THE UNIVERSITY OF WARWICK

EC331: Research in Applied Economics

What determines the asset allocation of UK defined-benefit pension schemes?[1]

1003854
Department of Economics
University of Warwick, UK
April 2013

Word Count: 5023

Abstract

This paper investigates the empirical relationship between FTSE-100 defined–benefit (DB) pension schemes' and their asset allocation strategy in 2011. The first part of the paper applies the OLS estimation technique to determine the effects of pension fund-related, macroeconomic, and sponsor-related variables on equity and bond holdings of schemes. The second part of the paper tests hypotheses from past literature to identify the most commonly used pension fund investment strategy. This paper concludes that in 2011, well-funded schemes were more risk-averse, whilst underfunded schemes employ riskier strategies. Asset-liability matching (ALM) was the most commonly employed strategy of UK DB-schemes. Finally, this paper suggests that the government has a catalytic role to play in developing the market for high-quality long-dated bonds, and in providing incentives for funds to continue prudent ALM.

[1] The author is grateful to Ms. Elizabeth Jones for her supervision and guidance throughout the project, to Prof. Jeremy Smith for Econometric advice, and to Dr. Gianna Boero for the introductory course lectures. Any errors remain the author's own.

Table of Contents

1. Introduction

Since the 2008 financial crisis, the UK pensions market has faced increasing market volatility caused by sluggish equities, unattractive yields, and rising life expectancy. The aggregate deficit of 6,533 UK defined-benefit (DB) schemes was £255.2 billion at the end of 2011, a dramatic worsening of the £46.1 billion surplus at the end of January 2011[2]. Consequently, zero FTSE-100 companies currently provide a final-salary scheme to new employees[3]; and risk management is widespread.

Pension funds are important players in global financial markets, thus it is surprising to find little coherence in literature analysing the determinants of the riskiness of funds' portfolios. Investment banks prefer targeting new clients by observing market trends and seeing if the scheme in question is misaligned with its peer group. This provides motivation for the investigation into the empirical relationship between pension funds and their investment strategy.

This paper considers:

- What determines UK DB-schemes' asset allocation?
- To remedy the gaping deficit, should portfolios have higher equity holdings to generate higher returns or hold more assets giving stable, but lower returns?
- What is the optimal level at which to switch between risky and safe assets?

Past literature on pension fund asset allocation have mostly been cross-sectional, covered US plans and are out-of-date (Bodie et al., 1984; Friedman, 1983). The sole UK-based multivariate study provides the basis of my study (He, 2008). Other papers investigate the relationship between asymmetries in fund governance, and incentives arising from the UK pensions market's regulatory environment, on asset allocation decisions; yet none of these collectively analyses all relevant factors.

[2] Pension Protection Fund, PPF 7800 Index provides latest funding position, on a s179 basis and indexed using the RPI.
[3] LCP, Accounting for Pensions 2012

This paper's novel elements embody usage of the most recent data, adaptation of tests in existing literature and investigation into untested determinants of asset allocation. The paper focuses on the determinants of equity and bond holdings of schemes; then seeks to conclude asset-liability matching (ALM) as the most commonly employed investment strategy of UK DB-schemes.

2. Literature Review

2.1 UK defined-benefit schemes[4] (DB-schemes)

DB pension schemes are segregated pools of capital that collateralise the future liabilities of DB-plans (Bodie, 1984). Members are entitled to some benefit determined by their length of service and final salary; whilst employer contributions are subject to funding level changes. Benefits are indexed for inflation to prevent the erosion of purchasing power. A sponsor[5] takes on pension liabilities, subject to inflation, mortality rates, and discount rate.

2.2 Traditional Independent Balance Sheet View VS. Modern Corporate Finance View

Bodie (1984) defines the 'traditional' standpoint as pension fund management separate from its sponsor, free from corporate financial policy constraints and in members' interests. This view has been criticised – supposedly independent trustees that manage funds are sponsor-appointed, making it difficult to believe how trustees can ignore its employer's interests. Furthermore, pension fund performance has closer ties to the sponsor than the beneficiaries – a well-performing fund reduces sponsor contribution; and rises for a poorly-performing fund (Black, 1980).

The modern corporate finance view 'augments the balance sheet' (Bagehot, 1972) to include pension liabilities as another set of firm liabilities, whilst pension assets act as collateral for pension liabilities. Applying Modigliani-Miller (1958)'s 'non-independent corporation' conclusion, DB-schemes are 'pass-through entities' – plan risks and returns pass through to shareholders. Given no taxes,

[4] 'Fund', 'Scheme', and 'Plan' are used interchangeably throughout.
[5] 'Corporate', 'Firm', and 'Sponsor' are used interchangeably throughout.

transaction costs, or asymmetric information; and firm value is unaffected by its choice of financing; modern corporate finance concludes firm capital structure as key in determining pension asset allocation.

Friedman (1983) produced the first extensive paper that identified evidence of corporate financial fund management in US corporate pension schemes in 1977. His analysis confirmed that pension and corporate financing decisions are related – pension assets held in bonds and pension liabilities were both positively related to sponsor liabilities; and corporate gearing depended positively on pension liabilities.

Testing the validity of Friedman (1983)'s results, Bodie (1984) analysed tax effects, profitability and risk for US corporate pension plans in 1980, and similarly concluded that corporations manage pension funds as part of their balance sheet. Interestingly, the traditional and corporate financial views were not mutually exclusive in the dataset, as larger plan management took on traditional characteristics, whilst smaller plan governance embodied the corporate financial perspective.

Friedman (1983) and Bodie (1984)'s conflicting views despite both studies being carried out in the US only three years apart, provide testable hypotheses. He (2008)'s multivariate panel data and cross-sectional analysis for UK pension funds also finds evidence against the corporate financial perspective, which he attributed to UK trust laws obligating the separate management of pension funds from sponsors.

2.3 Asset-Liability Management (ALM)

ALM is 'the practice of managing a business so decisions taken with respect to assets and liabilities are coordinated… to meet its future cash flow needs' (Society of Actuaries, 2003). The present value of pension liabilities is hedged against interest rate, inflation and longevity risk by matching pension assets to liabilities to reduce long-term costs with return-driven investments.

Pension fund trustees focused excessively on maximising returns in bullish times, and must now employ ALM to address the deterioration of their funded status (Chernoff, 2003). Unsurprisingly, there is less literature on ALM as it is relatively new to pension finance. He (2008) predicted that liability-driven investment (LDI) will rise in future years as firms realise that as pension investment is not their expertise, 'it does not make sense to put the core business at risk… from a risky pension fund investment strategy.'

Remedying pension deficits results in contradiction: equity holdings must rise for a low contribution rate over time; but bond holdings must also rise for a stable contribution rate[6]. UK pension funds were increasingly risk-averse – equity holdings fell since 2006, reaching 41.1% in 2011; whilst fixed-interest holdings generally rose.

Table 1: DB Scheme Average Asset Allocation (Pension Protection Fund (PPF)/ The Pensions Regulator)

	2006	2007	2008	2009	2010	2011
Equities	61.1%	59.5%	53.6%	46.4%	42.0%	41.1%
Gilts & Fixed-Interest	28.3%	29.6%	32.9%	37.1%	40.4%	40.1%
Insurance Policies	0.9%	0.8%	1.1%	1.4%	1.4%	1.6%
Cash & Deposits	2.3%	2.3%	3.0%	3.9%	3.9%	4.1%
Property	4.3%	5.2%	5.6%	5.2%	4.6%	4.4%
Other Investments						
- 'Other'	3.1%	2.5%	3.8%	4.5%	5.4%	6.3%
- 'Hedge Funds'	N/A	N/A	N/A	1.5%	2.2%	2.4%

Some columns do not sum to 100% due to rounding.

This can be explained by Prospect Theory (Kahneman & Tversky, 1979).

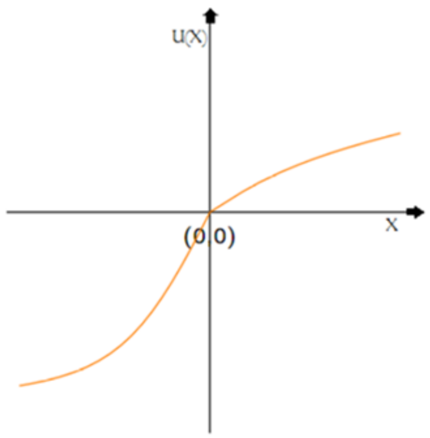


Figure 1: Kahneman-Tversky Value Function

[6] Surprising as equity and bond holdings are seen as substitutes.

Figure 1 plots investment returns (x) against the pension fund's utility from it (y). The value function is steeper for negative than for positive returns. Funds are risk-averse, preferring to hedge their liabilities in the concave domain of gains; and risk-loving in the convex domain of losses, attempting to generate higher returns to offset their liabilities.

Explanations for increased bond holdings of UK funds could stem from Blake (2001), who suggested bonds are most suitable in matching short-term liabilities, as the discount rate used in actuarial assumptions is based on bond yields; or from Bodie (1999), who concluded that schemes with a financially stable sponsor need not hold equities, thus minimising additional contributions. In both cases, bond-dominated portfolios are advocated, but for different reasons.

Another view is that the standard deviation of equity returns decreases on average as investment duration increases, giving rise to the 'mean reversion of long-run equity returns' – a long-run upward trend (Kritzman, 2000). Yet others argue that equity returns follow a random walk, so long and short-run performances are equally risky. Although the validity of 'mean reversion' is debatable, it explains why pension funds might hold equities to match long-term liabilities.

However, as more DB-schemes are being closed to new entrants, pension investment duration has decreased. Despite the lack of coherence in literature, UK data appears to show that trustees have realised that a middle ground between 'maximising expected returns' and ALM must be achieved (Booth, 2004).

3. Hypotheses

Subject to empirical scrutiny in this paper are the following:

Table 2: Testable hypotheses

	Hypothesised Direction of Effect	
Determinants/ Dependent Variable	**Equity Holdings**	**Bond Holdings**
Scheme Maturity	Negative	Positive
Sponsor Size	Positive	Negative
Market Value of Pension Assets	Positive	Negative
Funding Level	Positive	Negative
Corporate Gearing	Negative	Positive
Level of Employer Contributions	Negative	Positive
Sponsor Profitability	Positive	Negative

- Corporate financial perspective implies a significant positive relationship between firm profitability and degree of pension funding.
- Corporate financial perspective implies that pension funds should be invested at either one of two extremes.
- Asset-Liability Matching is the most commonly used asset allocation strategy of UK DB-schemes.

4. Methodology

Simplifying multi-asset scheme portfolio modelling, compositions are generalised to equities or bonds (nearly 90% of a typical portfolio).

The ideal dependent variable for the model is a risk measure of the fund's asset allocation. But as such a variable is unattainable, equity and bond[7] holdings will act as proxies.

