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What SSAP 24 can tell us about accounting quality

By P. J. Sweeting

Abstract

Statement of Standard Accounting Practice (SSAP) 24 required, for the first time, particular levels of disclosure in relation to firms' pension arrangements. Whilst this was a major step forward, it allowed a significant degree of discretion. This discretion meant that SSAP 24 was an observable measure of the quality and quantity of accounting disclosure for firms. This information can be used to determine the types of firms that give less information or use weaker assumptions. In my analysis, I find some evidence that large firms give more complete disclosures, but also that they are more able to exert influence on their actuaries to use weaker assumptions for the valuation of pension scheme liabilities. There is also some evidence that more profitable firms disclose less, so firms with a higher average tax rate might want to overfund their pension scheme. Finally, there is evidence that highly levered funds are less likely to give complete disclosure, and that when they do disclose their assumptions, they use a weaker basis.

Keywords

Statement of Standard Accounting Practice; SSAP 24; Accounting Disclosure; Valuation of Pension Scheme Liabilities; Disclosure Assumptions

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1. Introduction

1.1 Statement of Standard Accounting Practice (SSAP) 24, published by the Institute of Chartered Accountants in England and Wales (1988) provided the first attempt in UK accounting to standardise both the calculation of pension costs and the disclosure of information relating to this calculation, particularly relating to defined benefit (DB) pension schemes. It was in effect for periods ending on or after 1 July 1988 and remained in force until the introduction of Financial Reporting Standard (FRS) 17 published by the Accounting Standards Board (2000), which superseded SSAP 24 for all accounting years ending on or after 1 January 2005, although a number of firms continued to account under the earlier standard after this date.

1.2 However, although SSAP 24 introduced a degree of standardisation, it left considerable scope for discretion in the choice of assumptions, making like-for-like comparisons difficult. There have also been significant differences in the extent of disclosure under SSAP 24 between firms and over time. Significant differences are also apparent between the assumptions used when these are disclosed.

1.3 This is actually very helpful, in that it can tell us about the willingness of a firm to disclose information and the strength of the assumptions used by a firm. The extent and value of pension scheme disclosures under SSAP 24 are reasonably easy to assess; however, these areas can be regarded as a proxy for the general quality of a firm's accounting disclosures, which is more difficult to measure.

1.4 FRS 17 allows much less scope to omit important information or alter the actuarial basis used. This means that alternative proxies must be found for accounting quality, since the option of using SSAP 24 disclosures is no longer available. One way to do this is to consider the types of firms that might give better or worse disclosure and to test hypotheses in relation to SSAP 24 disclosures. If evidence of links is found, then this means that inferences about the nature of firms and their propensity to disclose fully and accurately can be made. This is important as it could allow analysts to recognise the firms whose disclosures should be treated with greater caution based on observable characteristics of those firms, regardless of whether they had defined benefit pension schemes and regardless of the pensions accounting rules used.

1.5 This means that a process that could be followed is:

– in periods where SSAP 24 disclosures are being made, assess the SSAP 24-related variables where there are differences in the extent of disclosure or prudence in the basis used;
– identify the extent to which levels of disclosure of these variables are linked to other observable characteristics of a firm; and
– use these characteristics to indicate the more general quality of a firm's disclosure in periods where SSAP 24 disclosures are not being made, either because there is no defined benefit pension scheme or because the reporting on such an arrangement is being carried out under another accounting standard.

1.6 It is the first two of these stages that I am concerned with in this paper. In one part of the analysis, I select pension scheme disclosures where there is a sufficient mix of firms disclosing and failing to disclose information. I then use logit analysis to determine the extent to which various proxies for firm type affect the disclosure of pension scheme information. Where a significant relationship is found, these results can then be used to infer the extent to which firm accounting information, used as a proxy for firm type, affects the quality of accounting disclosure generally. In the second part of the analysis, I concentrate on pension scheme valuation assumptions where the level of disclosure is wide enough that the values of disclosures can be analysed. Here, least squares regression is used, this time to determine the extent to which various proxies for firm type affect the strength or weakness of the pension scheme valuation basis. Again, where a significant relationship is found, these results might indicate the extent to which firm accounting information, again used as a proxy for firm type, affects the quality of accounting disclosure.

1.7 In this analysis, I use only non-financial firms. I do this because pension scheme assets and liabilities are closely related to leverage and issues of capital structure. In particular, pension scheme liabilities can be regarded as a type of company debt, collateralised by pension scheme assets. Given that financial firms treat these factors very differently to non-financial firms, I exclude the former from this analysis. Furthermore, the tax treatment of financial firms differs from that of other companies, adding another complication that would make the interpretation of the results if financial firms were included more difficult.

1.8 The structure of this paper is as follows. First, I give an overview of the history of SSAP 24 and its disclosure requirements. I then look at the previous studies that have considered influences on

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pensions funding, and other research relevant to the issues that I am considering. I go on to describe the dataset that I use before analysing the factors influencing the extent of disclosure within SSAP 24. Next, I analyse the influences on the values of the disclosures, before giving my conclusions.

2. An Overview of SSAP 24

2.1 SSAP 24 sets out the principles to be followed in calculating pension costs and, importantly, the disclosures required. As well as information on the various balance sheet and profit and loss account disclosures, details of the most recent formal actuarial valuation or subsequent review are required, in particular:

– the actuarial method used and a brief description of the main actuarial assumptions;

– the market value of scheme assets at the date of their valuation or review; and

– the level of funding expressed in percentage terms.

2.2 This information should, in theory, enable those analysing company accounts to assess the impact of that company's pension arrangements. In particular, the assumptions should allow the conversion of all pension information to a consistent basis. This would allow analysts to allow for the financial impact of pension scheme assets and liabilities on the equity value of the sponsoring employer. However, even if full disclosure is given, SSAP 24 has a number of features that limit its usefulness.

2.3 First, no information on the maturity of the pension scheme's liabilities is given; even the split between active members, deferred pensioners and current pensioners is absent. Furthermore, a common approach to reporting – and one allowed by the Standard – is to give the market value of assets and to quote the funding level as the ratio of the actuarial value of pension scheme assets divided by the actuarial value of the liabilities. Although the main actuarial assumptions are required – which includes the dividend growth assumption when appropriate – the asset allocation is not required. This means that in many cases whilst it is possible to derive a value of the liabilities from the actuarial value of assets and the funding level, the assumptions behind these liabilities are not clear.

2.4 Even where adjustment is possible, it is not always clear whether the stated assumptions are appropriate. For example, the assumption used for increases to pensions in payment is a single number or a range which is used to represent the full range of pension scheme increases due to members. It is impossible to represent the complexity of pension scheme benefits in this way, or to assess the validity of the assumption. Similarly, different rates of assumed salary growth will be appropriate for different firms, and it is difficult to say what the number should be for any one firm, so a higher salary growth assumption might reflect the nature of a firm rather than being more conservative. These factors do limit the extent to which conclusions can be drawn from differences in assumptions. Industry dummy variables are used to try to control for this effect, but it is important to recognise that these are issues of interpretation rather than issues with SSAP 24.

3. Data

3.1 The sample for this chapter consists of companies listed on the FTSE100 using all FT Economic Groups except Financials for the period 1989–2005. Additional information is collected for firms with DB pension schemes reporting under SSAP 24. As noted earlier, financial firms

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are excluded because the concept of leverage is important in the analysis, and this concept is less appropriate for these such firms, as noted by Feldstein & Seligman (1981), Fama & French (1992), Rajan & Zingales (1995) and Garvey & Hanka (1999). Graham (1996) also points out that such firms are subject to different tax treatment to non-financial firms, which would also complicate the analysis. This leaves the following FT Economic Groups:

- cyclical consumer goods;
- non-cyclical consumer goods;
- cyclical services;
- non-cyclical services;
- resources;
- basic industries;
- general industries;
- utilities; and
- information technology.

3.2 Since defined contribution (DC) pension schemes are by definition fully funded (apart from late contributions) and perfectly matched, these schemes are not allowed for in the analysis.

3.3 In analysing the assumptions, I concentrate on the main United Kingdom DB pensions arrangements. The reasons for this are that assumptions for UK schemes and overseas schemes are not comparable, and that in terms of determining issues such as the appropriate assumptions and the level of funding, it is reasonable to assume that management will pay most attention to the largest arrangement. This is only straightforward where a firm both has a single dominant UK pension scheme and gives disclosures for this scheme separately from other pension schemes; in most cases, a degree of subjectivity is required. I have used the following rules-of-thumb:

- where there is more than one UK pension arrangement, use only the largest if it is at least twice as large as the next largest;
- if it is less than twice as large, use the largest and all those more than half as large as this and calculate weighted averages for the funding level and any assumptions based on the market value of assets and funding levels;
- where it is clear that the UK pension arrangement is a major one but the assumptions are given as a range for all arrangements, take the midpoint of the assumptions; use the average if it is given;
- similarly for funding levels and assets, if aggregate information is given but it is clear that the UK arrangement is a major part of this total, use the aggregate; and
- if this information is given but it is clear that the UK pension arrangement is not a major part, class the firm as having no (significant) DB arrangements.

3.4 The usefulness of some of the disclosures is clear: the market value of assets shows how large the pension scheme is and the funding level gives the ratio of pension scheme assets to pension scheme liabilities. However, more information than this is needed to allow consistent comparison between pension schemes. First, assumptions underlying the value of pension scheme liabilities often cannot be determined from just the market value of assets and the funding level. This is because, as mentioned earlier, the funding level is usually expressed as the ratio of the actuarial value of pension scheme assets to the actuarial value of the liabilities. Therefore I need either the actuarial value of pension scheme assets (AVA) or sufficient information to convert the market value of assets into an actuarial value. I look at the extent to which the actuarial value of pension scheme assets is disclosed. In order to convert a market value of assets into an actuarial value, three types of information are needed: the asset allocation of the pension scheme; the method of conversion to actuarial values for each asset class; and the assumptions used in the conversion. No more than one firm in any one year discloses its pension scheme asset allocation under SSAP 24 (although this information is generally available to some degree from the FRS 17 disclosures from 2000 onwards); disclosure of the methodology is also rare; however, given that the largest asset class for most pension schemes is an investment in equities, an indication of the strength of the basis can be determined by looking at the net rate at which dividends are discounted using a Gordon (1962) growth approach (i-d) to arrive at an actuarial value of equities. The extent to which this information is disclosed or can otherwise be determined is also of interest.

3.5 Of course, this issue is removed if pension scheme assets and liabilities are both taken at market value. This is the case if FRS 17 has been adopted, but also if a market value basis (MVB) is used.

3.6 The discussion above centres on the derivation of the value of assets used. However, it is also interesting to consider the strength of the basis used to value the liabilities and even the extent to which information is disclosed to enable the assessment of the basis. In particular, the net pre-retirement liability discount rate (i-e) and the net post-retirement liability discount rate (i-p) indicate the strength of the basis used to value the liabilities. Even if this information is given, more information is needed (and not given) to enable the liabilities to be converted to consistent bases. For example, as discussed earlier, the duration and type of the liabilities (active member, deferred pensioner or current pensioner) is needed, as is information on the assumptions used for mortality and other demographic inputs. Furthermore, it is not always appropriate to standardise all assumptions – for example, the salary increase assumption will reflect each firm's particular situation, and demographic assumptions (which are given by only two firms in any one year at most) are similarly specific.

3.7 I use data for whole years during which SSAP 24 numbers are reported, so I look at the constituents of the FTSE100 on every 31 December from 1989 to 2005 inclusive, and use figures from the accounts produced that would be available at that date assuming a three month publication lag, so for inclusion in analysis as at 31/12/XXXX, I use data from accounts with year ends up to and including 30/09/XXXX. This gives a total of 1,298 firm-years, of which 1,061 reported under SSAP 24. However, a number of firms are excluded because data for the firm-related explanatory variables are unavailable. I also exclude the small number remaining where no market value of pension scheme assets or funding level is given, since these are also used as explanatory variables, the former as part of the ratio of pension scheme to firm market value. This reduces the total number of firm-years investigated from 1,061 to 975, within which there are 136 unique firms. The breakdown of disclosure within these firms is given in Table 1.

3.8 In this table, "i", "e", "p" and "d" refer to the discount rate used to value the assets and liabilities, the rate of earnings growth, the rate of pension increase and the dividend growth assumption respectively. The term i-e refers to the net pre-retirement liability discount rate, i-p refers to the net post-retirement liability discount rate, and i-d refers to the net dividend discount rate. MVA and AVA refer to the market and actuarial (or assessed) values of pension scheme assets, and MVB refers to pension scheme valuations carried out using a market value basis, where the assets are taken at market value and liabilities are valued using the bond yields effective at the

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Table 1. Extent of disclosure within SSAP 24 (Data Used for Analysis); Net pre-retirement liability discount rate (i-e); Net post-retirement liability discount rate (i-p); Net dividend discount rate (i-d); Market value of pensions scheme assets (MVA); Actuarial value of pension scheme assets (AVA); Market value basis (MVB); and Pension scheme funding level (FL).

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Total
i-e	18	61	65	71	67	68	70	69	64	58	57	54	55	55	54	42	39	**967**
i-p	11	40	48	51	50	50	51	57	54	45	47	47	48	51	50	42	39	**781**
i-d	5	17	20	26	28	28	32	42	40	35	36	33	25	13	11	5	2	**398**
MVA	18	64	68	72	67	68	70	69	64	58	57	54	56	55	54	42	39	**975**
AVA	2	4	3	5	5	6	8	7	7	7	12	14	22	29	31	27	23	**212**
i-d and AVA	0	0	0	1	1	1	2	5	5	4	5	4	4	2	2	1	0	**37**
i-d or AVA	7	21	23	30	32	33	38	44	42	38	43	43	43	40	40	31	25	**573**
i-d not AVA	5	17	20	25	27	27	30	37	35	31	31	29	21	11	9	4	2	**361**
MVB	0	0	0	0	0	0	0	0	0	1	4	7	11	21	23	22	20	**109**
FL	18	64	68	72	67	68	70	69	64	58	57	54	56	55	54	42	39	**975**
Total	**18**	**64**	**68**	**72**	**67**	**68**	**70**	**69**	**64**	**58**	**57**	**54**	**56**	**55**	**54**	**42**	**39**	975

date of valuation. A valuation is taken to use a market value basis either if the accounts state that such an approach has been used, or if the actuarial value of pension scheme assets and market value of assets are equal. FL refers to the funding level, the ratio of the actuarial value of pension scheme assets to the value of the pension scheme liabilities.

3.9 Because I am using data with different year ends, data are not strictly comparable within any calendar year. Also, actuarial valuations tended to be carried out only triennially in accordance with actuarial regulations. This means that assumptions from valuations nearly 3 years apart might be compared. This second point affects only the analysis of values and not the extent of disclosure.

3.10 As mentioned earlier, there are two types of analysis that I carry out. These consider:

– the extent of disclosure within SSAP 24; and
– SSAP 24 assumptions used.

