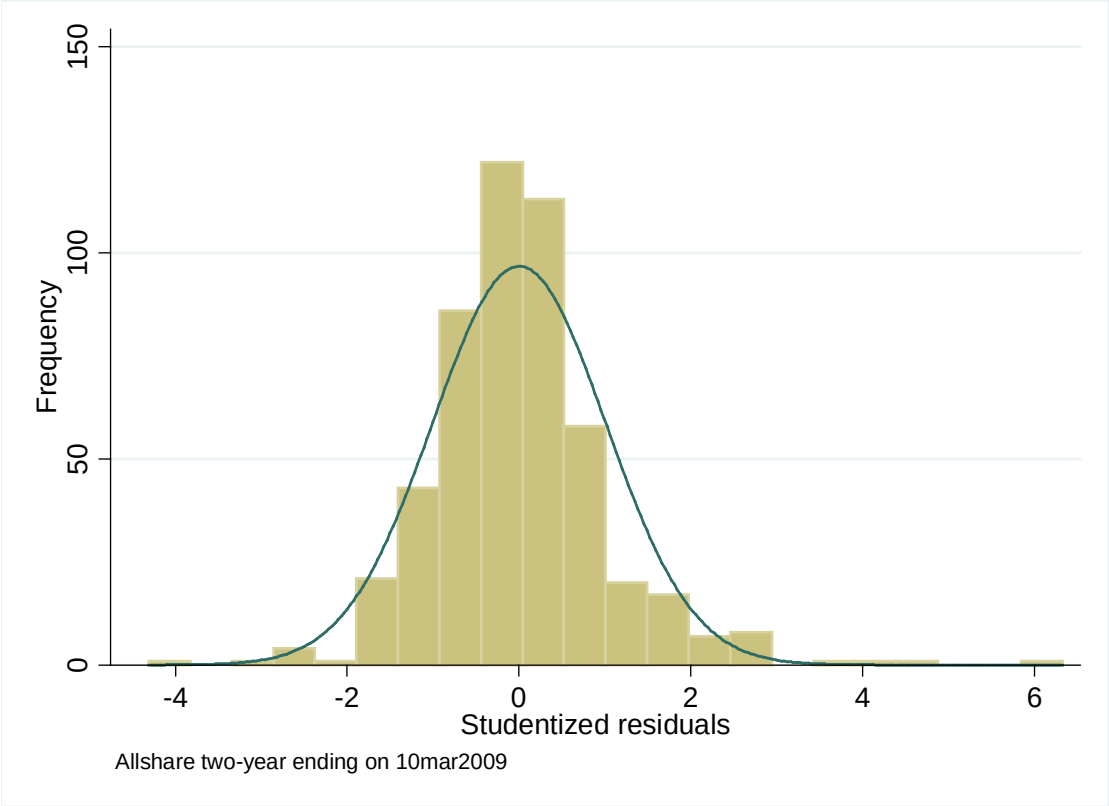


Figure 6: Studentized residuals from the one-year Allshare regression

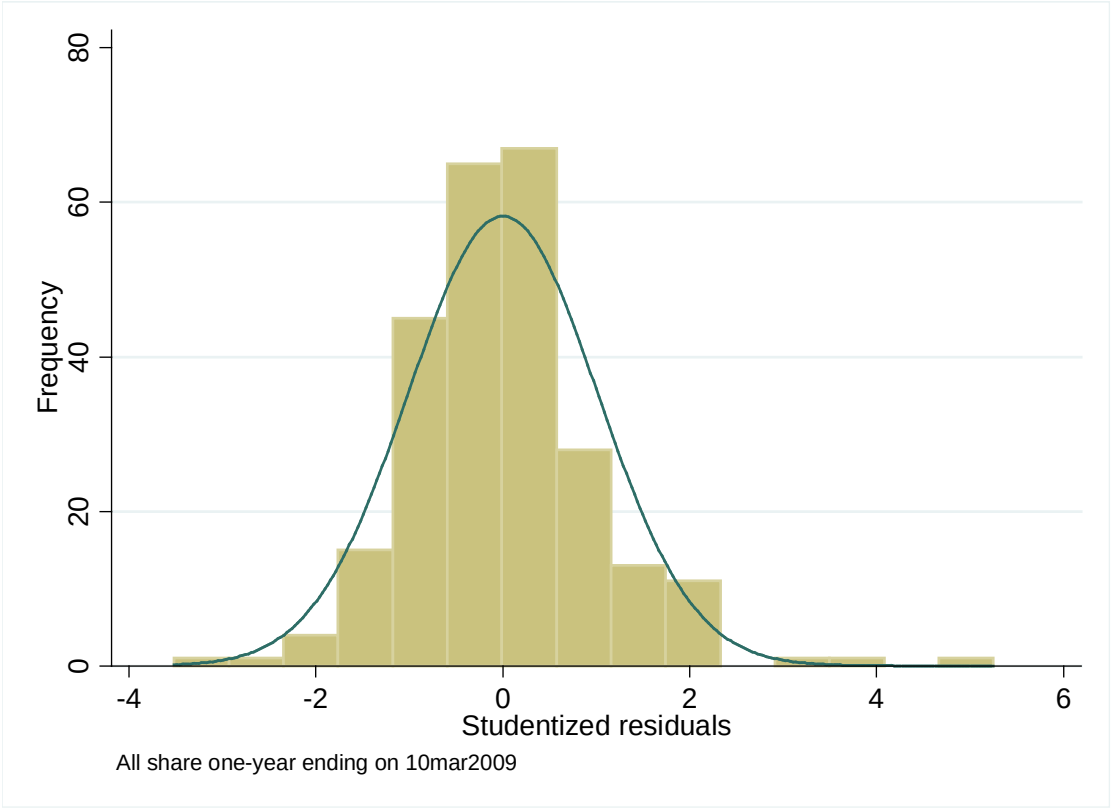