The models take the form[8]:

$$equities_i = \alpha_i + fn\left(explanatory\,variables\right)_i + \varepsilon_i$$

$$sum\_bonds_i = \alpha_i + fn\left(explanatory\,variables\right)_i + \varepsilon_i$$

[7] Includes index-linked and fixed-interest holdings
[8] Dependent variables are a percentage of the total fund's assets.

Initial analysis (Section 6.1) tests the significance of possible determinants of pension fund asset allocation[9] – including macroeconomic variables capturing the effect of the economy on fund holdings, pension scheme characteristics capturing demographics and investment horizon, and sponsor risk profile variables.

The models do not predict probabilistic or binary outcomes; hence, the Ordinary Least Squares (OLS) method is appropriate. Validity tests (Section 6.2) will ensure model robustness. The second part of analysis (Section 6.3) comprises testable hypotheses from literature to identify evidence of the traditional perspective, corporate financial perspective, or ALM in the dataset.

5. Summary Statistics

A cross-sectional dataset for FTSE-100 entities in 2011, of which only 82 provide sufficient disclosure on its DB-scheme, was compiled using the following sources:

- Pension fund figures: LCP, Accounting for Pensions 2012; firm's Annual Report 2011
- Sponsor figures: Bloomberg; Forecasting Analysis and Modelling Environment database

Summary statistics show that the average proportion held in equities is 37.6%, and 47.9% in bonds. Risk-aversion is evident in the asset-side of funds' balance sheet, probably consequent of the recession. The ranges of equity and bond holdings are large, showing a lack of consensus in asset allocation. Of the three types of bonds, fixed-interest bonds, associated with hedging short-term liabilities, had the highest mean; its popularity perhaps reflecting the ageing population and shorter investment horizon in the UK.

[9] Appendix 1: Detailed variables list

Table 3: Average portfolio allocations for UK pension funds (2011)

Variable	Obs	Mean	Std. Dev.	Min	Max
equities	82	0.376	0.163	0.033	0.834
sum_bonds	82	0.479	0.157	0.16	0.886
corporate_bonds	82	0.149	0.076	0	0.375
fixed_interest	82	0.174	0.102	0	0.567
index_linked	82	0.155	0.074	0	0.438
property	82	0.036	0.037	0	0.16
cash	82	0.047	0.058	0	0.28
other_alternatives	82	0.061	0.081	0	0.37

N.B. sum_bonds = corporate_bonds + fixed_interest + index_linked

The higher *maturity_ratio* is, the older the scheme's age structure, and the shorter its investment horizon. From *Figure 2,* the range of *maturity_ratio* is small[10] – between 0 and 0.08, indicating that UK DB-schemes are similar in terms of age structure. This has implications should funds demand assets of similar maturities to match liabilities of a similar nature, for greater demand without increasing supply could drive up asset prices in this maturity range.

Figure 2: Distribution of Maturity Ratio – FTSE-100 DB-schemes

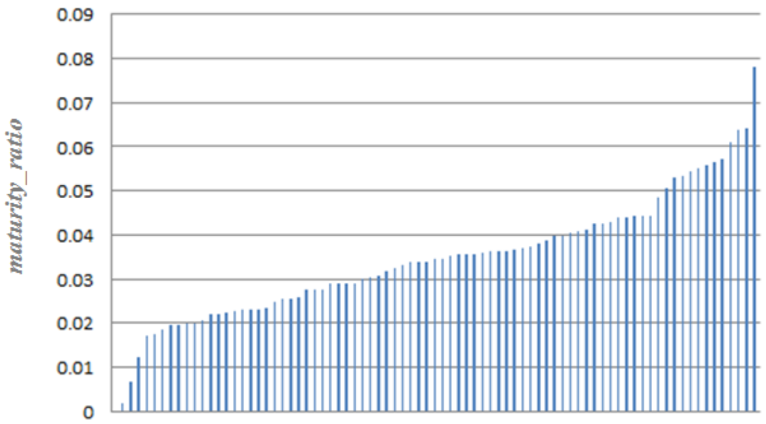


Figure 3 displays the trend that as *maturity_ratio* rises, bond holdings rise and equity holdings fall. Mature schemes are more risk-averse as they comprise more pensioner's liabilities – which are fixed and most imminent. Hence, they prefer short-dated bonds over equities, as these give more secure returns.

[10] Disregarding outlier – Fresnillo Plc.

Figure 3: Scheme Asset Allocation by Maturity Ratio

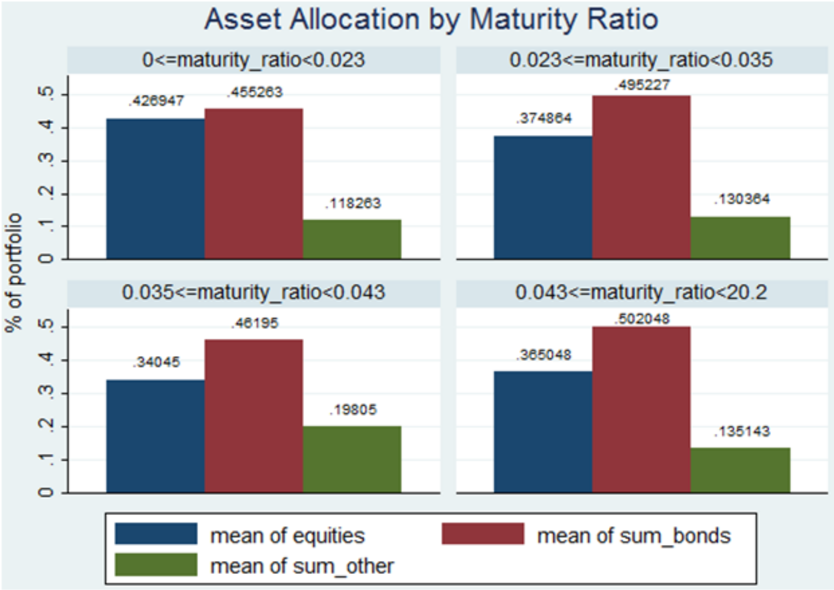
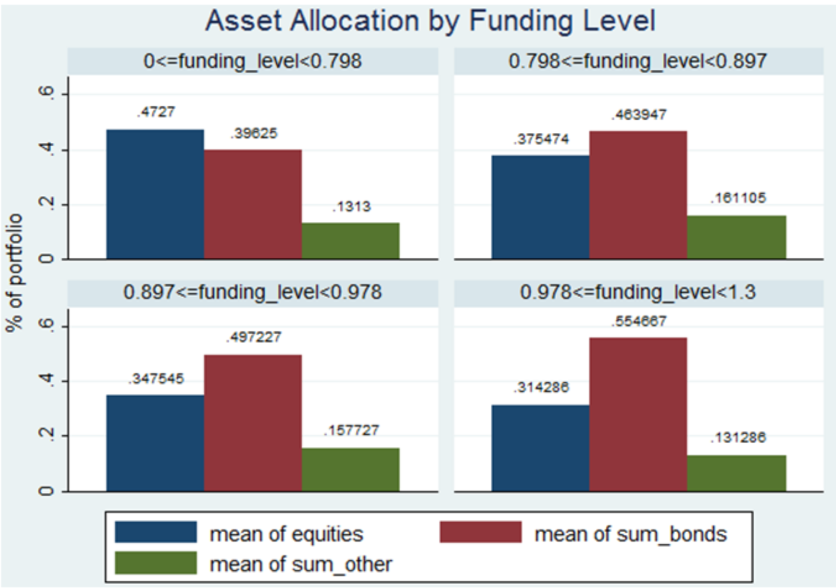


Figure 4 shows that equity holdings fall and bond holdings rise for funding level increases. This contrasts intuition that being better-funded, the scheme should be more risk-loving as it has a larger asset safety net. Prospect Theory can explain this risk-aversion – in the domain of gains, funds are more risk-averse; and more risk-loving in the domain of losses. Uncertain market conditions in 2011 might also have eliminated incentives for investors to generate higher returns from equities, instead preferring bond-dominated portfolios.

Figure 4: Scheme Asset Allocation by Scheme Funding Level



6. Results and Discussion

6.1 Determinants of Pension Fund Equity and Bond Holdings

The regressors explain around 39.4% of the variation in equity holdings, and 49% in bond holdings. The final models for pension fund *i* are:

$$\begin{aligned} equities_i = \alpha_i + \beta_1 maturity\_ratio_i + \beta_2 funding\_level_i + \beta_3 exprtn\_equities\_pctpa_i + \beta_4 ln\_pension\_assets_i \\ + \beta_5 beta_i + \beta_6 effective\_tax\_rate_i + \beta_7 ln\_mkt\_cap_i + \beta_8 future\_pension\_increase_i \\ + \beta_9 ln\_net\_debt_i + \varepsilon_i \end{aligned}$$

$$\begin{aligned} sum\_bonds_i = \alpha_i + \beta_1 maturity\_ratio_i + \beta_2 funding\_level_i + \beta_3 exprtn\_equities\_pctpa_i + \beta_4 ln\_pension\_assets_i \\ + \beta_5 effective\_tax\_rate_i + \beta_6 gearing\_1_i + \beta_7 deficit\_size_i + \beta_8 discount\_rate_i \\ + \beta_9 salary\_increase_i + \beta_{10} future\_pension\_increase_i + \beta_{11} beta_i + \beta_{12} payout\_ratio_i \\ + \beta_{13} ln\_net\_debt_i + \varepsilon_i \end{aligned}$$

where $i = 1, 2, ..., 82$

All analysis by variable categories below corresponds to *Tables 4a* and *4b*, where Regressions (1) are the key variables models, (2) and (3) are the models including macroeconomic and sponsor variables respectively, and (4) are the OLS-estimated final specifications.

6.1.1 Pension Scheme Static Asset Allocation and Demographic Variables

Key determinants of pension asset allocation are *maturity_ratio* (Bodie, 1984) and *funding_level* (Bodie, 1984; Friedman, 1983) – which along with other pension-related variables, are examined in Regressions (1). *gearing_1*'s (which rises for firms more vulnerable to business cycle downturns) insignificance in determining asset allocation provides initial evidence against the corporate financial perspective (He, 2008).