3.11 The dependent variables in the analysis relate to pensions, and whilst pensions items also feature as independent variables, the majority of the independent variables are company rather than pensions items. The company items used include those chosen from related literature on determinants of capital structure. Given that company pension schemes can be viewed as an extension of capital structure, as discussed by many authors from Graham & Dodd (1951) onwards, it is reasonable to expect that the variables that affect capital structure might also affect decision relating to the pension scheme.

4. Hypotheses for Determinants of Disclosure

4.1 Looking first at the extent of disclosure, I turn to the relationships that I would expect between the level of disclosure and the explanatory variables. I first consider the pension scheme funding level. Feldstein & Morck (1983) and Bodie *et al.* (1985) find that firms with underfunded pension funds select higher discount rates with which to value their pension scheme liabilities, and Thies & Sturrock (1988) find that underfunded pension schemes undervalue their liabilities. This suggests that underfunded pension schemes should be less likely to give full disclosures in order to hide the weakness of the basis used.

4.2 If a pension scheme were large in relation to a firm, then company management might be inclined to alter the pension scheme results in order that attention is not drawn to a pension scheme in poor financial health. This would suggest less complete disclosures; however one might instead expect analysts to take more interest in the scheme if it were large in relation to the firm, so requiring more complete disclosure. For this reason, the ratio of the pension scheme assets to firm market value is included. I use market values for both the pension scheme and firm size, so the ratio should to some extent be cushioned against market movements.

4.3 One might also expect larger firms to be subject to greater scrutiny and so more likely to give good disclosures. The proxies I consider for firm size are total balance sheet assets, equity market value and sales. Total balance sheet assets is more stable from year to year than either of the other options which are more prone to change with market sentiment (market value) or the economic cycle (sales). A variable related to total assets also better reflects the true size of an undertaking; market values reflect expectations of future growth as much as the current size of an organisation, and a large sales volume can be generated by a comparatively small firm in some industries; I therefore use only total assets.

4.4 The size of asset base might also be an issue, the asset base being the tangible assets held, such as property and machinery. Bradley *et al.* (1984) point out that if a high proportion of a firm's assets are intangible, then the lack of collateral might make it expensive to raise debt. This could be expected to persist if the issue is simply that a firm has limited assets of any kind. An implication of this is that a firm with a small asset base should give a lower level of disclosure so that slack can be built into the pension scheme valuation basis and the pension scheme can more easily be used as a source of company funding through the payment of lower contributions. Indeed, Francis & Reiter (1987) note that deficit funding might be cheaper than using external funding once external funding has reached a particular level. As a proxy for a firm's asset base I use the ratio of sales to total assets.

4.5 Firm profitability could also be a factor. Thies & Sturrock (1988) show that firms with poor profitability undervalue their liabilities. Such firms might be less inclined to give complete disclosure. This is effectively treating profitability as a risk proxy and Francis & Reiter (1987) recognise that riskier firms are more likely to want to underfund their pension schemes, since the put option that the firm has on the deficit, outlined by Sharpe (1976), is more valuable. This implies that an unprofitable firm might be inclined to give fewer or inferior disclosures in order to disguise a weak actuarial basis. However, profitability might be regarded as a proxy for the average tax rate, and Francis & Reiter also note that firms with higher tax rates should be more likely to fully fund (or even overfund) their pension schemes, to take advantage of tax advantages. Francis & Reiter refer to marginal rather than average rates, but the principle is the same. This might imply that profitable firms might wish to disguise a strong actuarial basis by giving only limited disclosures. The measure of profitability I use is EBIT divided by total assets.

4.6 Non-debt tax shields are also of interest. Francis & Reiter (1987) point out that overfunding is consistent with the use of non-debt tax shields discussed by DeAngelo & Masulis (1980), so if non-pension non-debt tax shields are low, then a firm might be less likely to give full disclosure so that the actuarial basis can be hidden and higher (tax deductible) contributions can be paid into the pension scheme in order to reduce taxable profits. A common and significant non-debt tax shield is depreciation, so I use depreciation, depletion and amortisation (DDA) as a proxy after initially standardising by dividing by EBIT before depreciation and amortisation (EBITDA). This is the most common denominator used in the literature for standardisation.

4.7 The growth/value proxy could indicate the extent to which management is likely to want to build financial slack into the valuation basis. I would expect growth firms, which have greater investment requirements, as described in the "pecking order" literature of Myers (1984), Myers & Majluf (1984), and others, to be more likely to use a pension scheme as a form of additional funding. Similarly, Francis & Reiter (1987) note that funding derived from a pension scheme deficit might be cheaper than that derived externally once external funding has reached a particular level. Additional funding might more easily be raised if the actuarial basis is weak, and a weak basis less likely be disclosed. A number of potential variables can be used as growth proxies, the main ones being the earnings to price ratio, the ratio of book to market value and the dividend yield. None of these three proxies is without problems: the earnings to price and market to book ratios both have a tendency to throw up extreme values for some firms, whilst the earnings to price ratio and dividend yield are low for both very young growth firms (which are growing too fast to produce substantial if any earnings or dividends) and very mature firms (which are in decline so have depressed earnings and dividends). Indeed, Blume (1980) finds that returns are higher for those firms paying higher dividends or no dividends at all. However, the exact choice of growth/value proxy does not seem to greatly affect the results. I therefore show results only for the dividend yield.

4.8 I also consider leverage. Francis & Reiter (1987) find that firms with underfunded schemes are more likely to be more levered than average and Gopalakrishnan & Sugrue (1995) find that the discount rate is positively linked to leverage. Both of these factors might lead firms with higher levels of leverage to be less likely to disclose their assumptions. Furthermore, debt, and long term debt in particular increases the sensitivity of a firm's profitability to interest rates. Given that pension scheme liabilities are debt-like, a highly-levered firm might be more likely to manipulate the pension scheme results in order that the scheme is not a source of further volatility. This in turn could mean that non-disclosure, enabling more discretion over the actuarial basis, is likely. I therefore include leverage as an explanatory variable, using the ratio of book debt over the sum of book debt and the market value of equity. I use book debt because it is more readily available than the market value of debt, and more likely to include all debt. It also measures the obligation rather than the market value of the obligation, which is what leverage is intended to measure. I use the market value of equity since this gives a better indication of the value of the firm.

4.9 It is worth noting that sales over assets, depreciation, depletion and amortisation (DDA) over EBITDA, dividend yield, the earnings to price ration and the market to book ratio might instead be proxies for another factor: firm age. Older firms might reasonably be expected to have accrued relatively high levels of assets relative to sales (so having lower levels of sales over assets), which in turn generate high levels of depreciation relative to earnings (giving higher levels of DDA over EBITDA). They are also likely to be in the "mature", "revival" or "decline" than the "birth" or "growth" phases as defined by Miller & Friesen (1984), and so have higher levels of dividend yield and earnings to price ratio, and lower levels of market to book ratio. The older a firm is, the more likely it is to have had reasons to manipulate its pension scheme funding levels lower in times of profit and higher in times of loss. In other words, the more incentive such a firm will have had to disclose less in relation to its pension scheme at some point in time.

4.10 A summary of the expected relationships is given in Table 2. The signs indicate the relationship that would be expected between an explanatory variable and the disclosure of

Table 2. Predicted signs for the extent of disclosure of explanatory variables.

	Predicted Sign (Raw Data)	Predicted Sign (Log)	Predicted Sign (Rank)
Pension Scheme Funding Level	+		−
Pension Scheme Assets to Firm Market Value	+/−		+/−
Firm Total Assets	+	+	
Sales over Assets	−		+
EBIT over Assets	+/−		+/−
DDA over EBITDA	+		−
Dividend Yield	+		−
Leverage	−		+

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information, the dependent variable here being unity for disclosure and zero for non-disclosure. The log and rank transforms of the raw data are discussed below.

4.11 Next I consider the strength of the assumptions disclosed. Looking at previous literature, the work of Feldstein & Morck (1983), Bodie *et al.* (1985) and Thies & Sturrock (1988) all suggests that underfunded schemes are more likely to use weaker valuation bases. However, an alternative explanation is that those using a weaker basis might do so in order to overstate the funding level. Either way, this suggests a link between the value of the disclosure and the pension scheme funding level.

4.12 From the earlier analysis, a firm with a disproportionately large pension scheme should be more likely to use a weaker valuation basis in order to lessen the apparent importance of the pension scheme; however, such a firm might also be less able to adopt such a strategy due to the high profile nature of the pension scheme. The proxy here is the ratio of pension scheme assets to the value of the firm.

4.13 Similarly, a large firm should be less able to take such measures, being subject to greater scrutiny, so should be more likely to use a stronger actuarial basis; however, there is an alternative scenario. Mautz & Sharaf (1961) point out that the financial dependence of auditors on their clients reduces the independence of the auditor. DeAngelo (1981) finds that the independence is increased the larger the audit firm, but Reynolds & Francis (2001) hypothesise that larger clients might be able to exercise greater influence on their auditors. They find no evidence of this, but in relation to pension schemes this might imply that a larger firm has a greater ability to pressure the actuary into using a weaker pension scheme valuation basis. The proxy considered here is the value of the firm's assets.

4.14 As discussed earlier, the size of asset base should also be an issue, and the asset tangibility argument of Bradley *et al.* (1984) can also be extended to this analysis. A firm with a smaller asset base – thus wanting to use the pension scheme as a source of company funding – should be more likely to use a weaker actuarial basis. The proxy I use for the size of asset base is the ratio of sales-to-assets.

4.15 Firm profitability, for which I use EBIT over assets, should again be a factor. As discussed earlier, Thies & Sturrock (1988) show that firms with poor profitability undervalue their liabilities, so I might expect to see weaker actuarial bases used by unprofitable firms. The same result might be expected if profitability is regarded as a risk proxy, since Francis & Reiter (1987) show that riskier firms are more likely to want to under-fund their pension schemes, so using a weaker basis. However, some of the earlier analysis also suggests that profitability might instead be regarded as a proxy for the marginal tax rate. Francis & Reiter note that firms with higher marginal tax rates should be more likely to fully fund (or even over-fund) their pension schemes, to take advantage of tax advantages. This suggests the same conclusion for the proxy, since a more profitable firm should be expected to use a stronger actuarial basis to justify over-funding.

4.16 Similarly, a low level of non-debt tax shields, for which I use the ratio of depreciation, depletion and amortisation to EBITDA as a proxy, suggests that a stronger valuation basis might be used since low tax shields would increase the need to use the pension scheme for tax management.

4.17 The value and growth distinction should again be important in this analysis. I would expect growth firms to use weaker actuarial bases in order to use the pension scheme as an additional source of funding. As before, I use the dividend yield, the earnings to price ratio and the market to book ratio as value/growth proxies. Finally, leverage should also be relevant. Gopalakrishnan & Sugrue (1995)

Table 3. Predicted signs for the values of explanatory variables.

	Predicted Sign (Raw Data)	Predicted Sign (Log)	Predicted Sign (Rank)
Pension Scheme Funding Level	+/−		+/−
Pension Scheme Assets to Firm Market Value	+/−		+/–
Firm Total Assets	+/−	+/−	
Sales over Assets	+		−
EBIT over Assets	−		+
DDA over EBITDA	+		−
Dividend Yield	−		+
Leverage	+		−

find that the discount rate is positively linked to leverage, and given the incentive for highly levered firms to understate the importance of their pension schemes, I should expect such firms to use a weaker actuarial basis. I use the same measure of leverage as described earlier.

4.18 This means that the coefficients in the regression equation for the net dividend discount rate should have the opposite signs to those in the regression equations for the net pre-retirement liability discount rate and the net post-retirement liability discount rate, since a strong basis for the liabilities means a low net discount rate, whereas for the assets it means a high net discount rate. However, it is also worth considering the situation where the signs are the same in all sets of regressions. This could instead mean that particular types of firms prefer to use particularly high (or low) net discount rates in both their assets and liabilities.

4.19 I give the expected signs of the coefficients in Table 3. These are the coefficients that would be expected for the liability-related variables, the net pre- and post-retirement discount rates; the opposite would be expected for the net dividend discount rate. This is because a small value of the liability-related discount rates increases the size of the liabilities, and so is part of a "strong" basis; however, a low asset-related discount rate increases the size of the assets, and so is part of a "weak" basis.

4.20 Therefore, to summarise, the non-pensions independent variables I consider are:

– a firm size proxy, for which I use total assets;
– an asset base proxy, for which I use the ratio of sales to total assets;
– a firm profitability proxy, for which I use the ratio of earnings before interest and tax (EBIT) to total assets;
– a non-debt tax shield proxy, for which I use depreciation, depletion and amortisation (DDA) over earnings before interest, tax, depreciation and amortisation (EBITDA);
– a growth/value firm proxy, for which I use the dividend yield; and
– leverage, which I define as the ratio of the book value of debt over the sum of the book value of debt and the market value of equity.

4.21 The independent variables I use that relate directly to the pension scheme are:

– the ratio of pension scheme asset market value to the market value of firm equity; and
– the pension scheme funding level.

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4.22 Most pension scheme data for UK firms is not available on databases. I therefore extract the information that I use directly from the pensions notes in the accounts. I use electronic versions of the accounts and, when these are unavailable, hard copies from the British Library, the London Business School Library and the Strathclyde Business School Library. All other data are taken from DataStream.

4.23 Because the dataset is taken from a subset of the 100 largest UK public limited companies, there is a risk that the conclusions will not reflect the full range of UK firms. In particular, the sample contains a disproportionately high number of multinational firms whose motivations (and disclosures) may well differ from those of more domestically focused firms. No action is taken to counter this; however, it is a feature that needs to be taken into account when analysing the results.

5. Extent of disclosure within SSAP 24

5.1 First, I look at firms reporting under SSAP 24 and the extent of disclosure. In order to do this I treat each year's observation from a particular firm separately. This allows for the fact that a change in a company's situation over time might influence the level of its disclosure.

5.2 The data available for analysis constitute an unbalanced panel, since different firms are available for analysis in different years. For example, a firm might enter the sample in 1994 and remain in the sample until 2002; another may be in the sample from 1989, remaining until 1999. The first firm will contribute nine observations, and the second will contribute eleven. For all firms, the dependent variable takes a value of unity in each year that a value is disclosed and zero when a value is not given. This means that the dependent variable can (and does) change from year to year for a single firm, since the decision by firms as to whether to make particular disclosures can (and does) change over time.

5.3 The fact that many firms have observations in multiple years can cause problems, since each observation is taken separately. In particular, there is likely to be correlation between the right-hand-side variables, since the rank of the size proxies and many of the accounting ratios can be expected to remain relatively stable over time for a particular firm. I therefore use appropriate statistical methods to control for this issue, in particular by calculating robust standard errors. It is worth expanding on what this means. In any regression equation, the uncertainty around any coefficient is given by the standard error. The larger the standard error, the less likely it is that the coefficient is significantly different from zero – in other words, the less likely it is that independent variable helps to explain the dependent variable. If there are a number of observations from each firm, then because these observations are more likely to be close to each other the standard error for all observations is likely to be lower than it would be if there was only one observation for each firm. Robust standard errors allow for this clustering, and are higher than unadjusted standard errors to compensate for the fact that the inter-relation between the observations gives an artificially low level of volatility.