Figure 7: Studentized residuals from the one-year Allworld regression

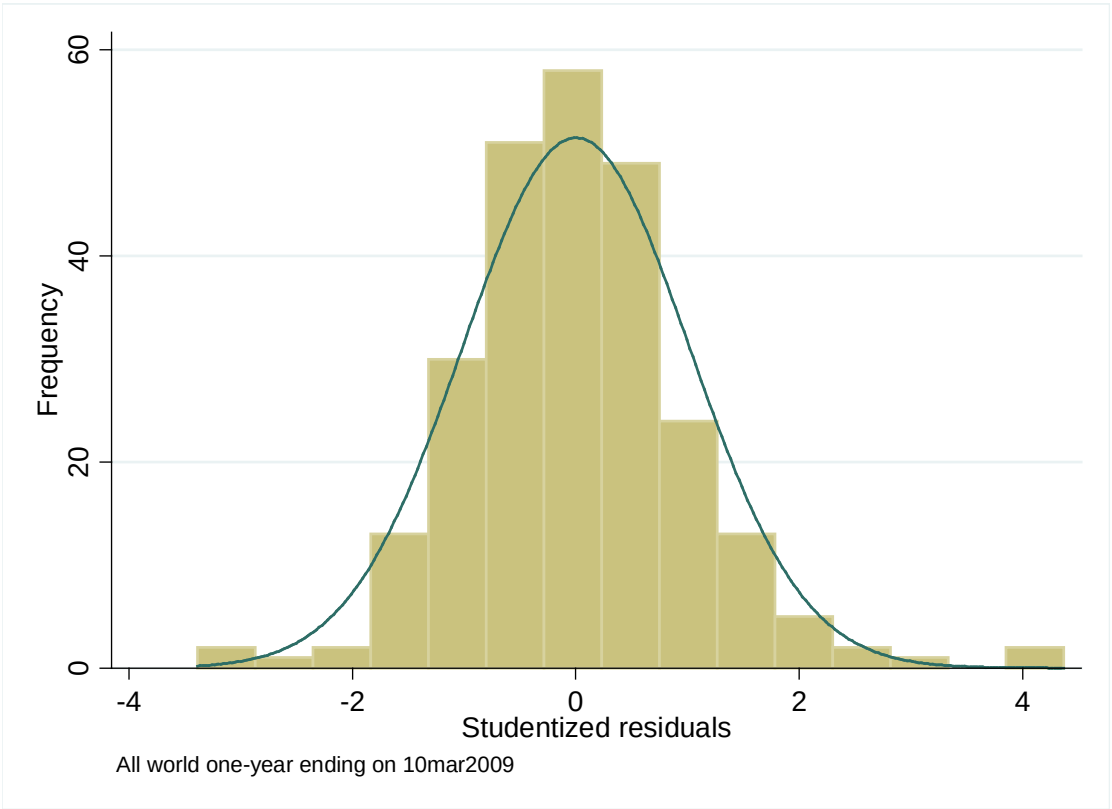
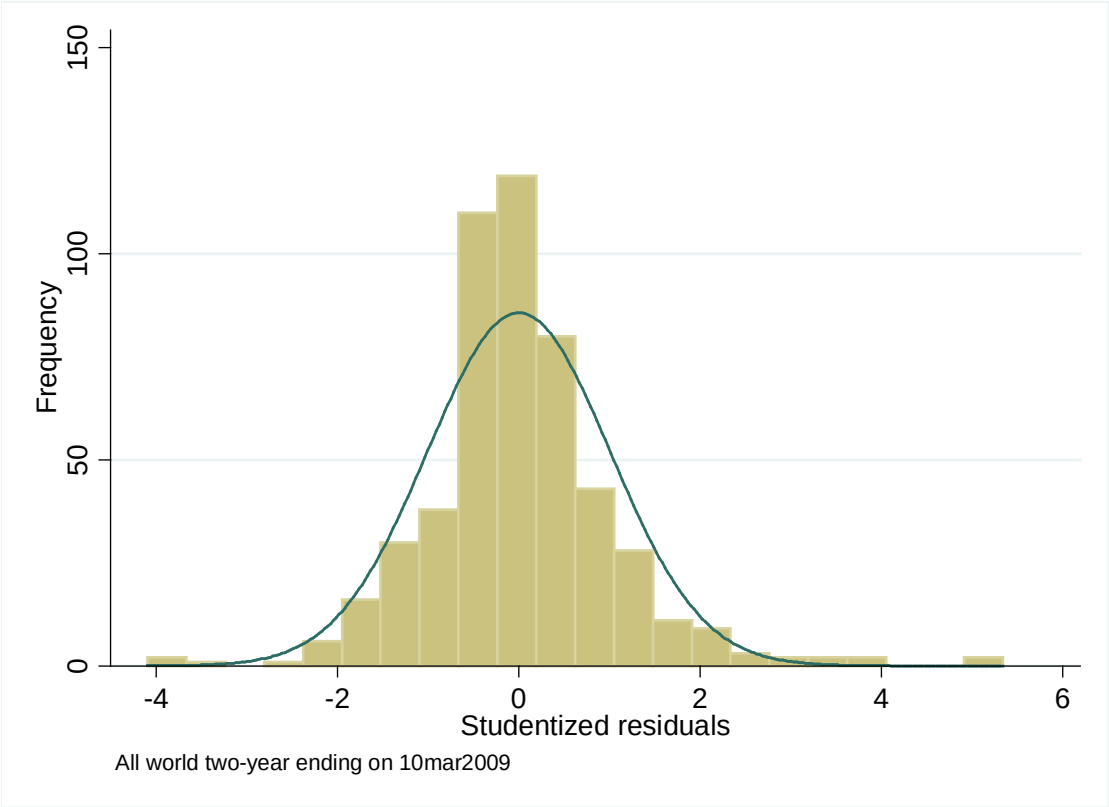