Maturity ratio proxies the scheme's age structure (He, 2008):

$$maturity\_ratio = \frac{pensions\ paid}{total\ funded\ pension\ liabilities}$$

In Regressions (4), *maturity_ratio* has insignificant negative and significant positive effects on equities and bonds respectively. For more mature schemes, comprising more short-end liabilities, equity holdings fall and bond holdings rise (Campbell & Viceira, 2002; Alestalo & Puttonen, 2006; Gerber & Weber, 2007). However, the coefficient's insignificance in the equities model is perhaps due to equities being inherently volatile in the short-run, and thus unsuitable in matching short-term liabilities. Blake (2001) concludes bonds as the best asset to match short-term liabilities. As my results show that schemes' equity-bond mixes are determined by *maturity_ratio* – derived from beneficiaries' ages, the traditional perspective is evident in management of these schemes.

funding_level measures fund solvency (He, 2008):

$$funding\_level = \frac{total\ pension\ assets}{total\ funded\ pension\ liabilities}$$

In Regressions (4), for a 1% rise in *funding_level*, equities fall by 0.32%, and bonds rise by 0.52%. *funding_level*'s significant negative effect on equities and positive effect on bonds is surprising, as better-funded schemes should take on more risk (Friedman, 1983; Bodie, 1984; Gerber & Weber, 2007). As mentioned previously, Prospect Theory – individuals are risk-averse in the domain of gains and risk-seeking in the domain of losses – possibly explains my contradictory results. Hence, well-funded schemes lock in their profits and invest conservatively in bonds, and underfunded schemes aggressively take on equity risk to improve funding levels.

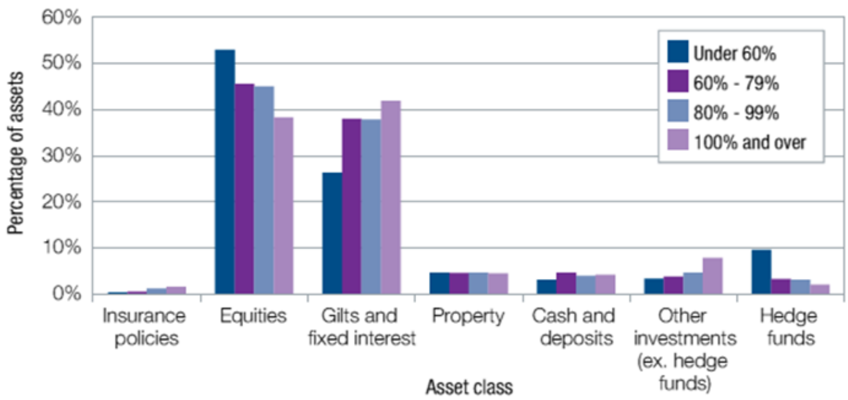
The PPF also concluded the risk-aversion tendencies of better-funded schemes, with 'the greatest share of their assets invested in gilts, and the smallest share invested in equities'. *Figure 5* shows the worst-funded funds[11] holding the most in equities (around 52%); and the least in gilts and fixed-

[11] Under 60% funding

interest (around 26%); contrasting the most well-funded funds[12] which hold around 38% in equities and 42% in gilts.

Furthermore, the 'PPF effect' suggests that PPF's existence (which bails out insolvent funds) has prompted trustees to account for the safety net when making asset allocation decisions, leading to excessive risk-taking by underfunded funds (He, 2008).

Figure 5: Weighted-Average Asset Allocation by Funding Level (PPF, 2011)



Another key variable is *exptn_equities_pctpa* (annual expected returns to equities). Regression (4) for equities shows a significant positive effect – for 1% rise in *exprtn_equities_pctpa*, equity holdings rise by 3.345%. This is unsurprising, as higher equity returns increases equities' attractiveness to investors. *exprtn_equities_pctpa* has no significant effect on bond holdings. Since *exprtn_equities_pctpa* does not have an opposite effect on bond holdings, bonds and equities may not be perfect substitutes.

For all specifications, *effective_tax_rate* has a significant positive effect on equities, and a significant negative effect on bonds. For sponsors, bond holdings generally incur higher taxes than equities (Bodie, 1984). Hence, assuming funds are 'pass-through entities' managed with regard to the sponsor, a high effective tax rate on sponsors should cause funds to favour bonds, so as to exploit the pre-tax asset returns that pension funds enjoy. My result contradicts this speculation, and is discussed further in Section 6.3.2.

[12] 100% and over

In Regressions (1), market value of pension assets (*ln_pension_assets*) is insignificant for equities and significant for bonds. Adding more relevant variables, we obtain Regressions (4), where *ln_pension_assets* has a significant, albeit small, negative effect on equities and significant positive effect on bonds. This is not as hypothesised because a larger fund should take on more risk (He, 2008) Perhaps when considering asset allocation, funds do not isolate the asset-side of their balance sheet, but also account for liabilities. Large funds have more members to account for, so portfolio risks must be minimised accordingly.

Similarly, assuming an insolvent scheme will be rescued by its sponsors; a strong sponsor covenant (i.e. large market capitalisation – proxies sponsor size) should allow funds to increase risk-taking (Friedman, 1983) – shown by the positive coefficient on *ln_mkt_cap* in Regression (4) for equities. However, from its insignificance, I conclude that sponsor size has no significant effect on equity holdings; which might indicate that UK pension funds are managed separately from sponsors, disproving the corporate financial view.

6.1.2 Macroeconomic Variables

Adding macroeconomic variables, Regressions (2) shows that *maturity_ratio* and *exprtn_equities_pctpa* lose their significance in the bonds model – the macroeconomic variables capture the effect of these variables on bond holdings. However, I retain both for their economic significance. In the equities model, most variables retain their significance from Regression (1).

salary_increase is most relevant to active (long-term) liabilities, as active members' final salary is not fixed. A higher projected salary increase raises the fund's projected benefit obligation (PBO), which should depress bond holdings as they are more suited to matching short-term liabilities (Blake, 2001); whilst equity holdings rise to exploit 'the mean reversion of equity returns in the long-run'. Furthermore, bonds with sufficient duration to match long-term liabilities are not always available.

Surprisingly, Regression (4) for bonds shows that bond holdings rise as *salary_increase* increases (more long-term liabilities)[13].

discount_rate is used to discount schemes' expected future payments to calculate the net present value of pension liabilities (He, 2008). In Regression (4) for bonds, it has a negative effect (for 1% rise in *discount_rate*, bond holdings fall by 11.37%). A higher *discount_rate* lowers the PBO of a fund, so the scheme needs fewer assets today to generate returns to pay off the PBO. Consequently, funds tend to be less risk-averse and hold fewer bonds. Today's low discount rates are a burden to pension schemes and have been argued to inaccurately reflect the scheme's expected risk-free returns, instead accounting for central bank policies (Pozen & Hamacher, 2012). Discount rates may forecast PBO more effectively if calculated using future expectations, rather than past data. A forward interest rate on risk-free assets such as gilts could be a benchmark for *discount_rate*.

6.1.3 Sponsor Risk Profile Variables

Regressions (3) are consequent of dropping insignificant macroeconomic variables, and adding sponsor-related variables – many of which have not been tested in previous literature[14]. Almost all sponsor-related variables were insignificant[15], disproving the corporate financial perspective.

payout_ratio is the dividend pay-out to shareholders (Investopedia, 2012):

$$payout\_ratio = \frac{\text{dividends per share}}{\text{earnings per share}}.$$

As dividends are dependent on *exprtn_equities_pctpa*, including *payout_ratio* in the same model as *exprtn_equities_pctpa* is potentially subject to multicollinearity. Fortunately, the correlation matrix concludes a non-substantial correlation[16]. Regressions (4) show that *payout_ratio* has a significant,

[13] Further explained in Section 6.3.3: 'Active Liabilities'
[14] Hence, this section's analysis has less backing from past literature.
[15] Appendix 1: explanation for insignificance of Sector and Credit Rating dummies
[16] $\rho_{exprtn\_equities\_pctpa,\, payout\_ratio} = -0.0117$

albeit small negative effect on bonds – the higher the dividend pay-out, the less attractive bonds are, and the lower the bond holdings. A high *payout_ratio* indicates a more profitable sponsor, so pension funds can take on more risk by raising equity holdings, but the insignificance of *payout_ratio*'s coefficient in the equities model (Regression (3)) may imply that sponsor financial condition does not affect fund asset allocation.

Table 4a: Equity Holdings Model Specifications

	(1)	(2)	(3)	(4)
VARIABLES	*equities*	*equities*	*equities*	*equities*
maturity_ratio	-0.0122	-1.583	-0.00656	-0.00452
	(0.00859)	(1.253)	(0.0145)	(0.00867)
funding_level	-0.334**	-0.450***	-0.484***	-0.320**
	(0.136)	(0.155)	(0.162)	(0.131)
exprtn_equities_pctpa	4.925***	3.451*	3.878**	3.345**
	(1.581)	(2.036)	(1.812)	(1.671)
ln_pension_assets	-0.0309	-0.0343***	-0.0528***	-0.0384***
	(0.0200)	(0.0127)	(0.0192)	(0.0120)
beta	-0.0726**	-0.0505	-0.153***	-0.0549*
	(0.0320)	(0.0380)	(0.0525)	(0.0319)
effective_tax_rate	0.444**	0.345	0.252	0.458***
	(0.169)	(0.212)	(0.229)	(0.158)
ln_mkt_cap	0.0251	0.0306*	-0.0968	0.0143
	(0.0166)	(0.0166)	(0.0602)	(0.0163)
future_pension_increase		3.452	5.956*	4.462
		(4.272)	(3.036)	(2.844)
deficit_size		-0.108		
		(0.0846)		
inflation_pctpa		-2.523		
		(5.566)		
discount_rate		6.796		
		(7.333)		
salary_increase		-0.337		
		(0.563)		
adjusted_eps			0.00252	
			(0.0267)	
payout_ratio			0.000985	
			(0.000849)	
ln_total_debt			0.0209	
			(0.0334)	
ln_no_outstanding_shares			-0.0164	
			(0.0197)	
ln_ebitda			0.142*	
			(0.0763)	
ln_no_of_employees			-0.0199	
			(0.0201)	
ln_net_debt			-0.00357	0.00911
			(0.00978)	(0.00570)
retail_leisure_svcs			0.00610	
			(0.0995)	
eng_constr			0.111	
			(0.0877)	
telecoms_media			0.0264	
			(0.0948)	
healthcare			0.00122	
			(0.110)	
utilities			-0.192*	
			(0.0993)	
production			0.0497	
			(0.109)	
rating_good			-0.154	
			(0.103)	
rating_med			0.0461	
			(0.0614)	
rating_low			-0.0792	
			(0.0521)	
gearing_1	0.0227			
	(0.0759)			
ln_employer_contrib	-0.00863			
	(0.0194)			
Constant	0.315	0.180	0.931**	0.337
	(0.217)	(0.244)	(0.403)	(0.206)
Observations	81	76	73	80
R-squared	0.346	0.401	0.556	0.394
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1			