5.4 In order for the analysis in this section to be useful, I carry it out only when the number of instances of a disclosure being made is far enough away from the total number of observations and from zero. This rules out the combined disclosure of the net dividend discount rate and the actuarial value of pension scheme assets (where no more than six firms in any one year disclose both items) and the net pre-retirement liability discount rate (where only eight firms over the whole period fail to disclose this item). Also, since no firms under analysis adopted a market value basis before 1998, I only analyse data from this year onwards.

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5.5 The raw data is not suitable for analysis without some adjustment. In particular, there is significant positive skew in the firm size proxy, and the remaining variables show skew and leptokurtosis, all through the calculation of the Bera-Jarque statistic. This is a "portmanteau" test that uses the skew and kurtosis of a dataset to give an indication of whether the dataset is normally distributed. For a variable which always take values greater than zero and where positive skew is the issue, logarithms can be taken. This approach is suitable for the data given as absolute values (rather than ratios), namely firm total assets. Taking the natural logarithms of this variable's values does reduce skew and brings the Bera-Jarque statistics to levels such that there is no statistically significant non-normality. There are still a number of data points beyond three standard deviations of the mean; however, given that the variables span seventeen years and are not dimensionless (unlike the remaining ratio variables which are), some change in the mean of annual observations is to be expected from year to year, and the result is likely to be leptokurtosis. In the regression analysis later on, year-to-year change is taken care of by using dummy variables for all but one of the years; however, for this to be the only change needed there would need to be only a limited incidence of extreme observations within each year for these variables.

5.6 Having dealt with the size proxies, I next turn to the remaining variables, all of which are ratios. Accounting ratios in particular produce distributions with large numbers of extreme observations. Kolari *et al.* (1989) and Buckmaster & Saniga (1990) find range of non-normal distribution shapes in ratios – J, reverse J, U – all of which suggest lots of outliers. An approach suggested by Kane & Meade (1998) specifically for dealing with financial ratios is to use ranks instead. In particular, they find that models using this approach have more explanatory and predictive power than those using data converted with other transformations. I therefore transform all ratio data using this approach, ranking within years. It is worth noting that the order of ranked variables is the reverse of the order of the raw variables.

5.7 Next, I carry out univariate analysis. For the log-transformed size proxies, I compare the means. Having calculated the means, I then calculate the standard deviations and degrees of freedom in order to carry out a two-tailed t-test. For the rank-transformed variables, I use the Mann-Whitney U test as derived by Mann & Whitney (1947). The calculation of U is such that large values for the underlying pre-ranked data result in large values of U.

5.8. Net Post-Retirement Liability Discount Rate

5.8.1 I consider each item in turn, first looking at the net post-retirement liability discount rate. First I consider the difference between the explanatory variables for firms disclosing and failing to disclose the net post-retirement liability discount rate, looking at the difference between the means for the log-transformed variables in Table 4 and the Mann-Whitney U Statistic in Table 5.

Table 4. Difference between explanatory variables for firms disclosing/not disclosing the net post-retirement liability discount rate (i-p); Log-transformed variable.

X	Predicted Difference	E(x) i-p	E(x) no i-p	Joint Standard Deviation	Joint Degrees of Freedom	Two-Tailed p Value	Significance
Firm Total Assets – log	>	1.42	1.29	0.08	285.93	0.1125	
Number		**781**	194				

Significance codes: ***1%; **5%; *10%.

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Table 5. Results of U Test for firms disclosing/not disclosing the net post-retirement liability discount rate (i-p); Ranked variables.

X	Predicted Difference	U_{ip}	$U_{No\ ip}$	Expected Value of U	Standard Deviation of U^{+}	Two-Tailed p Value	Significance
Pension Scheme Funding Level – rank	>	69,533.0	81,981.0			0.0762	*
Pension Scheme Assets to Firm Market Value – rank	</>	69,849.0	81,665.0			0.0923	*
Sales over Assets – rank	<	77,823.5	73,690.5	↑	↑	0.5562	
EBIT over Assets – rank	</>	61,086.0	90,428.0	75,757.0	3,510.4	0.0000	***
DDA over EBITDA – rank	>	79,382.0	72,132.0	↓	↓	0.3016	
Dividend Yield – rank	>	71,805.0	79,709.0			0.2502	
Leverage – rank	<	75,664.0	75,850.0			0.9790	
Number		781	194				

Significance codes: ***1%; **5%; *10%.

$^{+}$The standard deviation actually used in the calculations is adjusted for tied ranks.

5.8.2 Table 4 provides only weak evidence that larger firms are more likely to disclose the net post-retirement liability discount rate, in line with the hypothesis that such firms are under greater pressure to provide this information.

5.8.3 Table 5 suggests that firms whose pension schemes are well funded are actually less likely to disclose the net post-retirement liability discount rate, suggesting that high funding levels are actually an indication of a weak actuarial basis. Another possibility is that firms failing to disclose their pension increases had no guaranteed pension escalation and included no allowance for discretionary increases in their valuations. This would also lead to such firms having better funded pension schemes. The results also suggest that firms with disproportionally large pension schemes are less likely to disclose the net post-retirement liability discount rate. This supports the hypothesis that such firms might be more likely to want to play down the impact of the pension scheme on the firm's underlying business. Table 5 also suggests that those firms disclosing the net post-retirement liability discount rate are significantly less likely to be profitable than those failing to disclose, supporting the tax management hypothesis for EBIT over assets.

5.8.4 Next, I look at whether there is a significant difference across economic groups when it comes to the disclosure of the net post-retirement liability discount rate. This is interesting in its own right, but also useful for assessing the extent to which the results above are not more a reflection of sector biases. I use the binomial distribution rather than an approximation. To do this, I use the following approach:

– I first divide firms by FTSE economic group;
– next, I choose an economic group and consider the probability that a firm in this group discloses the net post-retirement liability discount rate;
– I then calculate the proportion of firms in other economic groups combined that disclose the net post-retirement liability discount rate;
– using this proportion as the population probability, I then calculate the cumulative binomial probability for the chosen economic group and assess the statistical significance of any difference; and
– I repeat this for all economic groups.

5.8.5 I give the results based on full data in Table 6. This suggests different levels of disclosure for all but three economic groups. When looking at the logit regression below, I include the significantly different economic groups as dummy variables.

5.8.6 Next, I carry out logit regression analysis on the data. A level of "1" for the dependent variable denotes a firm disclosing the net post-retirement liability discount rate and a level of "0" denotes a failure to disclose. I include the explanatory variables described earlier, together with a number of dummy variables. First, there are those arising from the economic group analysis above. The economic groups of basic industries, cyclical services, general industrials, non-cyclical services, resources and utilities appear to be the most suitable. Both company and year fixed effects are considered in order to exploit the panel-based nature of the data. For the company fixed effects, the lack of variability in the dependent variable in a logit regression means that including the additional 135 dummy variables results in no solutions to the regression being found. I therefore omit company fixed effects. For year fixed effects, the obvious action would be to include dummy variables for all but one year (1989 to 2004, excluding 2005); however, in both 2004 and 2005, all firms that I consider disclose the net post-retirement liability discount rate. In order that a solution may be found to the regressions, I therefore additionally omit the dummy variables for 2003 and 2004.

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Table 6. Difference in firms disclosing/not disclosing the net post-retirement liability discount rate (i-p) between economic groups.

	Number in Group	Number in Group Disclosing i-p	p Value	Significance
Basic Industries	117	64	0.0000	***
Cyclical Consumer Goods	21	19	0.1751	
Cyclical Services	284	255	0.0000	***
General Industrials	77	53	0.0069	***
Information Technology	15	12	0.5981	
Non-Cyclical Consumer Goods	184	142	0.1263	
Non-Cyclical Services	108	79	0.0294	**
Resources	63	61	0.0001	***
Utilities	106	96	0.0011	***
Total	**975**	**781**		

Significance codes: ***1%; **5%; *10%.

5.8.7 I also carry out a Hausman test to determine whether ignoring the remaining year dummies would result in omitted variables bias. The results of the tests suggest that the null hypothesis of random effects can be rejected at the 1% level of significance and that the year dummies should be included.

5.8.8 The equation used in this part of the analysis is given in two parts. The first, in (1), gives the basic structure of the regression. Here, the latent variable in respect of firm i in year t is $y^*_{i,t}$. This is defined in term of the various explanatory variables. These are discussed in Chapter 3, but given again here for ease of reference. The size proxy is given as $\text{lnTA}_{i,t}$, the logarithm of a firm's total assets. The other terms in the equation are: the ranks of sales over assets ($\text{rSoA}_{i,t}$), EBIT over assets ($\text{rEBIToA}_{i,t}$), depreciation, depletion and amortisation over EBITDA ($\text{DDAoEBITDA}_{i,t}$), dividend yield ($\text{rDY}_{i,t}$), leverage ($\text{rL}_{i,t}$); a dummy variable for each year ($\text{YearDummy}_{z,i,t}$) which is equal to 1 when z = t and zero otherwise; and dummy variables for the economic groups basic industries ($\text{BI}_{i,t}$), cyclical services ($\text{CS}_{i,t}$), general industrials ($\text{GI}_{i,t}$), non-cyclical services ($\text{NCS}_{i,t}$), resources ($\text{R}_{i,t}$) and utilities ($\text{U}_{i,t}$), the subscript i denoting the observations for firm i and the subscript t denoting the observation in year t in all cases. The final term in this regression, $\varepsilon_{i,t}$, is the error term for firm i in year t.

$$
\begin{aligned}
y^*_{i,t} = {} & \beta_0 + \beta_1 \text{rFL}_{i,t} + \beta_2 \text{rPStoCo}_{i,t} + \beta_3 \text{lnTA}_{i,t} + \beta_4 \text{rSoA}_{i,t} + \beta_5 \text{rEBIToA}_{i,t} \\
& + \beta_6 \text{rDDAoEBITDA}_{i,t} + \beta_7 \text{rDY}_{i,t} + \beta_8 \text{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1980} \text{YearDummy}_{z,i,t} \\
& + \beta_{26} \text{BI}_{i,t} + \beta_{27} \text{CS}_{i,t} + \beta_{28} \text{GI}_{i,t} + \beta_{29} \text{NCS}_{i,t} + \beta_{30} \text{R}_{i,t} + \beta_{31} \text{U}_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{1}
$$

5.8.9 The latent variable $y^*_{i,t}$ can in theory take values from $-\infty$ to $+\infty$. However, the dependent variable, $y_{i,t}$, is the probability that a firm discloses the net post-retirement discount rate. This can only take a value from zero to unity, as shown in (2), so in a logit regression the latent variable is transformed using the formula in (3).

$$
y_{i,t} = \begin{cases} 1 \text{ if } y^*_{i,t} > 0 \\ 0 \text{ if } y^*_{i,t} \le 0. \end{cases} \tag{2}
$$

$$
P(y_{i,t} = 1 | x_{i,t}) = \frac{e^{x'_{i,t}\beta}}{1 + e^{x'_{i,t}\beta}} \tag{3}
$$

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Table 7. Logit analysis of firms disclosing/not disclosing the net post-retirement liability discount rate (i-p).

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.22			
Adj Pseudo-R^2	0.19			
(Intercept)	2.27	0.80***	1.23*	
Pension Scheme Funding Level – Rank	−0.08	0.04**	0.10	−0.40
Pension Scheme Assets to Firm Market Value – rank	−0.04	0.05	0.10	−0.18
Firm Total Assets – log	5.16	13.48	24.30	0.06
Sales over Assets – rank	−0.20	0.05***	0.09**	−0.97
EBIT over Assets – rank	0.30	0.05***	0.09***	1.46
DDA over EBITDA – rank	0.22	0.05***	0.09**	1.08
Dividend Yield – rank	0.05	0.04	0.06	0.23
Leverage – rank	0.02	0.05	0.11	0.10
Basic Industries	−1.07	0.30***	0.81	−1.07
Cyclical Services	0.81	0.28***	0.67	0.81
General Industrials	−0.78	0.34**	0.81	−0.78
Non-Cyclical Services	0.00	0.36	0.73	0.00
Resources	2.94	0.79***	1.24**	2.94
Utilities	1.55	0.41***	0.72**	1.55

Significance codes: ***1%; **5%; *10%; (Standard errors given in round parentheses).
Statistics for year dummies are not shown.

where $x_{i,t}$ is the vector of explanatory variables and β is the vector of regression coefficients. The results of the regression are given in Table 7. I also give the pseudo-R^2 as defined by McFadden (1974), and the adjusted pseudo-R^2 as defined by Ben-Akiva & Lerman (1985).

5.8.10 In these regressions, a positive coefficient for a particular explanatory variable means that an increase in this variable leads to a firm being more likely to disclose the item under investigation.

5.8.11 The sign on the coefficient of the rank of pension scheme funding level is now in line with that predicted, but the significance of the coefficient disappears once the standard errors are adjusted to allow for the fact that each firm may have a number of observations.

5.8.12 The coefficients on the rank of the ratio of pension scheme to firm market value and firm total assets are no longer significant even before the allowance for clustering. Again the year dummies have an impact here, the coefficients on the size proxies being significant in regressions where year dummies are absent.

5.8.13 The multivariate analysis results in the coefficients on the rank of sales over assets becoming significant. The coefficient is negative and significant at the 1% level of confidence (and at the 5% level of confidence if clustering is allowed for). The coefficient is the opposite of that expected, suggesting either that firms with a small asset base are actually more likely to give full disclosure, or that the rank of sales over assets is a proxy for firm age rather than asset base.

5.8.14 The coefficient on the rank of EBIT over assets is positive and significant at the 1% level of confidence, remaining so when clustering is allowed for. This suggests that more profitable

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firms are less likely to give complete disclosures, supporting the idea that such firms use their defined benefit pension schemes to manage their tax positions. This is consistent with the univariate analysis above.

5.8.15 The coefficient on the rank of depreciation, depletion and amortisation over EBITDA is also positive and significant at the 1% level of confidence, the level of significance falling slightly to 5% when clustering is allowed for. This suggests, however, that firms with lower non-debt tax shields are actually more likely to disclose the net post-retirement liability discount rate, contradicting the tax management hypothesis and suggesting that this variable is either not a good proxy for the level of non-debt tax shields or a good proxy for firm age.

5.8.16 The coefficients on all of the economic group dummy variables except non-cyclical services are significant. The signs suggest that basic industries and general industrials are less likely than average to disclose, whereas the remainder are more likely. However, when clustering is allowed for, only the coefficients on the dummies for Resources and Utilities remain significant, at the 5% level.