Figure 8: Studentized residuals from the two-year Allworld regression



There is no "right answer" to the treatment of outliers. In this case they clearly represent genuine data points. However, the presence of outliers can make standard OLS estimates less reliable.

As a guide to help understand the influence of outliers on our beta estimates we have carried out two analyses: looking at the impact of removing "influential outliers", and performing a "robust regression".

To identify influential outliers we calculate the 'Cook's D' measure of the influence of each point on the regression outcome. A usual threshold is to classify points with a D score over 4/N (number of observations) as influential, and we remove these points from the regressions. Table 9 and Table 10 show the results of removing influential outliers, and also show the results of "robust"[8] regressions.

Table 9: Removing influential outliers, one-year regressions

End date	Beta 'standard'	Beta 'robust'	no outliers	Number of outliers
	Allshare - 1 year			
31/08/2007	0.53	0.51	0.53	5
31/08/2008	0.98	0.97	0.97	2
10/03/2009	0.92	0.86	0.87	3
	Allworld - 1 year			
31/08/2007	0.62	0.60	0.64	5
31/08/2008	1.14	1.17	1.17	1
10/03/2009	0.82	0.82	0.88	5

Table 10: Removing influential outliers, two-year regressions

End date	Beta 'standard'	Beta 'robust'	no outliers	Number of outliers
	Allshare - 2 years			
31/08/2007	0.61	0.62	0.64	8
31/08/2008	0.85	0.80	0.85	6
10/03/2009	0.88	0.79	0.86	5
	Allworld - 2 years			
31/08/2007	0.71	0.74	0.73	9
31/08/2008	0.99	0.96	1.02	7
10/03/2009	0.83	0.84	0.85	9

We do not see any large differences between the standard beta estimates and either the robust regression results or the results of regressions without influential outliers. We also note that there are no more such outliers in the more recent data windows than in the earlier ones.

[8] Robust regressions assign less weight to outliers than OLS does, but does not necessarily remove influential outliers entirely.