Table 4b: Bond Holdings Model Specifications

	(1)	(2)	(3)	(4)
VARIABLES	*sum_bonds*	*sum_bonds*	*sum_bonds*	*sum_bonds*
maturity_ratio	0.0148*	1.427	0.0232	0.0317***
	(0.00767)	(1.146)	(0.0169)	(0.00850)
funding_level	0.436***	0.635***	0.702***	0.521***
	(0.127)	(0.141)	(0.178)	(0.128)
exprtn_equities_pctpa	-4.297***	-2.069	-1.326	
	(1.559)	(1.826)	(2.175)	
ln_pension_assets	0.0226*	0.0223*	0.0201	0.0228**
	(0.0124)	(0.0115)	(0.0181)	(0.00977)
effective_tax_rate	-0.335**	-0.427**	-0.496**	-0.536***
	(0.167)	(0.204)	(0.240)	(0.166)
gearing_1	-0.105	-0.120	-0.131	
	(0.0746)	(0.0718)	(0.0881)	
deficit_size		0.152*	0.163*	0.168***
		(0.0788)	(0.0840)	(0.0629)
discount_rate		-10.09	-9.821	-11.37***
		(6.095)	(6.449)	(3.505)
salary_increase		0.750	1.389*	1.709***
		(0.522)	(0.707)	(0.583)
future_pension_increase		-2.461	-4.407	
		(4.002)	(3.422)	
inflation_pctpa		-2.677		
		(5.205)		
adjusted_eps			0.0178	
			(0.0255)	
payout_ratio			-0.00183**	-0.00175***
			(0.000878)	(0.000659)
ln_total_debt			-0.00138	
			(0.0319)	
ln_no_outstanding_shares			0.0139	
			(0.0195)	
ln_ebitda			-0.0317	
			(0.0435)	
ln_no_of_employees			0.00598	
			(0.0195)	
ln_net_debt			-0.0113	-0.0139**
			(0.00931)	(0.00564)
retail_leisure_svcs			0.0882	
			(0.0946)	
eng_constr			0.0678	
			(0.0866)	
telecoms_media			0.00762	
			(0.0878)	
healthcare			0.0815	
			(0.104)	
utilities			0.177*	
			(0.0950)	
production			0.0565	
			(0.103)	
rating_good			0.0769	
			(0.0962)	
rating_med			0.0278	
			(0.0592)	
rating_low			0.0481	
			(0.0517)	
beta	0.0451			
	(0.0316)			
ln_mkt_cap	-0.00126			
	(0.0161)			
Constant	0.339	0.659***	0.604*	0.644***
	(0.212)	(0.192)	(0.339)	(0.173)
Observations	81	77	73	78
R-squared	0.299	0.410	0.588	0.490
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1			

6.2 Robustness Checks of Final Model Specifications

6.2.1 Multicollinearity, Heteroscedasticity, and Model Misspecification[17]

As some key regressors have been derived from other regressors within the dataset, correlation matrices were generated for each variable group[18]. $\rho \leq 0.75$ or $\rho \geq 0.75$ concludes strong correlation between two variables, and indicates a possible high degree of multicollinearity. Including these variables in the same model gives biased standard errors.

With heteroscedastic residuals, the OLS method is biased. Testing both models, there is sufficient evidence to not reject the null of homoscedastic errors. The low-powered Ramsey RESET test gives sufficient evidence to not reject the null of no omitted variables.

6.2.2 Endogeneity

funding_level is potentially endogenous – a high *exprtn_equities_pctpa* simultaneously increases *funding_level* and equity holdings; whilst a high *deficit_size* simultaneously decreases *funding_level* and bond holdings. *ln_pension_assets* is also potentially endogenous from reverse causality – equity and bond holdings are affected by pension fund size, but also determine pension fund size.

Suggestions of instruments have been scarce in past literature. I use two period lags of *funding_level* and *ln_pension_assets* as instruments, as they are unlikely to be influenced by current shocks captured by the error term of my final models, yet are correlated to the potentially endogenous variables. Implementing the Two Stage Least Squares (2SLS)[19] technique, these instruments are found to be exogenous and relevant; but IV standard errors and coefficients are similar to those under OLS (*Table 5*). Therefore, *funding_level* and *ln_pension_assets* are only slightly biased, and the OLS estimator remains as the final model specification.

[17] Appendix 4: All robustness tests available.
[18] Appendix 2: Potential sources of multicollinearity are highlighted.
[19] Appendix 4

Table 5: OLS VS. IV – Final Models

	(1)	(2)	(3)	(4)
VARIABLES	equities, OLS	equities, IV	sum_bonds, OLS	sum_bonds, IV
maturity_ratio	-0.00452	-0.00471	0.0317***	0.0283***
	(0.00867)	(0.00827)	(0.00850)	(0.00781)
funding_level	-0.320**	-0.170	0.521***	0.455***
	(0.131)	(0.157)	(0.128)	(0.142)
exprtn_equities_pctpa	3.345**	3.344**		
	(1.671)	(1.616)		
ln_pension_assets	-0.0384***	0.0411***	0.0228**	0.0207**
	(0.0120)	(0.0126)	(0.00977)	(0.00943)
beta	-0.0549*	-0.0556*		
	(0.0319)	(0.0306)		
effective_tax_rate	0.458***	0.449***	-0.536***	-0.497***
	(0.158)	(0.152)	(0.166)	(0.151)
ln_mkt_cap	0.0143	0.0174		
	(0.0163)	(0.0161)		
future_pension_increase	4.462	3.797		
	(2.844)	(2.749)		
ln_net_debt	0.00911	0.0100*	-0.0139**	-0.0156***
	(0.00570)	(0.00552)	(0.00564)	(0.00522)
deficit_size			0.168***	0.175***
			(0.0629)	(0.0566)
discount_rate			-11.37***	-9.592***
			(3.505)	(3.249)
salary_increase			1.709***	1.935***
			(0.583)	(0.529)
payout_ratio			-0.00175***	-0.00220***
			(0.000659)	(0.000617)
Constant	0.337	0.209	0.644***	0.650***
	(0.206)	(0.215)	(0.173)	(0.158)
Observations	80	78	78	76
R-squared	0.394	0.369	0.490	0.526
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1			

6.3 Determining the Most Commonly Used Asset Allocation Strategy

Testing the following hypotheses can identify the traditional perspective, the corporate financial perspective, or ALM in my sample.

6.3.1 The corporate financial perspective implies a significant positive relationship between firm profitability and degree of pension funding. (Bodie, 1984)

A more profitable sponsor should invest in more pension assets, raising its pension scheme's funding level. In replicating Bodie (1984)'s specification[20], without access to an inflation-adjusted measure of sponsor profitability, the most suitable proxy was *exprtn_equities_pctpa*, as *ln_operating_profit* was

[20] Appendix 3: Bodie (1984)'s regression output for comparison.

highly correlated with many regressors (multicollinearity). *exprtn_equities_pctpa* has a significant negative effect on *funding_level* (*Table 6*), contrasting Bodie (1984). For a 1% rise in *exprtn_equities_pctpa*, *funding_level* falls by 3.57%.

Table 6: Determinants of Pension Funding Level

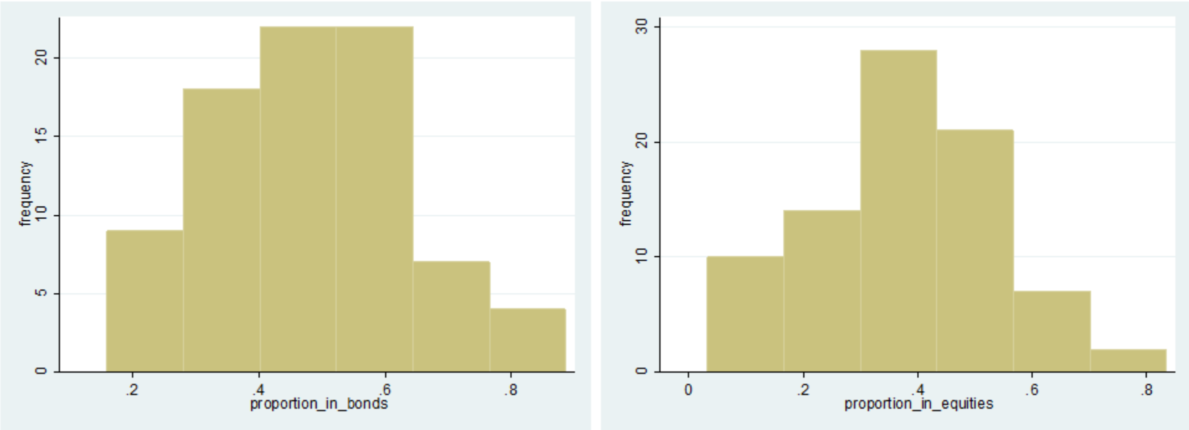
	(1)	(2)
VARIABLES	funding_level	funding_level
exprtn_equities_pctpa	-0.367	-3.570***
	(1.382)	(1.192)
ln_pension_assets		0.105***
		(0.0142)
discount_rate		15.19***
		(2.514)
ln_pensions_paid		-0.0523***
		(0.0157)
ln_firm_turnover		-0.0391***
		(0.0117)
ln_firm_assets		0.0238***
		(0.00833)
ln_employer_contrib		-0.0341**
		(0.0151)
Constant	0.927***	0.0863
	(0.101)	(0.147)
Observations	82	81
R-squared	0.001	0.531
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1	

However, my results agree with Friedman (1983), contradicting the corporate financial perspective. It is difficult to attribute the difference in my results to Bodie (1984)'s, to any particular variable due to different model specifications, and use of data from a different year.

<u>6.3.2 The corporate financial perspective implies that pension funds should be invested at either one of two extremes. (Bodie, 1984)</u>

Pension funds act as a tax shelter for corporations, with a comparative advantage in their ability to be invested in heavily-taxed assets, as firms earn a pre-tax rate of return on any pension fund-held asset. Hence, the corporate financial perspective predicts that sponsors should maximise its pension fund's funding level, with an extreme configuration in a particular asset – usually highly-taxed bonds, to exploit the tax shelter (Black, 1980; Cocco & Volpin, 2006). Underfunded plans will be skewed towards stocks to generate higher returns and overfunded plans towards taxable bonds to lock in profits.

Figure 6: Distribution of Bond and Equity Holdings



However, Bodie (1984) concluded a bi-modal bond holdings distribution – US funds are not managed according to the corporate financial perspective. Similarly, this paper finds a non-extremal bond-equity holdings distribution – more than 70% of pension funds hold mixed portfolios. This concludes that UK pension funds are effectively governed by regulation preventing sponsor-orientated fund management, consequently preventing tax evasion via pension funds.