5.9. Net Dividend Discount Rate

5.9.1 Next, I look at asset side, first considering the disclosure of the net interest rate used to discount dividends when valuing equity holdings. There are two possibilities with the level of disclosure for this variable. First, the factors that influenced the level of disclosure of other variables might similarly influence the disclosure of the net dividend discount rate: firms that are more likely to disclose the net post-retirement liability discount rate and the actuarial value of pension scheme assets – the disclosure of which is discussed later – might also be more likely to disclose the net dividend discount rate; however, given that the net dividend discount rate is not sufficient to derive the actuarial value of pension scheme assets from the market value of pension scheme assets, it might be that disclosure of the net dividend discount rate is seen as an alternative to disclosing the actuarial value of pension scheme assets for firms wishing to disclose less information. Indeed, for much of the period under investigation it is clear that firms disclosed the net dividend discount rate or the actuarial value of pension scheme assets rather than both. This changes in later years, but since the purpose of disclosing the net dividend discount rate is to help analysts to understand the value placed on the actuarial value of pension scheme assets, the disclosure of the former when the latter is already given could be seen as redundant. I assume initially that disclosure of the net dividend discount rate is in line with the disclosure of other variables – in other words, more is better – and that the expected signs are the same as for the net post-retirement liability discount rate.

5.9.2 First I consider the difference between the explanatory variables for firms disclosing and failing to disclose the net dividend discount rate, looking at the difference between the means for the log-transformed variables in Table 8 and the Mann-Whitney U Statistic in 9.

Looking at the differences between the variables for the "disclosing" and "non-disclosing" groups in Table 8, the coefficient log of total assets supports the hypothesis that smaller firms disclose the net dividend discount rate rather than giving the fuller disclosure of the actuarial value of pension scheme assets.

5.9.3 Moving on to Table 9, it is clear that those firms disclosing the net dividend discount rate are those whose pension schemes have higher funding levels. This is consistent with the

Table 8. Difference between explanatory variables for firms disclosing/not disclosing the net dividend discount rate (i-d); Log-transformed variable.

X	Predicted Difference	E(x) i-d	E(x) no i-d	Joint Standard Deviation	Joint Degrees of Freedom	Two-Tailed p Value	Significance
Firm Total Assets – log	>	1.33	1.44	0.06	899.26	0.0791	*
Number		**398**	**577**				

Significance codes: ***1%; **5%; *10%.

hypothesis that firms with well-funded pension schemes might be more likely to give complete disclosure. It is also consistent with the multivariate analysis of the net post-retirement liability discount rate, but not the univariate analysis on this variable.

5.9.4 The results also suggest that firms who have disproportionally large pension schemes are more likely to disclose the net dividend discount rate than those with small schemes. This could be taken either as support for the argument that if a firm's pension scheme is disproportionally large, then the market will expect greater disclosure; or, conversely it could signal the fact that firms with large pension schemes prefer to disclose the net dividend discount rate rather than the more useful actuarial value of pension scheme assets in order to allow the overstatement of funding levels.

5.9.5 As with the net post-retirement liability discount rate, there is no significant difference in the rank of sales over assets between those firms disclosing and not disclosing the net dividend discount rate. However, also as with the net post-retirement liability discount rate, there is a significant difference in the profitability of those firms disclosing the net dividend discount rate and those failing to make disclosure, with more profitable firms being more likely to disclose the net dividend discount rate. Again, this difference has two interpretations: it might mean that the rank of EBIT over assets is a proxy for bankruptcy risk, and less profitable firms are less willing to give complete disclosures; however, it might also mean that the rank of EBIT over assets is a tax proxy, and that more profitable firms would rather disclose the net dividend discount rate than the actuarial value of pension scheme assets.

5.9.6 The difference between the ranks of the non-debt tax shield proxy, the rank of depreciation, depletion and amortisation over EBITDA, is also significant. This suggests that firms with large non-debt tax shields are less likely to disclose the net dividend discount rate. If more disclosure is regarded as better, then these results are consistent with the logit regressions of the net post-retirement liability discount rate, suggesting that this variable is either not a good proxy for non-debt tax shields or a good proxy for firm age; however, the result might also suggest that this variable is a good non-debt tax shield proxy, and that the net dividend discount rate is regarded as inferior to disclosure of the actuarial value of pension scheme assets.

5.9.7 The rank of the dividend yield is significantly smaller for firms that disclose the net dividend discount rate, so disclosure is more common for growth firms. Since growth firms should be more likely to prize opacity, this suggests either that these variables are actually firm age proxies, or that that the net dividend discount rate is seen as an inferior form of disclosure.

5.9.8 Finally, I look at the rank of leverage. Firms with higher leverage are less likely to disclose the net dividend discount rate. Since such firms should be more likely to want to hide

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Table 9. Results of U-Test for firms disclosing/not disclosing the net dividend discount rate (i-d) ranked variables.

X	Predicted Difference	U_{id}	$U_{No\ id}$	Expected Value of U	Standard Deviation of U^{+}	Two-Tailed p Value	Significance
Pension Scheme Funding Level – rank	>	130,231.0	99,415.0			0.0004	***
Pension Scheme Assets to Firm Market Value – rank	</>	131,485.5	98,160.5			0.0001	***
Sales over Assets – rank	<	115,744.0	113,902.0	↑	↑	0.8313	
EBIT over Assets – rank	</>	129,466.0	100,180.0	114,823.0	4,321.8	0.0007	***
DDA over EBITDA – rank	>	104,460.5	125,185.5	↓	↓	0.0165	**
Dividend Yield – rank	>	106,663.5	122,982.5			0.0538	*
Leverage – rank	<	99,812.5	129,833.5			0.0005	***
Number		**398**	**577**				

Significance codes: ***1%; **5%; *10%.

$^{+}$The standard deviation actually used in the calculations is adjusted for tied ranks.

Table 10. Difference in firms disclosing/not disclosing the net dividend discount rate (i-d) between economic groups.

	Number in Group	Number in Group Disclosing i-d	p Value	Significance
Basic Industries	117	39	0.0370	**
Cyclical Consumer Goods	21	15	0.0037	***
Cyclical Services	284	114	0.3956	
General Industrials	77	33	0.3876	
Information Technology	15	13	0.0003	***
Non-Cyclical Consumer Goods	184	82	0.1149	
Non-Cyclical Services	108	48	0.2214	
Resources	63	18	0.0222	**
Utilities	106	36	0.0646	*
Total	**975**	**398**		

Significance codes: ***1%; **5%; *10%.

the state of their pension schemes, this suggests that not disclosing the net dividend discount rate is seen as a way of limiting disclosure rather than as an alternative to better disclosure.

5.9.9 Next, I look at any differences in disclosure between economic groups in Table 10. I find significant differences for five of the economic groups, all of which I include as dummy variables.

5.9.10 Finally, I carry out the logit regression, giving the results in Table 11. As before, a level of “1” for the dependent variable denotes a firm disclosing the net post-retirement liability discount rate and a level of “0” denotes a failure to disclose. Company fixed effects are again considered, but the large number of additional variables continues to cause problems with the logit regression. Regressions including year fixed effects converge comfortably on optimal solutions, and give variance/covariance matrices that are easily inverted. Hausman tests show in all cases that the null hypothesis of no year fixed effects can be rejected at the 1% level, so year fixed effects are included in all regressions.

5.9.11 The basic structure of the regression is given in (4), and the latent variable in respect of firm i in year t is again $y^*_{i,t}$. This is defined in term of the various explanatory variables given above.

$$
\begin{aligned}
y^*_{i,t} =& \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\
& + \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1980} \mathrm{YearDummy}_{z,i,t} \\
& + \beta_{26} \mathrm{BI}_{i,t} + \beta_{27} \mathrm{CCG}_{i,t} + \beta_{28} \mathrm{IT}_{i,t} + \beta_{29} \mathrm{R}_{i,t} + \beta_{30} \mathrm{U}_{i,t} + \varepsilon_{i,t}
\end{aligned}
\tag{4}
$$

5.9.12 The latent is utilised as before.

Again, I also give the pseudo-R^2 and the adjusted pseudo-R^2.

5.9.13 The coefficient on the rank of pension scheme funding level is negative and significant at the 1% level of confidence. This suggests that firms with high funding levels are more likely to give

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Table 11. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d).

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.15			
Adj Pseudo-R^2	0.13			
(Intercept)	−1.34	0.87	1.00	
Pension Scheme Funding Level – Rank	−0.09	0.03***	0.06	−0.45
Pension Scheme Assets to Firm Market Value – rank	−0.22	0.04***	0.06***	−1.07
Firm Total Assets – log	−12.03	10.46	20.85	−0.15
Sales over Assets – rank	0.08	0.03**	0.06	0.40
EBIT over Assets – rank	−0.06	0.04	0.06	−0.29
DDA over EBITDA – rank	0.02	0.04	0.07	0.11
Dividend Yield – rank	0.04	0.03	0.05	0.17
Leverage – rank	0.07	0.04*	0.06	0.32
Basic Industries	−0.82	0.28***	0.63	−0.82
Cyclical Consumer Goods	−0.32	0.21	0.37	−0.32
Information Technology	−0.71	0.31**	0.62	−0.71
Resources	0.30	0.29	0.51	0.30
Utilities	−0.80	0.39**	0.70	−0.80

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

complete disclosure, a conclusion consistent with the univariate analysis and the logit regressions using the net post-retirement liability discount rate. However, when the standard errors are adjusted to allow for clustering this significance disappears.

5.9.14 The coefficient on the rank of the ratio of pension scheme to firm market value is also negative and significant at the 1% level of confidence, remaining so even when the standard error is adjusted for clustering, suggesting that firms with disproportionally large pension schemes are more likely to disclose the net dividend discount rate. As with the univariate analysis, this could be taken either as support for the argument that if a firm's pension scheme is disproportionally large, then the market will expect greater disclosure; or, conversely it could signal the fact that firms with large pension schemes prefer to disclose the net dividend discount rate rather than the more useful actuarial value of pension scheme assets in order to allow the overstatement of funding levels.

5.9.15 The coefficient on the log of total assets is not significant. The rank of sales over assets, the asset base proxy, has a coefficient that is significant at the 5% level of confidence, and with a positive coefficient, although the significance disappears once clustering is allowed for in the standard errors. The coefficient on the rank of EBIT over assets is not significant.

5.9.16 In this multivariate analysis, the limited evidence in the univariate analysis for a difference between growth and value firms in terms of disclosure vanishes. There also only weak agreement with the earlier univariate results in relation to leverage, with results suggesting that more highly levered firms are less likely to disclose the net dividend discount rate, but with the significance disappearing when adjusted standard error is used.

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5.10 Actuarial Value of Assets

5.10.1 The extent of disclosure of the net dividend discount rate is one indicator of a firm's intentions on the asset side of the equation. However, the fact that rationales are available for increased disclosure of the net dividend discount rate being an indicator both of increased and reduced transparency means that the results are less than satisfactory, and it is by no means clear as to whether disclosure of the net dividend discount rate is regarded as good (or at least better than nothing) or bad (when compared with disclosure of the actuarial value of pension scheme assets). I return to this variable later in an effort to address this; however, in the meantime a less ambiguous indicator is the disclosure of the actuarial value of pension scheme assets (AVA). With this variable, the expectation should be that disclosing the actuarial value of pension scheme assets means that more information is being given. This being the case, the signs on the explanatory variables should be the same as those with the regressions of the net post-retirement liability discount rate.

5.10.2 Looking first at the differences between the log-transformed variable in Table 12, it is clear that larger firms are more likely than smaller firms to disclose the actuarial value of pension scheme assets, the difference being significant at the 1% level. This is in line with the hypothesis that larger firms are under pressure to give better disclosures.

5.10.3 Moving on to the U test, in Table 13, there are a number of significant results. First, firms disclosing the actuarial value of pension scheme assets appear to have pension schemes with lower funding levels, the difference being significant at the 1% level. This is consistent with earlier univariate analysis of the net post-retirement liability discount rate, but not subsequent multivariate analysis, suggesting judgement should reserved until the multivariate analysis of the actuarial value of pension scheme assets has been completed.

Firms disclosing the actuarial value of pension scheme assets also seem to have pension schemes which are smaller in relation to their sponsors than for those firms not making such a disclosure. This is consistent with earlier results that firms with disproportionally large pension schemes are less inclined to give full disclosure in order to play down the importance of the pension scheme.

5.10.4 The difference between the ranks of sales over assets for the two groups is also significant. The finding that those firms disclosing have larger asset bases is in line with the hypothesis, but contrary to earlier findings; however, the level of significance is only 10%.

5.10.5 The difference between the rankings for EBIT over assets is significant at the 1% level. Those disclosing the actuarial value of pension scheme assets are broadly less profitable than those failing to disclose. This is consistent with earlier results suggesting that more profitable firms give less complete disclosure in order to manage tax.

Table 12. Difference between explanatory variables for firms disclosing/not disclosing the actuarial value of pension scheme assets (AVA); Log-transformed variables.

X	Predicted Difference	E(x) AVA	E(x) no AVA	Joint Standard Deviation	Joint Degrees of Freedom	Two-Tailed p Value	Significance
Firm Total Assets – log	>	1.79	1.28	0.08	319.36	0.0000	***
Number		**212**	**763**				

Significance codes: ***1%; **5%; *10%.

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Table 13. Results of U Test for firms disclosing/not disclosing the actuarial value of pension scheme assets (AVA); Ranked variables.

X	Predicted Difference	U_{AVA}	$U_{No\ AVA}$	Expected Value of U	Standard Deviation of U+	Two-Tailed p Value	Significance
Pension Scheme Funding Level – rank	>	59,945.5	101,810.5			0.0000	***
Pension Scheme Assets to Firm Market Value – rank	</>	70,827.5	90,928.5			0.0056	***
Sales over Assets – rank	<	74,858.0	86,898.0	↑	↑	0.0970	*
EBIT over Assets – rank	</>	71,102.0	90,654.0	80,878.0	471.7	0.0070	***
DDA over EBITDA – rank	>	90,759.0	70,997.0	↓	↓	0.0064	***
Dividend Yield – rank	>	83,859.5	77,896.5			0.4012	
Leverage – rank	<	85,459.5	76,296.5			0.2064	
Number		**212**	**763**				

Significance codes: ***1%; **5%; *10%.
+The standard deviation actually used in the calculations is adjusted for tied ranks.

Table 14. Difference in firms disclosing/not disclosing the actuarial value of pension scheme assets (AVA) between economic groups.

	Number in Group	Number in Group Disclosing AVA	p Value	Significance
Basic Industries	117	17	0.0187	**
Cyclical Consumer Goods	21	3	0.2933	
Cyclical Services	284	67	0.1571	
General Industrials	77	13	0.1642	
Information Technology	15	0	0.0237	**
Non-Cyclical Consumer Goods	184	37	0.2883	
Non-Cyclical Services	108	24	0.4836	
Resources	63	16	0.2677	
Utilities	106	35	0.0016	***
Total	**975**	**212**		

Significance codes: ***1%; **5%; *10%.

5.10.6 Finally, firms disclosing the actuarial value of pension scheme assets are more likely to have higher levels of depreciation, depletion and amortisation over EBITDA, the difference being significant at the 1% level. This is consistent with the hypothesis that firms with lower non-debt tax shields are less likely to give full disclosure; however, it is inconsistent with earlier results.

5.10.7 Next I look at the differences in disclosure between economic groups, in Table 14. There are significant differences between the levels of disclosure for three economic groups: basic industries, information technology and utilities; however, for one of these the significant difference arises because there are no firms in that economic group – information technology – disclosing actuarial value of pension scheme assets. I therefore use only basic industries and utilities as dummy variables in the subsequent logit regressions.