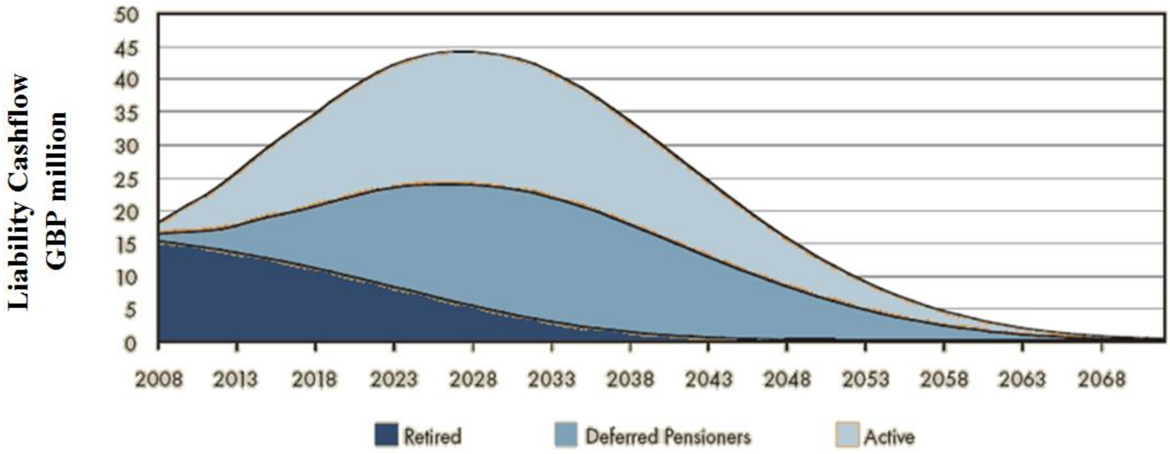
6.3.3 ALM is the most commonly used strategy in the UK pensions market in 2011 (He, 2008).

Volatile equity returns caused unstable employer contributions, adversely affecting sponsors' cashflows. Many DB-schemes closed to new entrants, shortening investment horizons – limiting their ability to take advantage of the 'mean reversion of equity returns in the long-run'. Hence, fund managers were deterred from 'maximising expected returns' (substantial investment in equities), resorting to ALM instead.

A scheme's composition of the three types of liabilities changes over time, and is illustrated in *Figure 7*[21]. Employing ALM, in 2008 more bonds and less equity should be held to match more short-term pensioner liabilities (Gerber & Weber, 2007). By 2028 when the scheme comprises mostly actives, the portfolio should be altered to hold more long-term liability matching assets. Without the alteration, an asset mismatch may result, and the fund would be exposed to unnecessary risks.

[21] Source: Northern Trust, available online: http://www.northerntrust.com/pointofview/08_Jan/graph_pensionbenefitsprofile.html

Figure 7: Hypothetical Benefits Profile



To determine if ALM has been employed in my sample, *Table 7* below displays the effects of determinants on index-linked and fixed-interest holdings. Index-linked bonds hedge long-run inflation risk (associated with active and deferred liabilities), whilst fixed-interest bonds hedge short-run inflation risk.

(i) Active liabilities

- Since volatility of equity return is generally higher than that of inflation rate, index-linked bonds are better matching assets for active liabilities. (Exley, 2001; Booth, 2004).

Active members are new to the workforce and just begun accumulating their pension. These liabilities are subject to long-term uncertainty and inflation risk.

salary_increase captures the ‘inflation’ faced by active liabilities (O’ Brien et. al, 2010). *salary_increase*’s effect on asset allocation may affect *maturity_ratio* as *salary_increase* is linked to seniority increase, which often rises with age. I suspected a quadratic relationship, with the youngest, most inexperienced and oldest workers receiving the lowest rate of salary increase, whilst recipients of the maximum rate will be between the two groups.

Figure 8: Maturity and Projected Salary Increase

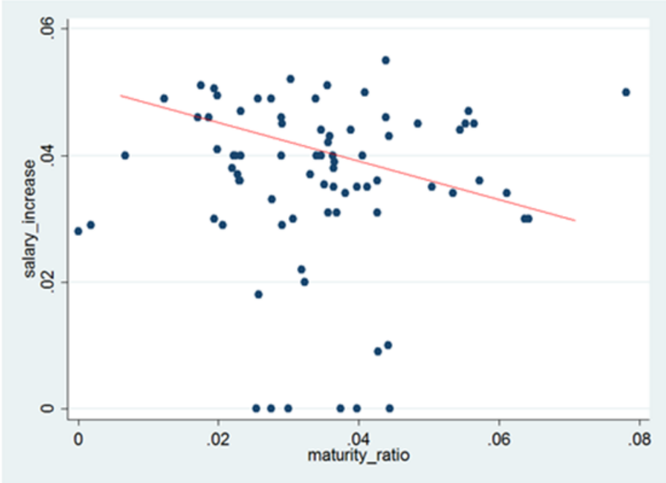


Figure 8 disproves my speculation – the weak negative, non-quadratic relationship between *salary_increase* and *maturity_ratio* (ignoring anomalies) can be explained – for a higher maturity ratio, schemes have more pensioners' than active liabilities, thus depressing average projected *salary_increase* as pensioners' final salaries are fixed. *salary_increase* took values around 0.04. This display of 'herd-behaviour'-type fund management – where actuarial assumptions are calculated to match peer behaviour – is criticised by Myners (2001), who posited that asset allocation should be fund-specific.

Regressing index-linked bonds on its possible determinants in Regression (1) of *Table 7*, the significant positive coefficient on *salary_increase* implies that as salary increase rises, index-linked holdings rise. This is as hypothesised – index-linked bonds are the best match for salary-growth linked active liabilities – and explains the earlier unexpected result of bond holdings rising despite a higher *salary_increase* (Section 6.1.2). Although literature has concluded bonds in general to be most appropriate in matching short-term liabilities, index-linked bonds are best at matching long-term liabilities. The significant negative coefficient on *maturity_ratio* also implies higher index-linked holdings for less mature pension funds (more active liabilities).

(ii) Deferred liabilities

- The most suitable asset to match deferred liabilities is index-linked bonds (Exley, 2001, Booth, 2004).

Deferred liabilities are for members still not of benefit redemption age; but, have left the firm with which they are accumulating benefits from. These are long-term, but final salary is fixed.

Adding *inflation_pctpa* to the index-linked model decreased the R^2 in Regression (2), and variables that were previously significant became insignificant. Surprisingly, it seems that there is no significant relationship between inflation and index-linked bonds; and hence *inflation_pctpa* is dropped from the regression. Perhaps deferred liabilities are too long-term, such that no bonds have sufficient duration to match ultra-long term inflation risk.

(iii) Pensioner liabilities

- Fixed-interest bonds are most suitable in matching pensioners' liabilities as they best match short-term inflation risk. (He, 2008)

Pensioners' liabilities are short-term and fixed. With *fixed_interest* as a proxy for pensioners' liabilities, *inflation_pctpa* had no significant effect on fixed-interest holdings. Instead, these are largely affected by current market conditions, and less by future projected inflation. As hypothesised, the significant positive coefficient on *maturity_ratio* means that as *maturity_ratio* rises (more pensioners' liabilities), fixed-interest holdings rise.

Seemingly, ALM has been applied to active and pensioners' liabilities, but not to deferred liabilities. This may be because deferred benefits are capped at LPI, and therefore less sensitive to inflation risk. Overall, my results provide more liability-driven investment than corporate financial policy-driven investment. Figures from KPMG's 2012 LDI Survey also illustrate ALM's popularity surge, as the value invested in LDI mandates in the UK rose from £243 billion to £312 billion over 2011.

Table 7: ALM Regression Outputs

VARIABLES	(1) index_linked	(2) index_linked	(3) fixed_interest
maturity_ratio	-0.00900**	0.0246	0.0164***
	(0.00357)	(0.528)	(0.00495)
funding_level	0.168***	0.199***	0.278***
	(0.0552)	(0.0618)	(0.0767)
ln_pension_assets	0.0147***	0.0156***	
	(0.00469)	(0.00534)	
gearing_1	-0.0589*	-0.0592*	
	(0.0322)	(0.0340)	
beta	0.0288*	0.0273*	
	(0.0151)	(0.0158)	
employer_contrib_turnover	0.102***	0.124***	
	(0.0380)	(0.0418)	
salary_increase	0.767***	0.755***	
	(0.265)	(0.284)	
future_pension_increase	-4.842***	-4.160***	-3.476**
	(1.138)	(1.533)	(1.622)
effective_tax_rate	-0.209**	-0.207**	
	(0.0836)	(0.0943)	
payout_ratio	-0.000536*	-0.000520	
	(0.000306)	(0.000332)	
inflation_pctpa		-3.368	
		(2.395)	
Constant	0.0932	0.141*	0.0239
	(0.0651)	(0.0765)	(0.0791)
Observations	77	73	81
R-squared	0.485	0.467	0.321
Standard errors in parentheses	*** p<0.01, ** p<0.05, * p<0.1		

7. Limitations and Extensions

Being restricted to publically available data in compiling my dataset made it impossible to obtain a suitable proxy to capture fund risk-aversion. Nominal and inflation hedge ratios for funds would be good proxies as the higher the hedge ratio, the more risk-averse the fund. Proxies were also used to model scheme age structure and profitability. The validity of these in modelling the behaviour of their intended variable could be questioned.

With time constraints, data is only restricted to 2011. If 2011 is not a 'typical year', it would be inappropriate to extrapolate this paper's conclusions. I speculate that post-2008, no year is 'typical', as even trustees are uncertain of how best to cover their losses given market volatility. Scope remains to combine dataset extension over a longer time period, with panel data analysis to observe time trends.

The low number of observations in my dataset meant that only regressors satisfying $(P>|t|) \leq 0.1$ were used. My sample could be expanded to include FTSE-250 constituents; but unattainable data will be problematic again as these firms need not provide full disclosure. Cross-country comparisons may be inconsistent due to differences in pension fund governance legislation.

Finally, the generalisation of fund assets to two classes – risky equities or safe bonds – might not be sufficiently conclusive. Assets in diverse pension portfolios are assumed to fall under one of the two classes. Naturally, an extension would be to breakdown assets into more classes.