5.10.8 The results for the logit regressions are given in Table 15.

5.10.9 As before, a level of “1” for the dependent variable denotes a firm disclosing the net post-retirement liability discount rate and a level of “0” denotes a failure to disclose. Company fixed effects are again considered, but the large number of additional variables continues to cause problems with the logit regression. Regressions including year fixed effects converge comfortably on optimal solutions, and give variance/covariance matrices that are easily inverted. Hausman tests show in all cases that the null hypothesis of no year fixed effects can be rejected at the 1% level, so year fixed effects are included in all regressions.

5.10.10 The basic structure of the regression is given in (5) in terms of $y^*_{i,t}$, the latent variable in respect of firm i in year t. This is defined in term of the various explanatory variables, as before.

$$\begin{aligned} y^*_{i,t} =& \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ & + \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1980} \mathrm{YearDummy}_{z,i,t} \\ & + \beta_{26} \mathrm{BI}_{i,t} + \beta_{27} \mathrm{U}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{5}$$

5.10.11 I also give the pseudo-R^2 and the adjusted pseudo-R^2 as before.

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Table 15. Logit analysis of firms disclosing/not disclosing the actuarial value of assets (AVA).

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.24			
Adj Pseudo-R^2	0.21			
(Intercept)	−1.45	(0.68)**	*(1.28)**	
Pension Scheme Funding Level – Rank	0.01	(0.04)	*(0.09)*	[0.04]
Pension Scheme Assets to Firm Market Value – rank	0.09	(0.04)**	*(0.08)*	[0.45]
Firm Total Assets – log	45.58	(12.66)***	*(28.66)*	[0.56]
Sales over Assets – rank	−0.03	(0.04)	*(0.10)*	[−0.14]
EBIT over Assets – rank	0.03	(0.05)	*(0.08)*	[0.16]
DDA over EBITDA – rank	0.14	(0.05)***	*(0.08)**	[0.67]
Dividend Yield – rank	−0.04	(0.04)	*(0.07)*	[−0.21]
Leverage – rank	0.05	(0.05)	*(0.07)*	[0.26]
Basic Industries	0.59	(0.40)	*(0.75)*	[0.59]
Utilities	0.66	(0.29)**	*(0.77)*	[0.66]

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

5.10.12 The coefficient on the rank of the ratio of pension scheme to firm market value is significant at the 5% level, with a positive sign, which is consistent with the univariate analysis. However, if clustering is allowed for in the standard errors, then the significance in the logit regression disappears.

5.10.13 Consistent with some of the earlier results is the observation that larger firms are more likely to give complete disclosures, with coefficient on the log of total assets being positive and significant at the 1% level, although again allowing for clustering removes this significance.

5.10.14 The coefficient on the rank of depreciation, depletion and amortisation over EBITDA is also positive and significant at the 1% level, remaining significant at the 10% level when clustering is allowed for. This is contrary to the hypothesis that firms with small non-debt tax shields are less likely to disclose fully. It is also contrary to the results of the univariate analysis, but it does reflect earlier findings that this variable is more likely to be a proxy for firm age. Interestingly, the coefficient on the rank of sales over assets, another variable where a significant difference was found in the univariate analysis, is no longer significant.

5.11. Mixed Asset-Related Disclosures

5.11.1 Having looked at these two items of disclosure on the asset side – the net dividend discount rate and the actuarial value of pension scheme assets – it is worth considering some joint test of disclosure. This is particularly important given the ambiguity surrounding the disclosure of the net dividend discount rate alone. As discussed above, once the actuarial value of pension scheme assets has been disclosed, disclosure of the net discount rate for the equity valuation does not add a great deal more information. Furthermore, I have already hypothesised – and found evidence for the hypothesis – that providing the net dividend discount rate might be regarded as an inferior form of disclosure to the provision of the actuarial value of pension scheme assets. This suggests several joint tests.

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5.11.2 The most basic is a test of no disclosure of any information on the asset side versus the disclosure of either the net dividend discount rate or the actuarial value of pension scheme assets. This can be analysed using a univariate approach, by industry, and using logit analysis as above. However, other hypotheses can be tested using an ordered logit regression. Whereas the dependent variable in a logit regression is binomial (either 0 or 1), the dependent variable in an ordered logit regression can take a number of values.

5.11.3 The first additional scenario is whether disclosure of both the net dividend discount rate and the actuarial value of pension scheme assets are regarded differently from the disclosure of only one of these items. Here, the dependent variable is takes the value of zero for no disclosure, 1 if either the net dividend discount rate or the actuarial value of pension scheme assets are disclosed, and 2 if both the net dividend discount rate and the actuarial value of pension scheme assets are disclosed.

5.11.4 A further hypothesis that can be tested is whether disclosure of the actuarial value of pension scheme assets has any importance if the net dividend discount rate is disclosed. Here, the dependent variable takes a value of 0 for no disclosure, 1 if the actuarial value of pension scheme assets is disclosed, and 2 if the net dividend discount rate is disclosed, with or without the actuarial value of assets.

5.11.5 Similarly, it can be asked whether disclosure of the net dividend discount rate has any importance if the actuarial value of pension scheme assets is disclosed. Here, the dependent variable takes a value of 0 for no disclosure, 1 if the net dividend discount rate is disclosed, and 2 if the actuarial value of pension scheme assets is disclosed, with or without the net dividend discount rate.

5.11.6 Finally, if the net dividend discount rate and the actuarial value of pension scheme assets are regarded as giving different degrees of information individually and combined, then an additional dependent variable is required. Here, I use a value of 0 for no disclosure, 1 for disclosure of the net dividend discount rate only, 2 for the disclosure of the actuarial value of pension scheme assets only, and 3 for disclosure of both. These values of dependent variables, together with other relevant information, are given in Table 16.

5.11.7 Next, I carry out analyses on these scenarios. First, I carry out univariate analysis on the first scenario. As before, the difference between means is considered for the log-transformed variables and a U test is carried out for the rank-transformed data. The first set of results is given in Table 17 and the second in Table 18.

Table 16. Dependent variable values in the analysis of asset-related disclosures, the net dividend discount rate (i-d) and the actuarial value of pension scheme assets (AVA).

Scenario	Regression Approach	No Disclosure	i-d Only	AVA Only	i-d and AVA
Disclosure of any asset-based information	Logit	0	1.0000	1.0000	1.0000
Disclosure of both versus disclosure of one	Ordered Logit	0	1.0000	1.0000	2.0000
Disclosure of AVA irrelevant	Ordered Logit	0	2.0000	1.0000	2.0000
Disclosure of i-d irrelevant	Ordered Logit	0	1.0000	2.0000	2.0000
Disclosure of AVA versus i-d versus both	Ordered Logit	0	1.0000	2.0000	3.0000

Table 17. Difference between explanatory variables for firms disclosing/not disclosing either the net dividend discount rate (i-d) or the actuarial value of pension scheme assets (AVA); Log-transformed variable.

X	Predicted Difference	E(x) i-d or AVA	E(x) no i-d or AVA	Joint Standard Deviation	Joint Degrees of Freedom	Two-Tailed p Value	Significance
Firm Total Assets – log	>	1.48	1.27	0.06	890.90	0.0008	***
Number		**573**	**402**				

Significance codes: ***1%; **5%; *10%.

5.11.8 The results for the size proxies are consistent with expectations and previous results – larger firms are more likely than smaller ones to give complete disclosure.

5.11.9 Moving on to the ranked variables, there appear to be very few significant differences between the variables. One difference that does exist is for the rank of the ration of pension scheme to firm value – those firms making some sort of asset-related disclosure appear to have proportionally larger pension schemes than those failing to make such disclosures, suggesting that the market expects greater disclosure from firms with proportionally large pension schemes. This is consistent with the univariate and multivariate analysis of the net dividend discount rate, but inconsistent with the univariate analysis of the net post-retirement liability discount rate and the univariate and multivariate analysis of the actuarial value of pension scheme assets.

5.11.10 Next I look at the difference between levels of disclosure for the various economic groups. I find differences in five groups, as shown in Table 19. These are included as dummy variables not only in this set of logit regressions, but in all four scenarios considering the disclosure of the net dividend discount rate and the actuarial value of pension scheme assets together.

5.11.11 Finally, I carry out the logit regression, giving the results in Table 20. As before, a level of "1" for the dependent variable denotes a firm disclosing either the net post-retirement liability discount rate or the actuarial value of pension scheme assets (or both) and a level of "0" denotes a failure to disclose either of these items. Company fixed effects are again considered, but the large number of additional variables continues to cause problems; however, Hausman tests show in all cases that the null hypothesis of no year fixed effects can be rejected at the 1% level, so year fixed effects are included in all regressions.

5.11.12 The basic structure of the regression is given in (6) in terms of $y^*_{i,t}$, the latent variable in respect of firm i in year t.

$$\begin{aligned} y^*_{i,t} = {} & \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ & + \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1980} \mathrm{YearDummy}_{z,i,t} \\ & + \beta_{26} \mathrm{BI}_{i,t} + \beta_{27} \mathrm{CCG}_{i,t} + \beta_{28} \mathrm{IT}_{i,t} + \beta_{29} \mathrm{NCCG}_{i,t} + \beta_{30} \mathrm{R}_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (6)$$

5.11.13 I also give the pseudo-R^2 and the adjusted pseudo-R^2 as before.

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Table 18. Results of U Test for firms disclosing/not disclosing the net dividend discount rate (i-d) or the actuarial value of pension scheme assets (AVA); Ranked variables.

X	Predicted Difference	$U_{id\ AVA}$	$U_{No\ id\ AVA}$	Expected Value of U	Standard Deviation of U^{+}	Two-Tailed p Value	Significance
Pension Scheme Funding Level – rank	>	110,921.5	119,424.5			0.3259	
Pension Scheme Assets to Firm Market Value – rank	</>	122,568.0	107,778.0			0.0875	*
Sales over Assets – rank	<	113,243.5	117,102.5	↑	↑	0.6558	
EBIT over Assets – rank	</>	120,331.5	110,014.5	115,173.0	4,328.4	0.2327	
DDA over EBITDA – rank	>	113,202.0	117,144.0	↓	↓	0.6488	
Dividend Yield – rank	>	112,896.5	117,449.5			0.5912	
Leverage – rank	<	104,490.5	125,855.5			0.0136	
Number		**573**	**402**				

Significance codes: ***1%; **5%; *10%.

[+]The standard deviation actually used in the calculations is adjusted for tied ranks.

Table 19. Difference in firms disclosing/not disclosing the net dividend discount rate (i-d) or the actuarial value of pension scheme assets (AVA) between economic groups.

	Number in Group	Number in Group Disclosing i-d	p Value	Significance
Basic Industries	117	54	0.0012	***
Cyclical Consumer Goods	21	18	0.0071	***
Cyclical Services	284	166	0.4613	
General Industrials	77	41	0.1697	
Information Technology	15	13	0.0201	**
Non-Cyclical Consumer Goods	184	119	0.0265	**
Non-Cyclical Services	108	67	0.2502	
Resources	63	31	0.0647	*
Utilities	106	64	0.3924	
Total	**975**	**573**		

Significance codes: ***1%; **5%; *10%.

Table 20. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d) and/or the actuarial value of assets (AVA); Scenario 1.

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.13			
Adj Pseudo-R^2	0.10			
(Intercept)	1.08	0.58*	0.84	
Pension Scheme Funding Level – Rank	−0.11	0.03***	0.06*	−0.53
Pension Scheme Assets to Firm Market Value – rank	−0.09	0.03***	0.06*	−0.46
Firm Total Assets – log	0.28	0.09***	0.19	0.35
Sales over Assets – rank	0.03	0.03	0.06	0.15
EBIT over Assets – rank	−0.05	0.04	0.06	−0.26
DDA over EBITDA – rank	0.10	0.04**	0.06	0.47
Dividend Yield – rank	−0.02	0.03	0.05	−0.09
Leverage – rank	0.10	0.04***	0.06*	0.49
Basic Industries	−0.28	0.23	0.47	−0.28
Cyclical Consumer Goods	2.02	0.66***	0.96**	2.02
Information Technology	1.48	0.81*	0.72**	1.48
Non-Cyclical Consumer Goods	0.05	0.20	0.41	0.05
Resources	−0.46	0.34	0.66	−0.46

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

5.11.14 The pseudo-R^2 value for this regression is 0.13. This is slightly lower than that for the regression considering the disclosure of i-d alone (0.15) and much lower than that considering the disclosure of the actuarial value of pension scheme assets alone (around 0.24).

5.11.15 The coefficient on the rank of pension scheme funding level is negative at the 1% level of significance, in line with the hypothesis that firms with higher funding levels disclose more. This level of significance falls to 10% once the standard error is adjusted for clustering. The coefficient on the other pension scheme-related variable – the rank of the ratio of pension

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scheme to firm value – is negative at the 1% level of significance, in line with hypothesis that sponsors with disproportionally large pension schemes more likely to disclose fully. This level of significance falls to 10% once robust standard errors are used. These results are also consistent with the univariate analysis on the disclosure of the net dividend discount rate and the actuarial value of pension scheme assets, and with the multivariate analysis of the net dividend discount rate alone; however, they are contrary to the multivariate analysis of the actuarial value of pension scheme assets alone.

5.11.16 One part of the analysis that reflects earlier results is that relating to size. The coefficient on the size proxy is positive and significant at the 1% level, supporting the hypothesis that larger firms disclose more. However, this significance disappears once the standard errors are adjusted to allow for clustering.

5.11.17 There are no statistically significant coefficients for the rank of sales over assets or EBIT over assets, but the coefficients on the rank of depreciation, depletion and amortisation over EBITDA are significant at the 5% level with a positive coefficient, although not once clustering is allowed for.

5.11.18 Finally, the coefficient on the rank of leverage is positive and significant at the 1% level, remaining so at the 10% level once clustering is allowed for. This is in line with hypothesis that firms with higher leverage will be less likely to give complete disclosure, and reflects the results of the analysis of the net dividend discount rate alone.

5.11.19 These results tend to support the analysis of both the net dividend discount rate and the actuarial value of pension scheme assets, and, to an extent, the idea that disclosure of the net dividend discount rate is better than no disclosure, rather than an inferior alternative to the disclosure of the actuarial value of pension scheme assets.