8. Conclusive Remarks

8.1 Results Summary

This paper sought to investigate the determinants of DB-schemes' asset allocation. Results are summarised below:

Table 8: Regression Results Summary

Dependent Variable	Independent Variable	Expected Coefficient	Coefficient	p-Value
equities	*maturity_ratio*	-	-0.00452	0.603
	funding_level	+	-0.320**	0.017
R^2 = 0.3945	*exprtn_equities_pctpa*	+	+3.345**	0.049
	ln_pension_assets	+	-0.0384***	0.002
	beta	-	-0.0549*	0.090
	effective_tax_rate	+	+0.458***	0.005
	ln_mkt_cap	+	+0.0143	0.386
	future_pension_increase	+	+4.462	0.121
	ln_net_debt	-	+0.00911	0.115
sum_bonds	*maturity_ratio*	+	+0.0317***	0.000
	funding_level	-	+0.521*	0.000
R^2 = 0.4901	*ln_pension_assets*	-	+0.0228**	0.022
	effective_tax_rate	-	-0.536***	0.002
	deficit_size	+	+0.168***	0.009
	discount_rate	-	-11.37***	0.002
	salary_increase	+	+1.709***	0.005
	payout_ratio	-	-0.00175***	0.010
	ln_net_debt	+	-0.0139**	0.016
funding_level	*exprtn_equities_pctpa*	+	-3.570***	0.004
	ln_pension_assets	+	+0.105***	0.000
R^2 = 0.5310	*discount_rate*	+	+15.19***	0.000
	ln_pensions_paid	-	-0.0523***	0.001
	ln_firm_turnover	+	-0.0391***	0.001
	ln_firm_assets	+	+0.0238***	0.006
	ln_employer_contrib	-	-0.0341**	0.027
index_linked	*maturity_ratio*	-	-0.00900**	0.014
	funding_level	-	+0.168***	0.003
R^2 = 0.4853	*ln_pension_assets*	+	+0.0147***	0.003
	gearing_1	-	-0.0589*	0.072
	beta	+	+0.0288*	0.061
	employer_contrib_turnover	+	+0.102***	0.009
	salary_increase	+	+0.767***	0.005
	future_pension_increase	+	-4.842***	0.000
	effective_tax_rate	-	-0.209**	0.015
	payout_ratio	-	-0.000536*	0.084
fixed_interest	*maturity_ratio*	+	+0.0164***	0.001
	funding_level	-	+0.278***	0.001
R^2 = 0.3212	*future_pension_increase*	-	-3.476**	0.035

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

With most sponsor-related variables either insignificant, or had unexpectedly-signed coefficients; UK legislation separating pension fund and sponsor management has been effective. Well-funded schemes lock in their profits by investing conservatively, whilst underfunded schemes employ riskier investment strategies for higher returns. But poor market conditions have meant that underfunded plans, despite raising equity holdings, could not improve funding levels; whilst overfunded plans' asset values eroded away – raising pension deficits.

8.2. Policy Implications

Pension assets amounted to 76% of UK GDP[22] in 2011, representing the savings of millions. Unsurprisingly, their decisions define capital allocation within the economy. Policy implications relate to regulation or benefit design for the future. It remains to be seen if pension asset allocation can be reached to enhance productivity and growth, whilst minimising risks.

With ALM's increased prominence, demand has risen for long-dated and index-linked bonds. The government has an advantage over corporates in the issuance of ultra-long dated bonds as it will never go bust – service of these bonds will never cease. Hence, the government should play a market-building role in designing more high-quality long-term securities. With rising life expectancy, hedging longevity risk is also a growing concern. Government issuance of longevity bonds would catalyse the development of this nascent market, which is presently hindered by transaction costs for potential issuers, driven up by price uncertainty and asymmetric information.

Policy could require funds to hold buffers above the full funding level. Solvency-II ensures financial stability via capital requirements on insurance schemes. The European Commission is currently examining how a similar regime for pension funds can be developed. However, it has been argued that as pension schemes pay out predictably over time, treating them like insurance schemes that could face large unexpected amounts of capital demand is incorrect.

[22] Towers Watson, 2011

Despite little evidence of the corporate financial perspective in my results, the UK pensions sector already has sponsor covenants and PPF's insurance against default in place, that meet the same aims as capital requirements. Whilst excessive regulation is unnecessary, certain aspects of Solvency-II, if adopted suitably, could create a much-needed regulatory framework for DB-schemes.

8.3 Conclusion

Along with market conditions and trustee's risk appetite, scheme age structure is a prime determinant of a DB-scheme's portfolio composition, and justifies retaining *maturity_ratio* in all model specifications, despite its insignificance in the final equities model. Its significant positive relationship with bond holdings reflects increasing use of LDI.

2011's sluggish equity returns and all-time interest rate lows generated minimal returns. Hence, funds rationally strayed from maximising returns with risky assets, focusing on funding the rising value of their liabilities instead. However, the lack of an explicit portfolio riskiness threshold is the source of conflict over the 'ideal' portfolio mix. Ultimately, scheme objectives will determine its response to market conditions and drive asset allocation.

9. Appendices

9.1 Appendix 1

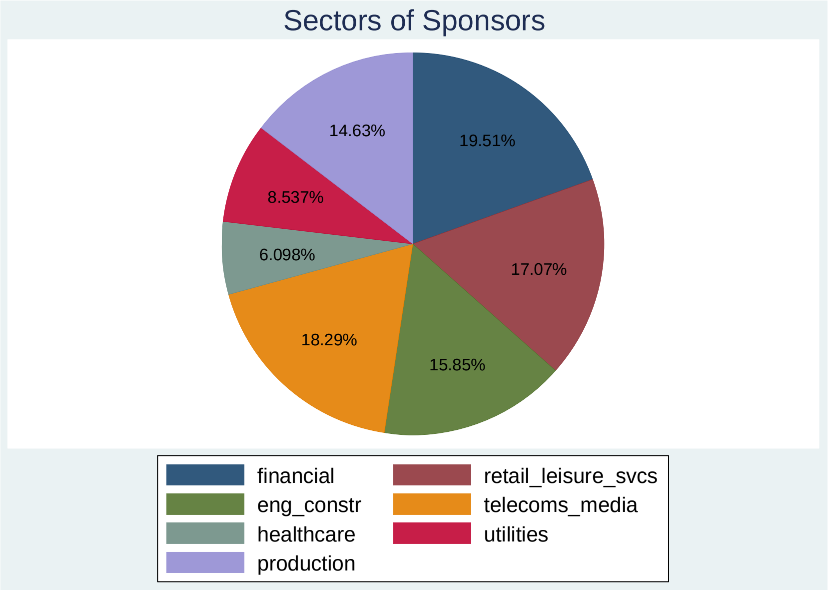
Table 8a: Dependent and Independent Variables in Final Models

Variable	**Description**	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**
equities	Percentage of DB scheme assets held in equities	82	0.376024	0.163882	0.033	0.834
sum_bonds	Percentage of DB scheme assets held in bonds	82	0.479598	0.157148	0.160	0.886
index_linked	Percentage of DB scheme assets held in index-linked (inflation-hedge) bonds.	82	0.155281	0.074484	0.000	0.438
fixed_interst	Percentage of DB scheme assets held in fixed-interest (nominal hedge) bonds	82	0.174329	0.102446	0.000	0.567
funding_level	Ratio of total scheme-held assets to total funded scheme liabilities. Measures degree of scheme solvency. Higher values associated with greater solvency.	82	0.900378	0.129391	0.553	1.250
maturity_ratio	Ratio of pensions paid to total funded scheme liabilities. Proxy for age structure of scheme. Higher values associated with increased maturity.	82	0.279782	2.221494	0.000	20.151
exprtn_equities_pctpa	Percentage of expected return to equity investments. Proxy for sponsor profitability.	82	0.072165	0.010465	0.025	0.087
ln_pension_assets	Natural logarithm of the market value of pension assets (GBP million) of the scheme.	82	7.451207	1.648315	2.890	10.630
beta	Volatility of sponsor's shares with respect to the overall financial market benchmark. β<0: Sponsor's share value moves opposite to movements in the stock market. β=0: Sponsor's share value is uncorrelated with movements in the stock market. 0<β<1: Sponsor's share value moves in the same direction as movements in the stock market, but less than stock market movement. β=1: Sponsor's share value moves in the same direction as movements in the stock market, about the same amount as stock market movement. β>1: Sponsor's share value moves in the same direction as movements in the stock market, but more than stock market movement.	82	1.015280	0.498825	0.085	2.319
effective_tax_rate	Average rate (%) at which the firm's pre-tax profits are taxed.	82	0.240107	0.098527	0.000	0.651
ln_mkt_cap	Natural logarithm of the market capitalisation of the firm (GBP million). Proxy for sponsor size.	81	9.106790	1.122705	7.050	11.910
salary_increase	Average projected percentage salary increase of scheme members. An actuarial assumption calculated by independent consultants to value pension liabilities. Most relevant to active scheme members.	81	0.039252	0.033841	0.000	0.315
future_pension_increase	Average expected percentage increase in future pensions for scheme members. An actuarial assumption calculated by independent consultants to value pension liabilities.	81	0.029764	0.006891	0.000	0.051
gearing_1	Corporate gearing (%) of a firm measures its financial leverage. Higher values are associated with a riskier firm.	82	0.647561	0.236766	0.100	1.460
deficit_size	Calculated by the difference between scheme assets and liabilities, as a percentage of total liabilities of the scheme.	82	0.029866	0.221807	0.809	0.667
discount_rate	Rate (%) used to discount schemes' expected future payments to calculate the net present value of pension liabilities. Higher values associated with lower projected benefit obligation of schemes.	82	0.050377	0.005325	0.028	0.075
payout_ratio	Amount of earnings paid out in dividends to shareholders of the firm, calculated by dividends per share divided by earnings per share (%).	79	48.664560	27.620770	0.000	180.320
ln_net_debt	Natural logarithm of the net debt of the sponsor (comprising of short-term debt, long-term debt, minus cash holdings).	82	6.202805	3.261475	0.000	12.020
employer_contrib_turnover	Ratio of employer contribution to firm turnover.	81	0.033098	0.173889	0.000	1.571
ln_employer_contrib	Natural logarithm of employer's scheme contribution (GBP million).	82	3.993415	1.559519	0.110	7.660
ln_pensions_paid	Natural logarithm of total pension benefit paid (GBP million).	82	4.189268	1.673279	0.220	7.640
ln_firm_turnover	Natural logarithm of the firm's turnover (GBP million).	81	8.853086	1.544924	3.040	12.650
ln_firm_assets	Natural logarithm of the market value of firm assets (GBP million). An alternative proxy for sponsor size.	82	9.594512	1.961716	1.900	14.310