5.11.20 Next, I look at scenario 2, the first ordered logit regression. As mentioned above, no analysis between economic groups can be carried out with this approach so I use the same economic group dummy variables as for scenario 1. I use a similar regression equation structure as for scenario 1. However, two constants are given here: one applied when the dependent variable $y_{i,t}$ is greater than or equal to 1, and another when $y_{i,t}$ is greater than or equal to 2. This means that the regression formulation for the latent variable $y^*_{i,t}$, given in (7), is slightly different:

$$\begin{aligned} y^*_{i,t} = {} & \beta_0 \mathrm{OL1}_{i,t} + \beta_1 \mathrm{OL2}_{i,t} + \beta_2 \mathrm{rFL}_{i,t} + \beta_3 \mathrm{rPStoCo}_{i,t} + \beta_4 \ln\mathrm{TA}_{i,t} + \beta_5 \mathrm{rSoA}_{i,t} \\ & + \beta_6 \mathrm{rEBIToA}_{i,t} + \beta_7 \mathrm{rDDAoEBITDA}_{i,t} + \beta_8 \mathrm{rDY}_{i,t} + \beta_9 \mathrm{rL}_{i,t} \\ & + \sum_{z=1989}^{2005} \beta_{z-1979} \mathrm{YearDummy}_{z,i,t} + \beta_{27} \mathrm{BI}_{i,t} + \beta_{28} \mathrm{CCG}_{i,t} + \beta_{29} \mathrm{IT}_{i,t} + \beta_{30} \mathrm{NCCG}_{i,t} \\ & + \beta_{31} \mathrm{R}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{7}$$

5.11.21 The items in this equation are the same as in previous version except that here $\mathrm{OL1}_{i,t}$ is equal to 1 if the dependent variable is greater than or equal to 1, and $\mathrm{OL2}_{i,t}$ is equal to 1 if the dependent variable is greater than or equal to 2.

5.11.22 I also give the pseudo-R^2 and the adjusted pseudo-R^2 as before. The results are shown in Table 21.

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Table 21. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d) and/or the actuarial value of assets (AVA); Scenario 2.

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.10			
Adj Pseudo-R^2	0.08			
OL1	0.86	0.55	0.77	
OL2	−3.11	0.57***	0.80***	
Pension Scheme Funding Level – Rank	−0.10	0.03***	0.06*	−0.50
Pension Scheme Assets to Firm Market Value – rank	−0.08	0.03***	0.05	−0.40
Firm Total Assets – log	0.27	0.09***	0.18	0.33
Sales over Assets – rank	0.04	0.03	0.06	0.18
EBIT over Assets – rank	−0.05	0.04	0.06	−0.22
DDA over EBITDA – rank	0.08	0.04**	0.06	0.40
Dividend Yield – rank	0.00	0.03	0.05	0.00
Leverage – rank	0.08	0.03**	0.05	0.41
Basic Industries	−0.35	0.22	0.46	−0.35
Cyclical Consumer Goods	1.34	0.48***	0.65**	1.34
Information Technology	0.83	0.58	0.46*	0.83
Non-Cyclical Consumer Goods	−0.17	0.19	0.37	−0.17
Resources	−0.61	0.33*	0.66	−0.61

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

5.11.23 Unsurprisingly, the results of the scenario 2 analysis are very similar to those from scenario 1, the main difference being slightly lower levels of significance for the rank of the ratio of pension scheme to firm value. The pseudo-R^2 is lower, being 0.10. Also worth noting is the strongly significant negative coefficient on $OL2_{i,t}$.

5.11.24 Next, I look at scenario 3, the results appearing in Table 22. Here, the model formulation is identical to scenario 2.

5.11.25 Most of the parameters here are similar to scenarios 1 and 2, although the coefficients on the rank of the ratio of pension scheme to firm market value are higher, being significant at the 1% level even after allowing for the clustering in the standard errors. The pseudo-R^2 values for scenario 3 are low, however, at 0.08.

5.11.26 I then look at scenario 4, the results appearing in Table 23. Here again, the model formulation is identical to scenario 2 and to scenario 3.

5.11.27 Once again, the results are similar to the earlier scenarios. The coefficient on OL1 is significant and positive. The significance of the coefficients on the pension scheme funding level and the ratio of pension scheme funding level to firm market value are lower than in scenario 3, being more like scenarios 1 and 2. The opposite is true for the size proxies, the ratio of depreciation, depletion and amortisation to earnings before interest and taxes, and leverage. Overall, unsurprisingly, the results resemble those of the logit analysis of the actuarial value of assets.

Table 22. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d) and/or the actuarial value of assets (AVA); Scenario 3.

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.08			
Adj Pseudo-R^2	0.06			
OL1	0.71	0.48	0.65	
OL2	−0.12	0.48	0.64	
Pension Scheme Funding Level – Rank	−0.10	0.03***	0.05**	−0.49
Pension Scheme Assets to Firm Market Value – rank	−0.10	0.03***	0.05**	−0.49
Firm Total Assets – log	0.16	0.08**	0.15	0.19
Sales over Assets – rank	0.03	0.03	0.05	0.16
EBIT over Assets – rank	−0.05	0.03	0.05	−0.25
DDA over EBITDA – rank	0.05	0.03	0.06	0.24
Dividend Yield – rank	0.02	0.03	0.04	0.08
Leverage – rank	0.07	0.03**	0.05	0.33
Basic Industries	−0.33	0.21	0.50	−0.33
Cyclical Consumer Goods	1.61	0.52***	1.12	1.61
Information Technology	2.09	0.81**	0.81***	2.09
Non-Cyclical Consumer Goods	0.04	0.18	0.34	0.04
Resources	−0.60	0.30**	0.58	−0.60

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

Table 23. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d) and/or the actuarial value of assets (AVA); Scenario 4.

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.11			
Adj Pseudo-R^2	0.10			
OL1	1.57	0.55***	0.90*	
OL2	−0.40	0.54	0.86	
Pension Scheme Funding Level – Rank	−0.07	0.03***	0.06**	−0.35
Pension Scheme Assets to Firm Market Value – rank	−0.03	0.03	0.05	−0.16
Firm Total Assets – log	0.30	0.08***	0.17*	0.36
Sales over Assets – rank	0.01	0.03	0.06	0.06
EBIT over Assets – rank	−0.02	0.03	0.06	−0.09
DDA over EBITDA – rank	0.10	0.03***	0.06*	0.47
Dividend Yield – rank	−0.04	0.03	0.04	−0.17
Leverage – rank	0.08	0.03***	0.05	0.41
Basic Industries	−0.26	0.21	0.43	−0.26
Cyclical Consumer Goods	1.05	0.40***	0.33***	1.05
Information Technology	0.28	0.46	0.33	0.28
Non-Cyclical Consumer Goods	−0.18	0.17	0.37	−0.18
Resources	−0.33	0.30	0.55	−0.33

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

Table 24. Logit analysis of firms disclosing/not disclosing the net dividend discount rate (i-d) and/or the actuarial value of assets (AVA); Scenario 5.

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.09			
Adj Pseudo-R^2	0.08			
OL1	1.38	0.52***	0.85	
OL2	−0.58	0.52	0.80	
OL3	−2.74	0.53***	0.83***	
Pension Scheme Funding Level – Rank	−0.07	0.03***	0.06	−0.35
Pension Scheme Assets to Firm Market Value – rank	−0.04	0.03	0.05	−0.17
Firm Total Assets – log	0.28	0.08***	0.17*	0.35
Sales over Assets – rank	0.02	0.03	0.06	0.08
EBIT over Assets – rank	−0.02	0.03	0.06	−0.09
DDA over EBITDA – rank	0.09	0.03***	0.06*	0.45
Dividend Yield – rank	−0.02	0.03	0.04	−0.12
Leverage – rank	0.08	0.03**	0.05	0.38
Basic Industries	−0.27	0.21	0.42	−0.27
Cyclical Consumer Goods	0.97	0.39**	0.35***	0.97
Information Technology	0.26	0.46	0.34	0.26
Non-Cyclical Consumer Goods	−0.23	0.17	0.36	−0.23
Resources	−0.42	0.30	0.55	−0.42

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

5.11.28 Finally, I consider scenario 5 in Table 24. Because another level is added to the dependent variables, the equations used are slightly different from the previous scenarios, and another constant is added, applied when the dependent variable $y_{i,t}$ is greater than or equal to 3. This means that the regression formulation for the latent variable $y^*_{i,t}$, given in (8), is slightly different again:

$$\begin{aligned} y^*_{i,t} = {} & \beta_0 \mathrm{OL1}_{i,t} + \beta_1 \mathrm{OL2}_{i,t} + \beta_2 \mathrm{OL3}_{i,t} + \beta_3 \mathrm{rFL}_{i,t} + \beta_4 \mathrm{rPStoCo}_{i,t} + \beta_5 \mathrm{lnTotA}_{i,t} \\ & + \beta_6 \mathrm{rSoA}_{i,t} + \beta_7 \mathrm{rEBIToA}_{i,t} + \beta_8 \mathrm{rDDAoEBITDA}_{i,t} + \beta_9 \mathrm{rDY}_{i,t} + \beta_{10} \mathrm{rL}_{i,t} \\ & + \sum_{z=1989}^{2005} \beta_{z-1978} \mathrm{YearDummy}_{z,i,t} + \beta_{28} \mathrm{BI}_{i,t} + \beta_{29} \mathrm{CCG}_{i,t} + \beta_{30} \mathrm{IT}_{i,t} + \beta_{31} \mathrm{NCCG}_{i,t} \\ & + \beta_{32} \mathrm{R}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{8}$$

5.11.29 The items in this equation are the same as previously except that here $\mathrm{OL3}_{i,t}$ is equal to 1 if the dependent variable is greater than or equal to 3.

5.11.30 I also give the pseudo-R^2 and the adjusted pseudo-R^2 as before. The results are shown in Table 24.

5.11.31 The pseudo-R^2 values in these regressions are again low at 0.09. The coefficients on OL1 and OL3 are positive and significant, even after clustering; otherwise, the results are similar to the other regressions. Key differences are that the coefficients on the ranks of the pension

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Table 25. Difference between explanatory variables for firms using/not using a market value basis (MVB); Log-transformed variables.

X	Predicted Difference	E(x) MVB	E(x) no MVB	Joint Standard Deviation	Joint Degrees of Freedom	Two-Tailed p Value	Significance
Firm Total Assets – log	>	1.82	1.65	0.12	228.28	0.1745	
Number		**108**	**249**				

Significance codes: ***1%; **5%; *10%.

scheme funding level and the ratio of pension scheme to firm market value are less significant that in other regressions.

5.11.32 The results suggest to some extent that disclosure of the net dividend discount rate gives the same message as disclosure of the actuarial value of assets (rather than an inferior alternative). There is also some evidence that disclosure of both of these items is better than the disclosure of only one, but if anything the evidence suggests that disclosure of the actuarial value of assets is more important that the disclosure of the net dividend discount rate.

5.11.33 Finally for this section, I consider the disclosure of results using a market value basis for the valuation of assets and liabilities. Firms using such an approach are giving more complete disclosure than those firms using what could be described as a more traditional actuarial approach where actuarial values are given.

5.11.34 Until relatively recently, the use of market-based valuations was limited. Only one firm used such a valuation approach in 1998, and no firms used this type of basis prior to this. I therefore use data only from 1999 to 2005.

5.11.35 As before, I first carry out some univariate tests, first considering the log-transformed variable in Table 25. There is limited evidence of any difference here.

5.11.36 Next, I look at the differences for the rank-transformed variables, using the U test described earlier. The results of this analysis are given in Table 26.

5.11.37 There are some significant differences here, predominantly in relation to the pension scheme variables. Firms with higher funding levels seem less likely to use a market-related basis, contrary to much of the previous analysis. Firms with disproportionally large pension schemes also seem less likely to use such a valuation approach. This suggests that such firms might be more inclined to underplay the size of their pension schemes. On the analysis of firm-related data, the only significant difference is in relation to rank of dividend yield where, as hypothesised, value firms appear more likely to use the more transparent market-related valuation approach.

5.11.38 Next, I consider any differences in disclosure between economic groups in Table 27.

5.11.39 These results suggest that there is only one economic group for which there is a significant difference in disclosure, and that is cyclical consumer goods. I therefore include this as a dummy

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Table 26. Difference between explanatory variables for firms using/not using a market value basis (MVB); Ranked variables.

X	Predicted Difference	U_{MVB}	$U_{No\ MVB}$	Expected Value of U	Standard Deviation of U^{+}	Two-Tailed p Value	Significance
Pension Scheme Funding Level – rank	>	10,926.0	15,966.0			0.0049	***
Pension Scheme Assets to Firm Market Value – rank	</>	11,333.0	15,559.0			0.0183	**
Sales over Assets – rank	<	14,189.5	12,702.5	↑	↑	0.4068	
EBIT over Assets – rank	</>	13,413.5	13,478.5	13,446.0	895.7	0.9715	
DDA over EBITDA – rank	>	13,139.5	13,752.5	↓	↓	0.7325	
Dividend Yield – rank	>	15,025.0	11,867.0			0.0739	*
Leverage – rank	<	13,614.0	13,278.0			0.8516	
Number		**108**	**249**				

Significance codes: ***1%; **5%; *10%.
+The standard deviation actually used in the calculations is adjusted for tied ranks.

Table 27. Difference in firms using/not using a market value basis (MVB) between economic groups.

	Number in Group	Number in Group Using MVB	p Value	Significance
Basic Industries	29	8	0.4558	
Cyclical Consumer Goods	4	3	0.0818	*
Cyclical Services	119	35	0.4261	
General Industrials	23	7	0.5700	
Information Technology	6	0	0.1101	
Non-Cyclical Consumer Goods	71	25	0.1542	
Non-Cyclical Services	43	10	0.1686	
Resources	20	9	0.1015	
Utilities	42	11	0.3222	
Total	**357**	**108**		

Significance codes: ***1%; **5%; *10%.

Table 28. Logit analysis of firms using/not using a market value basis (MVB).

	Coefficient	Standard Error	Robust Standard Error	Marginal Effects
Observations = 975				
Pseudo-R^2	0.17			
Adj Pseudo-R^2	0.14			
Intercept	−0.90	0.95	*1.25*	
Pension Scheme Funding Level – Rank	−0.01	0.15	*0.21*	−0.01
Pension Scheme Assets to Firm Market Value – rank	0.45	0.18**	*0.29*	0.79
Firm Total Assets – log	0.12	0.14	*0.22*	0.16
Sales over Assets – rank	−0.06	0.15	*0.25*	−0.11
EBIT over Assets – rank	0.12	0.21	*0.28*	0.21
DDA over EBITDA – rank	0.30	0.20	*0.24*	0.53
Dividend Yield – rank	−0.45	0.18**	*0.24**	−0.81
Leverage – rank	0.05	0.19	*0.33*	0.08
Cyclical Consumer Goods	3.17	1.29**	*0.55****	3.17

Significance codes: ***1%; **5%; *10%; Statistics for year dummies are not shown.

variable in the subsequent logit regression analysis. The results of the logit regression are given in Table 28.

The basic structure of the regression is given in (9). Here, the latent variable in respect of firm i in year t is again $y^*_{i,t}$.

$$\begin{aligned} y^*_{i,t} = {} & \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ & + \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1999}^{2005} \beta_{z-1990} \mathrm{YearDummy}_{z,i,t} \\ & + \beta_{16} \mathrm{CCG}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{9}$$

5.11.40 I also give the pseudo-R^2 and the adjusted pseudo-R^2 as before.

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Table 29. Data characteristics; Net pre-retirement liability discount rate (i-e); Net post-retirement liability discount rate (i-p); and Net dividend discount rate (i-d).

	i-e	i-p	i-d
Observations	967	781	398
Maximum	0.0525	0.0700	0.0665
95th Percentile	0.0300	0.0600	0.0500
90th Percentile	0.0297	0.0500	0.0463
75th Percentile	0.0250	0.0480	0.0450
50th Percentile	0.0200	0.0410	0.0450
25th Percentile	0.0200	0.0375	0.0376
10th Percentile	0.0150	0.0325	0.0317
5th Percentile	0.0142	0.0280	0.0295
Minimum	−0.0025	0.0100	0.0145
Mean	0.0218	0.0425	0.0417
Standard Deviation	0.0058	0.0087	0.0066
Skew	0.2273	0.3358	−0.7756
Excess Kurtosis	2.3343	1.0211	2.5579
Bera-Jarque Statistic	0.2356	0.0622	0.3729
> Mean +3 St Dev	13	10	3
< Mean −3 St Dev	5	1	3

5.11.41 The regression results do not provide many statistically significant variables outside the industry dummy. This is even truer after the allowance for clustering in the calculation of the standard errors. Interestingly, the coefficient on the rank of pension scheme funding level is significant if the year dummies are excluded, but Hausman tests suggest that the year dummies should be there.

6. Assumptions used under SSAP 24

6.1 Although the logit regressions give some useful insights, the fact that disclosure can only ever be binary in this type of regression limits the information that can be obtained. However, there is much greater heterogeneity in the values of those disclosures, so there is the potential to derive more information from this analysis.

6.2 As can be seen in Table 1, there are sufficient observations for the net pre-retirement liability discount rate (i-e), the net post-retirement liability discount rate (i-p) and the net dividend discount rate (i-d) to analyse all of these three items. As with the earlier analysis, I transform the right hand side variables to allow for issues such as extreme values. Before discussing the potential influences, I give summary details for the dependent variables in Table 29.

6.3. Net Pre-Retirement Discount Rate

6.3.1 Looking first at the net pre-retirement liability discount rate, I consider differences in the by economic group in Table 30. From this analysis, it appears that the resources economic group uses a significantly lower value of the net pre-retirement liability discount rate than other economic groups. This might reflect higher salary growth expectations in this economic group compared to

Table 30. Difference in value of the net pre-retirement liability discount rate (i-e) between economic groups.

	Number in Industry	Number not in Industry	E(i-e) Industry	E(i-e) not in Industry	Joint Standard Deviation	Joint Degrees of Freedom	t Value	Significance
Basic Industries	115	852	0.0218	0.0218	0.0006	150.66	0.9833	
Cyclical Consumer Goods	21	946	0.0214	0.0218	0.0009	23.23	0.6998	
Cyclical Services	284	683	0.0216	0.0218	0.0004	549.94	0.6973	
General Industrials	77	890	0.0215	0.0218	0.0005	110.09	0.5181	
Information Technology	15	952	0.0217	0.0218	0.0015	15.48	0.9534	
Non-Cyclical Consumer Goods	178	789	0.0223	0.0216	0.0006	225.48	0.2821	
Non-Cyclical Services	108	859	0.0222	0.0217	0.0006	130.73	0.4127	
Resources	63	904	0.0194	0.0219	0.0006	76.69	0.0002	***
Utilities	106	861	0.0224	0.0217	0.0005	147.27	0.1700	

Significance codes: ***1%; **5%; *10%.

others, or it might mean that the group simply uses a more conservative basis. I use resources as a dummy variable in the subsequent regression analysis.

6.3.2 Moving on to the regression analysis for the net pre-retirement liability discount rate, I use ordinary least squares regression with resources as a dummy variable. However, there are two issues that must be addressed. The first is that the data is censored. This means that only the companies that disclose a particular variable are included in the analysis of the disclosure of this variable. This seems sensible, but allowing for the fact that the data are censored in the regression analysis – which means that information from those firms not disclosing information is still included – gives better parameter estimates. I therefore run an additional censored regression including the variables for which no value of the net pre-retirement liability discount rate is given. A potentially more serious issue is the correlation between right hand side variables. I allow for this by additionally allowing for clustering to create robust standard errors. The effect of allowing for censoring may be to change the regression coefficients. Allowing for clustering should result in coefficients that are no different from those in the censored regression, but the standard errors might be expected to rise.

6.3.3 Both company and year fixed effects are considered in order to exploit the panel-based nature of the data. A Hausman test to determine whether ignoring the company fixed effects would result in omitted variables bias suggests that the null hypothesis of random effects cannot be rejected at any reasonable level of significance, so company dummies are not included; however, a Hausman on the year dummies suggests that the null hypothesis of random effects can be rejected at the 1% level of significance and that the year dummies should be included in order to avoid omitted variables bias.

6.3.4 The results of the regressions are given in Table 31, and the equation used is given as (10).

$$\begin{aligned}\mathrm{ie}_{i,t} =& \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ &+ \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1990} \mathrm{YearDummy}_{z,i,t} \\ &+ \beta_{26} \mathrm{R}_{i,t} + \varepsilon_{i,t}\end{aligned} \tag{10}$$

6.3.5 In this analysis, the goodness-of-fit of the basic equation is given by the R^2 and adjusted R^2 measures, whilst in the censored regressions the pseudo-R^2 and adjusted pseudo-R^2 are used. The values are the same for the regressions with and without allowance for clustering, since only the standard errors of the estimates differ between these regressions.

6.3.6 There is little difference between the basic and censored regressions. This is unsurprising given that there are only an additional 8 observations in the censored regression compared to the basic regression. It is interesting to note, however, that the pseudo-R^2 in the censored regression is so much lower than the R^2 in the basic regression.

6.3.7 The differences between the censored regressions with and without allowance for clustering are more pronounced.

6.3.8 The pension scheme-specific variables do not feature in any of the regressions. However, the size proxy is highly significant with a positive coefficient. The level of significance for the logs of firm total assets fall from 1% to 5% when clustering is allowed for, but this is still a significant result. This supports the idea that larger firms can exert greater pressure on their actuaries, and are able to

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Table 31. Regression analysis for the value of the net pre-retirement liability discount rate (i-e).

	Coefficient – Basic	Standard Error – Basic	Coefficient – Censored	Standard Error – Censored	Robust Standard Error – Censored
Observations = 967 (basic regression); 975 (censored regression)					
R^2 (basic)	0.11				
Adj R^2(basic)	0.09				
Pseudo-R^2 (censored)	0.02				
Adj Pseudo-R^2 (censored)	0.01				
Intercept	26.76	1.44***	26.80	1.42***	2.07***
Pension Scheme Funding Level – Rank	0.70	0.70	0.70	0.70	1.30
Pension Scheme Assets to Firm Market Value – rank	1.10	0.80	1.10	0.80	1.60
Firm Total Assets – log	1.20	0.23***	1.19	0.22***	0.51**
Sales over Assets – rank	−2.70	0.80***	−2.70	0.80***	1.80
EBIT over Assets – rank	−2.90	0.90***	−2.90	0.90***	1.30**
DDA over EBITDA – rank	−2.50	0.90***	−2.50	0.90***	1.50*
Dividend Yield – Rank	−1.20	0.80	−1.20	0.80	1.40
Leverage – rank	−1.10	0.90	−1.10	0.90	1.50
Resources	−3.33	0.81***	−3.33	0.80***	1.08***

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

negotiate the use of a weaker pension scheme liability valuation basis, although there is an possible alternative explanation – smaller firms might simply be in faster-growing sectors with higher pay growth.

6.3.9 The coefficient on the rank of sales over assets is negative and significance at the 1% level in a number of the regressions, supporting the idea that firms with a small asset base are more likely to use a weak basis ; however, this significance vanishes in all cases once clustering is allowed for.

6.3.10 The coefficient on the rank of EBIT over assets is negative and significant at the 1% level before allowing for clustering; however, this allowance still leaves the coefficients significant at the 5% level. The negative coefficient is inconsistent with the risk and tax management interpretations of this variable; however, the tax management hypothesis is reflected in the coefficient of the rank of depreciation, depletion and amortisation over EBITDA, which is negative and significant at the 1% level of significance, this level falling to 10% once clustering is allowed for.

6.3.11 Turning to the growth/value proxy, there is little evidence of anything. The coefficient on the rank of leverage is also insignificant. However, the economic group dummy variable is significant at the 1% level of confidence.

6.4. Net Post-Retirement Discount Rate

6.4.1 Next, I consider the results for the net post-retirement liability discount rate by economic group in Table 32. This time, firms in the non-cyclical consumer goods economic group appear to have significantly weaker bases, although this might be a reflection of a lower level of guaranteed post-retirement pension increases in this section. Conversely, the net post-retirement discount rates firms in the utilities economic group are significantly lower than for other firms. Whilst this might be an indication that firms in this group use a stronger basis, a more likely explanation is that most firms in this group were previously in the public sector, so their pension schemes were obliged to provide guaranteed indexation to pensions in payment. Whatever the reasons, it is important to control for these economic group-specific differences, so both economic groups are included in the later regressions as dummy variables.

6.4.2 Moving on to the regression analysis for the net post-retirement liability discount rate, I again use ordinary least squares regression, censored regression and censored regression with clustering.

6.4.3 As before, both company and year fixed effects are considered. A Hausman test to determine whether ignoring the company fixed effects would result in omitted variables bias suggests that the null hypothesis of random effects cannot be rejected at any reasonable level of significance, so company dummies are not included; however, a Hausman on the year dummies suggests that the null hypothesis of random effects can be rejected at the 1% level of significance and that the year dummies should be included in order to avoid omitted variables bias.

6.4.4 The results of the regressions are given in Table 33, and the equation used is given as (11)

$$\begin{aligned} \mathrm{ip}_{i,t} =& \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ &+ \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1990} \mathrm{YearDummy}_{z,i,t} \\ &+ \beta_{26} \mathrm{NCCG}_{i,t} + \beta_{27} \mathrm{U}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{11}$$

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Table 32. Difference in value of the net post-retirement liability discount rate (i-p) between economic groups.

	Number in Industry	Number not in Industry	E(i-p) Industry	E(i-p) not in Industry	Joint Standard Deviation	Joint Degrees of Freedom	t Value	Significance
Basic Industries	64	717	0.0415	0.0426	0.0010	80.94	0.2854	
Cyclical Consumer Goods	19	762	0.0476	0.0424	0.0032	19.36	0.1216	
Cyclical Services	255	526	0.0428	0.0424	0.0007	477.63	0.5071	
General Industrials	53	728	0.0439	0.0424	0.0013	60.40	0.2542	
Information Technology	12	769	0.0446	0.0425	0.0019	12.68	0.2953	
Non-Cyclical Consumer Goods	142	639	0.0437	0.0423	0.0009	197.33	0.0930	*
Non-Cyclical Services	79	702	0.0428	0.0425	0.0010	101.32	0.7204	
Resources	61	720	0.0433	0.0425	0.0011	73.01	0.4456	
Utilities	96	685	0.0378	0.0432	0.0006	221.29	0.0000	***

Significance codes: ***1%; **5%; *10%.

Table 33. Regression analysis for the value of the net pre-retirement liability discount rate (i-p).

	Coefficient – Basic	Standard Error – Basic	Coefficient – Censored	Standard Error – Censored	Robust Standard Error – Censored
Observations = 781 (basic regression); 975 (censored regression)					
R^2 (basic)	0.32				
Adj R^2(basic)	0.30				
Pseudo-R^2 (censored)	0.06				
Adj Pseudo-R^2 (censored)	0.05				
Intercept	34.75	2.05***	34.70	2.01***	3.09***
Pension Scheme Funding Level – Rank	0.40	1.10	0.40	1.10	1.80
Pension Scheme Assets to Firm Market Value – rank	2.90	1.10***	2.90	1.10***	2.30
Firm Total Assets – log	1.03	0.33***	1.03	0.32***	0.59*
Sales over Assets – rank	−3.50	1.20***	−3.50	1.20***	2.60
EBIT over Assets – rank	−1.30	1.40	−1.30	1.40	2.60
DDA over EBITDA – rank	−2.50	1.30*	−2.50	1.30*	2.70
Dividend Yield – Rank	−0.70	1.20	−0.70	1.20	1.80
Leverage – rank	−0.30	1.30	−0.30	1.30	2.30
Non-Cyclical Consumer Goods	1.35	0.79*	1.35	0.78*	1.87
Utilities	−3.74	0.93***	−3.74	0.91***	1.29***

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

6.4.5 As before, the goodness of fit of the basic equation is given by the R^2 and adjusted R^2 measures, whilst in the censored regressions the pseudo-R^2 and adjusted pseudo-R^2 are used. The values are the same for the regressions with and without allowance for clustering, since only the standard errors of the estimates differ between these regressions.

6.4.6 Despite the greater difference between the volume of censored and uncensored data, the differences between these two regressions are still small; however, when clustering is allowed for, it again results in substantial changes to the standard errors and, so, the levels of significance.

6.4.7 The R^2 for the ordinary least square regression is much higher than for the comparable the net pre-retirement liability discount rate. For the earlier regressions, the R^2 is 0.11 and the adjusted R^2 0.09; however, the R^2 from the later regression is 0.32 and the adjusted R^2 is 0.30. The pseudo-R^2 and adjusted pseudo-R^2 are also significantly different.

6.4.8 Before allowing for clustering, the coefficient on the rank of the ratio of pension scheme to firm market value is positive and significant. This is consistent with the hypothesis that proportionally larger pension schemes are too high-profile for sponsors to get away with using a weak basis; however, allowing for clustering renders this result insignificant.

6.4.9 The coefficient on the size proxy again remains significant, even after the allowance for clustering. Before the allowance for clustering, the significance level is 1%; however this is reduced to 10%. The coefficients are positive, supporting the hypothesis that larger firms have more influence over actuarial assumptions, also reflecting the analysis of the net pre-retirement liability discount rate, thus supporting the hypothesis (although not the findings) of Reynolds & Francis (2001).

6.4.10 Also consistent with the analysis of the net pre-retirement liability discount rate is the fact that the coefficient on the rank of sales over assets is negative and significant at the 1% level of confidence, although the significance disappears once clustering is allowed for.

6.4.11 In contrast with the analysis of the net pre-retirement liability discount rate, the coefficient on the rank of EBIT over assets is not significant at any reasonable level, although the negative sign of the coefficient is consistent with the analysis of the net post-retirement liability discount rate. Similarly, the sign of the coefficient on the rank of depreciation, depletion and amortisation over EBITDA are the same as in the analysis of the net pre-retirement liability discount rate but insignificant once clustering is allowed for. Furthermore, the coefficient on the value/growth proxy is insignificant even before the allowance for clustering, as is that on leverage.

6.4.12 However, one of the economic group dummies, utilities, has coefficients that are negative and significant at the 1% level of confidence, and the year dummies are significant in nearly all years.