Table 8b: Dropped Insignificant Variables

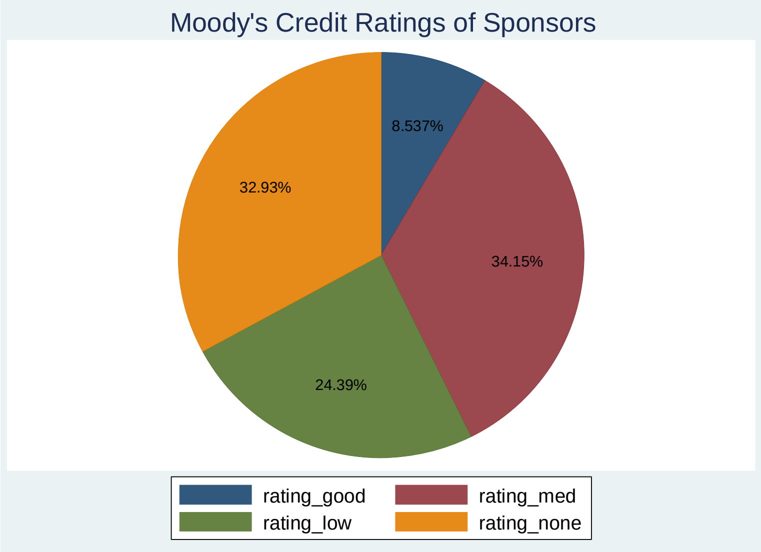
Variable	Description	Obs	Mean	Std. Dev.	Min	Max
inflation_pctpa	Projected annual inflation rate (%), actuarial assumption calculated by independent consultant.	78	0.0313256	0.0038715	0.016	0.042
ln_firm_liabs	Natural logarithm of market value of firm's total liabilities (GBP million).	82	9.079146	2.122598	1.15	14.22
employer_contrib_penassets	Ratio of employer scheme contribution to market value of pension assets.	82	0.1088585	0.6281265	0.0002	5.7226
per_employee_salaries_turnover_r	Ratio of per employee's salary to firm turnover.	79	54.39595	302.6204	0.19	2707
adjusted_eps	Adjusted earnings per share of sponsor (GBP), alternative measure of firm profitability. Determines share price, and is the proportion of firm profit allocated to each outstanding share of common stock.	82	0.8360768	0.9047382	0.02	5.04
ln_no_outstanding_shares	Natural logarithm of outstanding shares – stock currently held by investors, as well as those held by the public. Used to calculate firm's market cap and EPS. The more outstanding shares, the more diluted the stock pay-out.	81	14.08988	1.463535	8.19	18.05
ln_capital_exp	Natural logarithm of capital expenditure – funds used to acquire or improve physical assets e.g. property & equipment. More relevant to firms in construction/engineering sector.	71	5.736479	1.748126	2.48	9.71
ln_depreciation	Natural logarithm of depreciation – calculation of the cost of how much a tangible asset's value has been used up. Used in accounting to match the asset's expense to the asset's returns to the sponsor.	75	5.096533	1.79553	0	8.85
ln_operating_profits	Natural logarithm of sponsor operating profits – profits earned from the business's core operations, a.k.a. EBIT.	81	6.970247	1.351555	3.62	10.19
ln_ebitda	Natural logarithm of sponsor's earnings before interest, taxes, depreciation and amortisation. Used to compare profitability of sponsor, but not cashflow.	82	7.269024	1.293224	3.76	10.46
ln_hvt	Natural logarithm of the historical volatility of the sponsor's shares.	81	3.455667	0.8145474	2.728	9.891
ln_no_of_employees	Natural logarithm of number of employees hired by the sponsor.	81	10.19617	1.492847	5.2	13.37

Figure 8: Sponsors' Sector Breakdown



Sponsors were sorted according to sector, and dummies for these were all found to be jointly insignificant in both the equity and bond holdings models. Motivation for sectoral analysis derives from desire to identify 'herd-behaviour'-type fund management within sectors.

Figure 9: Moody's Credit Ratings of Sponsor's Corporate Bonds



As a possible proxy for sponsor risk-aversion, credit ratings of the sponsor's corporate bonds were incorporated into equity and bond holdings models as dummies. These were all individually and jointly insignificant, and were not available for all 82 observations in the dataset. Inclusion of these dummies generated excessive missing values.

rating_good: Aa1, Aa3, A1
rating_med: A2, A3, Baa1
rating_low: Ba1, Baa2, Baa3
rating_none: no value or WR

9.2 Appendix 2

Table 9: Correlation Matrices

Correlation Matrix: Macroeconomic Variables

	inflat~a	*salary~e*	*future~e*	*effect~e*	*discou~e*
inflation_pctpa	1				
salary_increase	0.0963	1			
future_pension_increase	0.5433	0.1253	1		
effective_tax_rate	-0.0005	0.5009	-0.1153	1	
discount_rate	0.6332	0.1322	0.7138	-0.0779	1

As expected, *future_pension_increase* has strong positive correlation with *inflation_pctpa*. Unexpectedly, there is almost no correlation between *salary_increase* and *inflation_pctpa*. One would have expected these to move in the same direction, and proportionately.

Correlation Matrix: Pension Scheme Demographics and Static Asset Allocation Variables

	maturi~o	*bond_e~o*	*ln_pe~ts*	*ln_pe~bs*	*fundin~l*	*defici~e*
maturity_ratio	1					
bond_equity_ratio	-0.0211	1				
ln_pension_assets	-0.3047	0.1752	1			
ln_pension_liabs	-0.2998	0.1457	0.996	1		
funding_level	-0.1218	0.4066	0.245	0.1588	1	
deficit_size	-0.1439	-0.0035	0.07	0.0654	0.0732	1

Possibility of high degree of multicollinearity between *ln_pension_assets* and *ln_pension_liabs*, as schemes with more assets tend to be large and have more accompanying liabilities. I expected some correlation between *ln_pension_assets* or *ln_pension_liabs* with *deficit_size* as this was derived from the aforementioned variables, but evidence shows that *deficit_size* has a similar sized, virtually non-existent relationship with the two.

Correlation Matrix: Sponsor Risk Profile Variables (Hidden Sector and Credit Ratings Dummies)

	exprtn~a	*ln_mkt~p*	*gearin~1*	*ln_fir~r*	*ln_fi~bs*	*ln_fi~ts*	*ln_pe~ts*	*adjust~s*	*payout~o*	*ln_tot~t*	*ln_n~res*	*ln_cap~p*
exprtn_equities_pctpa	1											
ln_mkt_cap	0.0299	1										
gearing_1	-0.0931	-0.0549	1									
ln_firm_turnover	0.0983	0.7846	0.0428	1								
ln_firm_liabs	0.0435	0.7576	0.3445	0.7815	1							
ln_firm_assets	0.0464	0.8381	0.0768	0.8129	0.9575	1						
ln_pension_assets	0.2214	0.4697	0.2371	0.7281	0.6985	0.648	1					
adjusted_eps	0.054	0.4859	-0.004	0.3236	0.2815	0.3012	0.1487	1				
payout_ratio	-0.0177	-0.0686	0.0635	-0.0069	-0.0036	-0.0095	-0.0053	-0.2411	1			
ln_total_debt	0.1282	0.6422	0.2745	0.6511	0.8333	0.7771	0.6688	0.2396	-0.0641	1		
ln_no_outstanding_shares	0.0271	0.4875	-0.032	0.5629	0.5289	0.5834	0.4986	-0.0599	0.1594	0.4405	1	
ln_capital_exp	0.1162	0.8226	-0.0131	0.7019	0.6843	0.7455	0.4395	0.3404	-0.1947	0.6416	0.4198	1
ln_depreciation	0.0849	0.7635	0.091	0.8398	0.6674	0.689	0.5867	0.333	-0.0647	0.5988	0.4498	0.8418
ln_operating_profits	-0.0135	0.9217	0.0168	0.8377	0.7862	0.8424	0.5865	0.4824	-0.0966	0.6675	0.5296	0.79
ln_ebitda	0.0888	0.9556	0.0089	0.8353	0.8212	0.8829	0.5914	0.4821	-0.0999	0.7177	0.5556	0.8649
ln_no_of_employees	-0.0582	0.3929	0.1902	0.7141	0.4499	0.4162	0.5479	0.1825	0.0125	0.4052	0.4699	0.3294
ln_net_debt	0.2076	0.4138	0.1659	0.3923	0.4157	0.3796	0.3587	0.0413	-0.2209	0.6388	0.2314	0.5963
beta	-0.0537	-0.0291	-0.1954	-0.0177	0.0022	0.0526	-0.1301	0.1706	-0.1488	-0.0955	-0.1271	-0.0448
hvt50d1y	0.0412	0.0997	0.0805	0.0689	0.1169	0.0995	0.0473	0.1215	0.0195	0.1193	-0.0027	0.0059
ln_employer_contrib	0.2423	0.5359	0.0351	0.7161	0.5872	0.6148	0.814	0.2024	0.091	0.4759	0.4359	0.5194
employer_contrib_turnover	0.0558	-0.1912	0.043	-0.2824	-0.1876	-0.1794	0.0198	-0.1707	0.0987	-0.254	-0.0346	-0.0716
employer_contrib_penassets	0.0286	0.0255	-0.2903	-0.1456	-0.3048	-0.1659	-0.3492	-0.0317	0.15	-0.5743	-0.0438	-0.0005

	ln_dep~n	*ln_ope~s*	*ln_ebi~a*	*ln_n~ees*	*ln_net~t*	*beta*	*hvt50d1y*	*ln_emp~b*	*employ~r*	*employ~s*
ln_depreciation	1									
ln_operating_profits	0.799	1								
ln_ebitda	0.8359	0.9493	1							
ln_no_of_employees	0.5885	0.5364	0.4648	1						
ln_net_debt	0.5332	0.4344	0.4938	0.2832	1					
beta	-0.0919	-0.0264	-0.0227	-0.1331	-0.272	1				
hvt50d1y	-0.0129	0.085	0.0823	0.0285	0.1158	-0.1612	1			
ln_employer_contrib	0.6452	0.6372	0.6323	0.5054	0.2532	-0.1063	0.0452	1		
employer_contrib_turnover	-0.056	-0.1535	-0.1347	-0.2115	-0.1211	-0.1485	-0.0533	0.3367	1	
employer_contrib_penassets	-0.0339	-0.0209	-0.0371	-0.1894	-0.2919	-0.0873	-0.0155	0.0634	0.4542	1

These correlation matrices were useful in determining which variables to incorporate into the models, to prevent multicollinearity. As *ln_total_debt*, *ln_operating_profits*, *ln_capital_exp*, *ln_depreciation*, *ln_ebitda* were highly correlated with each other or other explanatory variables, including them in the models would produce inconsistent, biased results. All problematic relationships have been highlighted, and most are not unexpected as often enough, firm's performance indicators are highly correlated. As expected, *ln_mkt_cap* and *ln_firm_assets* are highly correlated as these are both measures of the firm's size – and so cannot be used simultaneously in the models.

9.3 Appendix 3

Table 10: Determinants of Pension Funding Level, (Bodie, 1984)

Dependent Variable = PA/VPL (Vested Funding)

Independent Variables	Equation 1	2	3	4
CONSTANT	1.279 (0.160) t=8.0	1.352 (0.068) t=19.8	1.282 (0.172) t=7.5	1.304 (0.065) t=20.1
RONA (Profitability)	1.704 (0.481) t=3.5	1.739 (0.348) t=5.0	1.323 (0.554) t=2.4	1.714 (0.523) t=3.3
$\frac{CFWD}{A}$ (Carryforwards)	-0.504 (0.514) t=-1.0	-1.635 (0.938) t=-1.7		
$\frac{T}{A}$ (Taxes Paid)			1.177 (0.767) t=1.5	0.370 (0.662) t=0.6
BRAT (Bond Rating)	0.020 (0.020) t=1.0		0.016 (0.022) t=0.7	
BETAU (Unlevered Beta)		0.097 (0.064) t=1.5		0.100 (0.064) t=1.6
R^2	.04	.07	.05	.08
No. of Observations	240	360	226	338

- RONA: Inflation-adjusted return on net assets.
- CFWD: End-of-year magnitude of tax-loss carryforwards; alternative measure of tax paying status to 'Taxes Paid'.
- BRAT: S&P's Bond Rating (10=AAA, 1=D); alternative measure of risk to 'Unlevered Beta'.