6.5. Net Dividend Discount Rate

6.5.1 Finally, I consider the results for the net dividend discount rate. I would expect the relationships between the net dividend discount rate and the explanatory variables to have the opposite sign to those seen with the net pre-retirement liability discount rate and the net post-retirement liability discount rate. This is because the net pre-retirement liability discount rate

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and the net post-retirement liability discount rate are used to value the pension scheme liabilities. This means that a higher value of either of these variables gives a lower value of the liabilities, increasing the ratio of assets to liabilities, thus being a "weak" basis; however, a higher value of the net dividend discount rate gives a lower value of the equity investments (since the net dividend discount rate is used to discount the dividend stream of equity holdings, giving an actuarial value of pension scheme assets). This means that a high value of the net dividend discount rate would reduce the ratio of assets to liabilities, and thus would be a "strong" basis.

6.5.2 First, I look at the differences in the level of the net dividend discount rate by economic group in Table 34. This time, firms in the cyclical consumer goods and information technology economic groups appear to have significantly stronger bases, whilst the assumptions used by firms in the non-cyclical services economic group are significantly weaker than for other firms. All three economic groups are included in the later regressions as dummy variables.

6.5.3 For the regression analysis for the net dividend discount rate, I again use three approaches and again consider both company and year fixed effects. A Hausman test suggests that the null hypothesis of random effects cannot be rejected at any reasonable level of significance for company fixed effects, so company dummies are excluded, but the result of the test on year fixed effects suggests that year dummies should be used.

6.5.4 The results of the regressions are given in Table 35 and the equation used is given as (12).

$$\begin{aligned} \mathrm{id}_{i,t} =& \beta_0 + \beta_1 \mathrm{rFL}_{i,t} + \beta_2 \mathrm{rPStoCo}_{i,t} + \beta_3 \mathrm{lnTA}_{i,t} + \beta_4 \mathrm{rSoA}_{i,t} + \beta_5 \mathrm{rEBIToA}_{i,t} \\ &+ \beta_6 \mathrm{rDDAoEBITDA}_{i,t} + \beta_7 \mathrm{rDY}_{i,t} + \beta_8 \mathrm{rL}_{i,t} + \sum_{z=1989}^{2005} \beta_{z-1990} \mathrm{YearDummy}_{z,i,t} \\ &+ \beta_{26} \mathrm{CCG}_{i,t} + \beta_{27} \mathrm{IT}_{i,t} + \beta_{28} \mathrm{NCS}_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{12}$$

6.5.5 As before, the goodness of fit of the basic equation is given by the R^2 and adjusted R^2 measures, whilst in the censored regressions the pseudo-R^2 and adjusted pseudo-R^2 are used. The values are the same for the regressions with and without allowance for clustering, since only the standard errors of the estimates differ between these regressions.

6.5.6 The R^2 and adjusted R^2 in the analysis of the net dividend discount rate are higher than those for either the net post-retirement liability discount rate or the net pre-retirement liability discount rate being 0.52 and 0.48 respectively. The same is true of the pseudo-R^2 and adjusted pseudo-R^2. This is despite the low number of significant explanatory variables – except for the year dummies. This perhaps suggests that most of the differences in this variable come from year rather than company factors, and that this is picked up in results.

6.5.7 As with the analysis of the net pre-retirement liability discount rate and the net post-retirement liability discount rate, there is still a high degree of consistency between the basic and censored regressions, despite the fact that the latter contain around three times as many observations as the former. Only allowance for clustering makes any difference.

6.5.8 Turning to the explanatory variables, the coefficients on the ranks of pension scheme funding level and the ratio of pension scheme assets to firm market value are both positive and significant at the 1% or 5% level – at least until clustering is allowed for.

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Table 34. Difference in value of the net dividend discount rate (i-d) between economic groups.

	Number in Industry	Number not in Industry	E(i-d) Industry	E(i-d) not in Industry	Joint Standard Deviation	Joint Degrees of Freedom	t Value	Significance
Basic Industries	39	359	0.0429	0.0415	0.0009	54.87	0.1375	
Cyclical Consumer Goods	15	383	0.0462	0.0415	0.0008	23.42	0.0000	***
Cyclical Services	114	284	0.0410	0.0420	0.0007	239.01	0.1678	
General Industrials	33	365	0.0418	0.0417	0.0012	39.53	0.8753	
Information Technology	13	385	0.0437	0.0416	0.0009	18.31	0.0275	**
Non-Cyclical Consumer Goods	82	316	0.0424	0.0415	0.0009	109.19	0.3607	
Non-Cyclical Services	48	350	0.0397	0.0419	0.0012	56.19	0.0710	*
Resources	18	380	0.0403	0.0417	0.0014	20.16	0.3199	
Utilities	36	362	0.0415	0.0417	0.0010	46.23	0.8850	

Significance codes: ***1%; **5%; *10%.

Table 35. Regression analysis for the value of the net dividend discount rate (i-d).

	Coefficient – Basic	Standard Error – Basic	Coefficient – Censored	Standard Error – Censored	Robust Standard Error – Censored
Observations = 398 (basic regression); 975 (censored regression)					
R^2 (basic)	0.52				
Adj R^2(basic)	0.48				
Pseudo-R^2 (censored)	0.09				
Adj Pseudo-R^2 (censored)	0.07				
Intercept	31.10	3.74***	31.10	3.60***	6.14***
Pension Scheme Funding Level – Rank	2.70	1.10**	2.70	1.00***	2.00
Pension Scheme Assets to Firm Market Value – rank	2.60	1.20**	2.60	1.10**	1.90
Firm Total Assets – log	−0.15	0.37	−0.15	0.36	0.58
Sales over Assets – rank	−1.90	1.20	−1.90	1.10*	1.40
EBIT over Assets – rank	0.20	1.40	0.20	1.30	1.50
DDA over EBITDA – rank	−0.50	1.30	−0.50	1.20	1.70
Dividend Yield – Rank	1.70	1.10	1.70	1.10	0.80**
Leverage – rank	0.00	1.20	0.00	1.20	1.80
Cyclical Consumer Goods	1.10	1.32	1.10	1.27	0.58*
Information Technology	−0.06	1.43	−0.06	1.38	1.69
Non-Cyclical Services	−2.28	0.93**	−2.28	0.90**	1.97

Significance codes: ***1%; **5%; *10%; statistics for year dummies are not shown.

6.5.9 The coefficient on the size proxy is not significant, even before the allowance for clustering, and the coefficient on the rank of sales over assets is negative and significant at the 10% level only before allowing for clustering.

6.5.10 The only other variable with any degree of significance is the value/growth proxy. Here, the coefficient on the rank of dividend yield becomes significant at the 5% level *after* allowing for clustering. However, the coefficient is positive rather than negative as was predicted.

7. Conclusions

7.1 The results of the various analyses when taken together paint an interesting picture. As discussed above, Feldstein & Morck (1983) and Bodie *et al.* (1985) find that firms with underfunded pension funds select higher discount rates with which to value their pension scheme liabilities, and Thies & Sturrock (1988) find that underfunded pension schemes undervalue their liabilities. This suggests that underfunded pension schemes should be less likely to give full disclosures in order to hide the weakness of the basis used. Once robust standard errors have been used to remove the effects of clustering, there is only weak support for this hypothesis, with levels of significance below 10%. Furthermore, the results show no link between the strength of the liability valuation basis and the funding level.

7.2 The results for the disclosure of the net dividend discount rate alone and the combined results for disclosure of either the net dividend discount rate or the actuarial value of pension scheme assets suggest that firms with proportionally large pension schemes are more likely to given complete disclosure. The significance of other conclusions disappears once standard errors are adjusted to allow for clustering.

7.3 The only evidence that large firms give more complete disclosures, due to greater pressure from analysts, all but disappears once standard errors are adjusted for clustering. Only one regression, considering the disclosure of either the net dividend discount rate or the actuarial value of assets, has coefficients that remain significant in this case. However, there is evidence that larger firms were more able to exert influence on their actuaries to use weaker assumptions for the valuation of pension scheme liabilities. This influence is something that Reynolds & Francis (2001) hypothesised in relation to auditors but were unable to find.

7.4 The results in relation to the influence of the size of asset base are inconclusive. The work of Bradley *et al.* (1984) and Francis & Reiter (1987) suggests that firms with a low levels of tangible assets might give less information and use a weaker valuation basis in order to free up assets for investment. Firms do appear to give less information when the disclosure of the net dividend discount rate alone or combined with the actuarial value of pension scheme assets is considered; however, the opposite appears to be true when the disclosure of the net post-retirement liability discount rate is analysed. There is also evidence that such firms use high discount rates when valuing their liabilities, as expected – but also that high discount rate are used when valuing their assets. This perhaps suggests that firms with a small asset base need to use consistent assumptions for their assets and liabilities, but whilst the deficit (assets less liabilities) cannot be understated, the overall scheme size (assets and liabilities) can.

7.5 There is some evidence that more profitable firms disclose less. This can be taken to follow from the suggestion of Francis & Reiter (1987) that firms with a higher marginal tax rate might want to overfund their pension scheme, since such firms might be less inclined to give complete disclosure. Whilst tax relief is given on the contributions paid rather than any actuarial or accounting value, consistently higher levels of contributions would lead to a higher funding level, thus encouraging a lower level of disclosure. It does, though, suggest that profitability is a better proxy for the average tax rate than for the risk of insolvency. However, there is also some evidence that the more profitable a firm is, the weaker the valuation basis is for the pension scheme liabilities. This is contrary to the hypothesis from Thies & Sturrock (1988) and Francis & Reiter (1987) that firms with poor profitability undervalue their liabilities, and the implication that firms with higher marginal tax rates should be more likely to overstate their liabilities given the observation from Francis & Reiter (1987) that they should want to fully fund (or even overfund) their pension schemes, to take advantage of tax deductions. The only explanation here is that the strength of basis is actually a proxy for the quality of the earnings, and that a weak valuation basis suggests the overstatement of earnings elsewhere in the accounts.

7.6 The evidence in relation to non-debt tax shields is mixed. Francis & Reiter (1987) point out that overfunding is consistent with the use of non-debt tax shields discussed by DeAngelo & Masulis (1980), so if non-pension non-debt tax shields are low, then a firm might be less likely to give full disclosure so that the actuarial basis can be hidden and higher (tax deductible) contributions can be paid into the pension scheme in order to reduce taxable profits. There is actually evidence that firms with low non-debt tax shields give more complete disclosure than average. However, there is also some evidence that a firm with a low level of non-debt tax shields is more likely to use a strong valuation basis, thus overstating the liabilities, in line with expectations.

7.7 The evidence regarding the growth/value proxies is also mixed, and neither clearly supports or rejects the "pecking order"-based predictions of Myers (1984) and Myers & Majluf (1984), or the suggestion of Francis & Reiter (1987) that funding derived from a pension scheme deficit might be cheaper than that derived externally once external funding has reached a particular level. This is true both when considering the extent of disclosure and the values of the disclosures.

7.8 Finally, there is weak evidence that highly levered firms are less likely to give complete disclosure, and that when they do disclose their assumptions, they use a weaker basis. This is consistent with Francis & Reiter (1987), who find that firms with underfunded pension schemes are more likely to be more levered than average, and Gopalakrishnan & Sugrue (1995) who find that the discount rate is positively linked to leverage.

7.9 Overall, then, both the extent of SSAP 24 disclosure and the values of disclosures when given can provide some insights into the behaviour of firms, although the alternative explanations for many of the findings means that these insights must be qualified. There are no striking, unequivocal answers, but a number of indications and possibilities. However, if they are regarded as valid, then it is logical to extend these insights beyond the pension scheme and into the wider behaviour of the firm. Given that SSAP 24 is no longer with us, this is the most important result of this research. Analysts should recognise that whilst the reporting for important aspects of their business might be complete, it might not be accurate. They should also be aware that the risk that auditors will be swayed in the values they assign to various items increases with the size of the firm. Finally, the disclosures of highly levered firms should be given special attention, since such firms do seem more likely to understate financial obligations.

7.10 However, the strongest conclusions are tempered once the standard errors are adjusted to allow for clustering. This means that in many cases the most important factor is the firm considered rather than the characteristics of that firm.

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Appendix A: Statistical Methods

A1. The Bera-Jarque Test

This test is used to establish whether a set of data is normally distributed. It uses the skew (w) and excess kurtosis (k) of a data set of n observations to give a statistic B:

$$B = \frac{n}{6}\left(w^2 + \frac{k^2}{4}\right) \sim \chi_2^2$$

which has a chi-squared distribution with 2 degrees of freedom.

A2. The Mann-Whitney U Test

A2.1 The Mann-Whitney test has a number of uses, but in this paper I use it to determine whether the observations from one set of data are significantly different from the observations of another. The advantage of this test is that it uses the rank of the observations, so does not rely on the underlying distribution of the data.

A2.2 Consider a set of observations whose members can belong to either group 1 or group 2, and where the objective is to work out if the observations from one group are significantly different between the two groups. The first step is to rank all of the variables, so the highest value has a rank of 1, the second highest a rank of 2 and so on.

A2.3 The ranks for those firms belonging to group 1 are then taken. Let the sum of these ranks be R_1. The sum of the ranks for group 2 is R_2. If the number of observations in group 1 is n_1 and in group 2 is n_2, then:

$$U_1 = R_1 - \frac{n_1(n_1+1)}{2}$$

and

$$U_2 = R_2 - \frac{n_2(n_2+1)}{2}$$

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A2.4 For large values of n, U can be regarded as having an approximately normal distribution with a mean of $n_1 n_2/2$ and a variance of $n_1 n_2(n_1 + n_2 + 1)/12$, so whether either U_1 or U_2 is significantly different from its expected value can be tested using standard statistical methods.

A3. The Hausman Test

A3.1 The Hausman Test is used here to test whether omitting a set of variables would result in biased results. In particular, it considers the significance of a group of variables rather than an individual variable.

A3.2 Consider a regression specification $y = bX + e$, where y is the vector of dependent variables, X is the matrix of explanatory variables, b is the vector of coefficients and e is the vector of error terms. Then suppose there are two possible formulations for this equation, one with vector b_1 and data matrix X_1, and another with vector b_2 and data matrix b_2, where X_2 is equal to matrix X_1 but with several additional variables added. The Hausman test statistic, H, is calculated as:

$$H = (b_1 - b_0)'(\mathrm{Var}(b_0) - \mathrm{Var}(b_1))^{-1}(b_1 - b_0).$$

This has a chi-square distribution with k degrees of freedom, where k is the rank of $\mathrm{Var}(b_0) - \mathrm{Var}(b_1)$.

A4. Pseudo R^2 and Adjusted Pseudo R^2

These to statistics give the goodness of fit for non-linear regressions. They are intended to replace the coefficient of determination given in standard least squares regressions. The difference between them is that the adjusted pseudo R^2 carries a penalty that increases with the number of variables used:

$$R^2 = 1 - \frac{\ln \hat{L}(M_{Full})}{\ln \hat{L}\left(M_{Intercept}\right)}$$

$$R^2_{adj} = 1 - \frac{\ln \hat{L}(M_{Full}) - k}{\ln \hat{L}\left(M_{Intercept}\right)}$$

where $\hat{L}(M_{Full})$ is the estimated log likelihood function of the model as given, $\hat{L}\left(M_{Intercept}\right)$ is the estimated log likelihood function of the model as calculated with only an intercept, and *k* is the number of explanatory variables.

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