Key findings:

Heavier tax burdens are associated with higher funding levels.

Riskier firms with lower bond ratings will exhibit lower funding levels.

*Sponsor profitability has a significant positive effect on pension funding level, consistent with the corporate financial view. This paper found the opposite relationship between the two variables.

9.4 Appendix 4

2SLS Estimation Method Addressing Endogeneity

In my final equity and bond holdings models, two explanatory variables – *funding_level* and *ln_pension_assets* are potentially endogenous. In estimating by 2SLS, two instruments were included for each – *funding_level_l1*, *funding_level_l2*, *ln_pension_assets_l1* and *ln_pension_assets_l2*. The first two are two-year lags of *funding_level* and the remaining two are two-year lags of *ln_pension_assets*.

For the equity holdings model with nine regressors:

$$equities_i = \beta_0 + \beta_1 funding\_level_i + \beta_2 ln\_pension\_assets_i + \beta_j \left(explanatory\ variables \right)_i + u_1 \text{ where}$$

$j = 1, 2, 3, \ldots, 9$

First stage reduced form regressions:

$$funding\_level_i = \delta_{10} + \delta_{11} funding\_level\_l1_i + \delta_{12} funding\_level\_l2_i + \delta_{13} ln\_pension\_assets\_l1_i$$
$$+\delta_{14} ln\_pension\_assets\_l2_i + \delta_{1j} \left(explanatory\ variables\right)_i + \varepsilon_1$$

$$ln\_pension\_assets_i = \delta_{20} + \delta_{21} funding\_level\_l1_i + \delta_{22} funding\_level\_l2_i + \delta_{23} ln\_pension\_assets\_l1_i$$
$$+\delta_{24} ln\_pension\_assets\_l2_i + \delta_{2j} \left(explanatory\ variables\right)_i + \varepsilon_2$$

From these we obtain the fitted values: $\widehat{funding\_level}$ and $\widehat{ln\_pension\_assets}$.

Second stage regression:

$$equities_i = \beta_0 + \beta_1 \widehat{funding\_level}_i + \beta_2 \widehat{ln\_pension\_assets}_i + \beta_j \left(explanatory\ variables\right)_i + u_1$$

The estimated coefficients are 2SLS coefficients, and in the second stage regression, one cannot compute the correct standard errors, but STATA's *ivreg* command does this.

Carrying out a similar process for the bond holdings model with nine regressors:

$sum\_bonds_i = \beta_0 + \beta_1 funding\_level_i + \beta_2 ln\_pension\_assets_i + \beta_j \left(explanatory\ variables\right)_i + u_1$ where $j = 1, 2, 3, ..., 9$

The second stage regression is:

$$sum\_bonds_i = \beta_0 + \beta_1 \widehat{funding\_level}_i + \beta_2 \widehat{ln\_pension\_assets}_i + \beta_j \left(explanatory\ variables\right)_i + u_1$$

Results of IV regressions can be found in *Table 5*.

Breusch-Pagan Heteroscedasticity Test

Dependent Variable: *equities* (*Table 4a, (4)*)	**Dependent Variable: *sum_bonds* (*Table 4b, (4)*)**
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance Variables: fitted values of equities chi2(1) = 2.48 Prob > chi2 = 0.1155	Breusch-Pagan / Cook-Weisberg test for heteroskedasticity Ho: Constant variance Variables: fitted values of sum_bonds chi2(1) = 0.04 Prob > chi2 = 0.8514

Do not reject H_0 for both equity and bond holdings models – heteroscedasticity is not present in either models.

Ramsey RESET Model Misspecification Test

Dependent Variable: *equities* (*Table 4a, (4)*)	**Dependent Variable: *sum_bonds* (*Table 4b, (4)*)**
Ramsey RESET test using powers of the fitted values of equities Ho: model has no omitted variables F(3, 67) = 0.81 Prob > F = 0.4931	Ramsey RESET test using powers of the fitted values of sum_bonds Ho: model has no omitted variables F(3, 65) = 1.28 Prob > F = 0.2902

Do not reject H_0 for both equity and bond holdings models – both models are of the correct functional form.

10. Bibliography

Alestalo, N., and Puttonen, V. (2006). "Asset Allocation in Finnish Pension Funds". *Journal of Pension Economics and Finance,* Vol. 5 (1): pp. 27-44.

Annaert, J. et al. (2004). "The Value of Asset Allocation Advice: Evidence from The Economist's quarterly portfolio poll". *Journal of Banking & Finance* 29 (2005). pp. 661–680.

Bagehot, W. (1972). "Risk and Reward in Corporate Pension Funds". *Financial Analysts Journal,* Vol. (January-February): pp. 80-84.

Bagliano, F.C., Fugazza, C., and Nicodano, G. (2009). "Pension Funds, Life-Cycle Asset Allocation and Performance Evaluation". Part of project titled: *Optimal Asset Allocation For Defined Contribution Mandatory Pension Funds*, OECD. Turin, Italy.

Barrie, A. (2010). "Solvency II for DB pension funds: Reasons to be fearful?". *Barrie & Hibbert Insights,* July. Available at: http://www.barrhibb.com/documents/downloads/Solvency_II_for_DB_pension_funds.pdf

Black, F. (1980). "The tax consequences of long run pension policy". *Financial Analysts Journal*, 36: pp. 21-28.

Blake, D. (2001). "UK Pension Fund Management: How is Asset Allocation Influenced by the Valuation of Liabilities?". *Pension Institute Discussion Paper*, PI-0104. February.

Blake, D., Lehmann, B.N., and Timmermann, A. (1999). "Asset allocation dynamics and pension fund performance". *Journal of Business*, Vol. 72 (4), pp 429-461.

Bodie, Z., Light, J. O., and Morck, R. (1984). "Funding and Asset Allocation in Corporate Pension Plans: an Empirical Investigation", in Bodie, Z., J. Shoven and D. A. Wise (Eds), *Issues in Pension Economics*, University of Chicago Press, pp. 15-47.

Booth, P., Chadburn, R., Haberman, S., James, D., Khorasanee, Z., Plumb, R. H., Rickayzen, B. (2004). "Modern Actuarial Theory and Practice, Second Edition". London: A CRC Press Company.

Campbell, J.Y., and Viceira, L.M. (2002). "Strategic asset allocation. Portfolio choice for long-term investors". Oxford University Press.

Chernoff, J. (2003a). "Asset liability management back with a twist". *Pensions and Investments*, July 21, 2003.

Cocco, J.F., and Volpin, P.F. (2006). "The Corporate Governance of Defined Benefit Pension Plans: Evidence from the United Kingdom". London Business School & CEPR.

Economist (2002). "Booting Out Equities. Was Boots Right to Switch its Entire Pension Fund to Bonds?". *The Economist*, 16th February, A Survey of Pensions, pp. 16.

Edmonds, T. (2012). "Reforming Financial Markets VI: Solvency II". House of Commons Library: Standard Note 06339, Business and Transport Section. Available at: http://www.parliament.uk/briefing-papers/SN06339

Exley, C. J. (2001). "Pension funds and the UK economy". Paper presented to the Institute and Faculty of Actuaries Finance and Investment Conference, Institute and Faculty of Actuaries, London, UK.

Fabozzi, F. J., and Ryan, R. J. (2002). "Rethinking Pension Liabilities and Asset Allocation". *The Journal of Portfolio Management*, Summer 2002.

Friedman, B. M. (1983). "Pension Funding, Pension Assets Allocation and Corporate Finance: Evidence from Individual Company Data". Financial Assets of the United States Pension System (Bodie, Shoven, Eds.), University of Chicago Press, pp. 107-152.

Gerber, D. S., and Weber, R. (2007). "Aging, Asset Allocation, and Costs: Evidence for the Pension Fund Industry in Switzerland". *International Monetary Fund Working Paper* WP/07/29.

He, P. (2008). "Pension Fund Investment Strategy: A Quantitative Study for the Asset Allocation in UK Defined Benefit Pension Schemes". Nottingham, UK.

Kahneman, D., and Tversky, A. (1979). "Prospect Theory: An Analysis of Decision Under Risk". *Econometrica*, Vol. 47 (2): pp.263-292.

Kritzman, M. P. (2000). "Puzzles of Finance: Six Practical Problems and Their Remarkable Solution". John Wiley, New York, Chapter 3: Time Diversification, pp. 47-64.

Lane Clark & Peacock (2012). "Accounting for Pensions: UK and International". London: Lane Clark & Peacock LLP.

Markowitz, H. M. (1952). "Portfolio Selection". *Journal of Finance*, Vol. 7 (1): pp.77-91.

McCarthy, D., and Miles, D. (2011). "Optimal Portfolio Allocation for Corporate Pension Funds". Centre for Economic Policy Research Discussion Paper No. 8198.

Modigliani, F., and Miller, M. H. (1958). "The Cost of Capital, Corporation Finance and the Theory of the Firm". *American Economic Review*, 48: pp. 261-297.

O' Brien, C., Billings, M., Woods, M. (2010). "Pension risk disclosures by FTSE 100 companies". *The Institute of Chartered Accountants of Scotland*.

Pension Protection Fund and the Pension Regulator (2011). "The Purple Book: DB Pensions Universe Risk Profile". Available at: http://www.pensionprotectionfund.org.uk/DocumentLibrary/Documents/Purple%20Book_2011.pdf

Peskin, M., (1997). "Asset allocation and funding policy for corporate-sponsored defined-benefit plans". *Journal of Portfolio Management*, Winter 1997, pp.66-73.

Pozen, R., and Hamacher, T. (2012). "A Realistic Discount Rate for Pensions". *The Financial Times*, 19th August 2012.

Ryan, R., and Fabozzi, F. (2002). "Rethinking pension liabilities and asset allocation". *Journal of Portfolio Management*, Summer 2002, vol.28, pp.7-15.

Sharpe, W. F. (1976). "Corporate Pension Funding Policy", *Journal of Financial Economics*, Vol. 3, pp. 183-193.

Society of Actuaries (2003). "Professional Actuarial Specialty Guide: Asset-Liability Management". Illinois, USA.

Sullivan, M. (2009). "Credit Ratings and UK Defined Benefit Pension Fund Portfolio Values", June. University of West England: Department of Economics.

Visco, I. et al. (2005). "Ageing and pension system reform: implications for financial markets and economic policies", September. *G-10 Report*. Available at: http://www.imf.org/external/np/g10/2005/pdf/092005.pdf