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Pension Liabilities, Credit Spreads and Corporate Bond Returns: An Empirical Investigation

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Synopsis

This paper looks at the relationship between credit spread, corporate bond returns and pension liabilities using empirical techniques focusing purely on UK firms. I closely follow Cardinale (2007) in the first part of the investigation and find that for UK bonds there is no (or at best a very weak) relationship between credit spreads and pension deficits, whilst pension surpluses seem to be completely ignored by the market. There is a slightly stronger relationship between funded pension liabilities and credit spreads. I do, however, find that credit spreads are strongly positively correlated with other forms of long term leverage.

The second part of the investigation follows on from the first, testing to see whether one can achieve above average returns on a corporate bond portfolio by picking bonds of firms with relatively large, well funded pension plans. There is some evidence that this is the case, although further work will help to strengthen these conclusions as I am only able to investigate a fairly small sample of bonds over a short holding period.

The results of the paper suggest that information on pension liabilities, particularly pension deficits, is not priced into the value of corporate bonds as standard theory implies it should be. It also suggests that one can use this information to pick corporate bonds which achieve above average returns; further studies will hopefully show how persistent this effect is and whether analysts and investors are becoming better at pricing in pension information, particularly as pension accounting is still a relatively new concept in the UK.

Executive Summary

Objectives

The investigation has two primary aims:

- To discover whether pension liabilities affect credit spreads, looking at the effect of unfunded pension liabilities (pension deficits) separately to funded pension liabilities (i.e the size of plans in terms of total assets).
- To investigate whether one can make use of the market's possible misinterpretation of pension information, by using it to pick corporate bond portfolios that lead to above average returns.

Background

Credit spreads and pension liabilities

- There is a wide oeuvre of literature on the theory of corporate bond spreads, almost unanimous in their view that more leverage increases the probability of default, and thus credit spreads.
- There is empirical evidence that suggests that theoretical models of credit spreads sometimes perform poorly, and that spreads can be driven by local supply and demand issues.
- Cardinale (2007) finds that credit spreads in the US are positively correlated with pension deficits.
- Cardinale (2007) finds in the UK that credit spreads respond to funded pension liabilities more than pension deficits.

Corporate Bond returns and pension liabilities

- Franzoni & Marin (2006) find that one can make above average returns by picking stocks in the US where firms have well funded pension plans.
- They also find that this effect is persistent and lasts for around five years.

The UK environment

- UK companies have only recently had to acknowledge a fair value of pension liabilities on their balance sheets.
- Recent changes in legislation have made pension deficits more of an issue, giving Trustees more power to get funding for schemes.

Key findings

Credit spreads and pension liabilities

- I find little evidence that credit spreads are linked to pension leverage in the UK, at most there is a weak effect where pension deficits increase credit spreads.
- Pension surpluses do not seem to be priced into credit spreads at all.
- There is some evidence that credit spreads increase with the size of a pension plan, this seems to affect companies with pension surpluses more than those with pension deficits.

Corporate bond returns and pension liabilities

- There is some evidence that one can achieve above average returns by choosing corporate bonds whose firms have well funded, larger pension plans:
  - The effect is strong for 2 year holding periods from both 31 December 2005 and 31 March 2006.
  - There is a similar, but not statistically significant effect over the three years from 31 December 2002.
  - There is not a statistically significant effect over one year holding periods.
- The findings are tempered because there is a lack of data and the holding periods are necessarily short as accounting data is only available from the end of 2002.

Conclusions

- There is evidence that the firms' pension information, included in their published accounts, is not correcly priced by the market in the credit spreads of their corporate bonds at the outset.
- This is particularly relevant for pension deficits.
- The UK market appears different to the US market in this respect, a possible reason for this is that pension accounting is a newer concept in the UK compared to the US.
- Further work is needed to strengthen the conclusions, especially in respect of the work on corporate bond returns; as the data is limited and the holding periods are quite short.

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Chapter 1

Introduction

1.1 Terms of Reference and Objectives

The seed of my investigation is the work of Cardinale (2007), who published the first major study looking at credit spreads and pension liabilities. He focused on the US market, although he also considered the UK market and Japan. He finds that credit spreads in the US respond to pension leverage in a similar way to other forms of long term leverage, however the effect is stronger and on average pension leverage is about twice as expensive. There is also evidence of potential non-linearities in the relationship. On the other hand Cardinale finds that in the UK, unfunded pension leverage does not seem to affect credit spreads; whilst funded pension leverage (i.e. the level of pension assets) does increase credit spreads. In Japan he is unable to find any compelling relationship between pension liabilities and credit spreads.

My primary aim is therefore to follow Cardinale's investigation, focusing purely on the UK market. In particular I look at more recent data and concentrate on investment grade bonds. My goal is to try and replicate Cardinale's results and to try and find any more evidence as to how credit spreads respond to both funded and unfunded pension leverage, also to enhance the econometric techniques by looking at alternative specifications and additional variables.

I am also motivated by the work of Franzoni & Marin (2006) who find that equity prices systematically underestimate the effect of pension deficits, in particular that one can achieve above average returns by going long in a portfolio with stocks of firms with well funded pension plans, and short in firms with poorly funded plans.

On the assumption that the corporate bond market misprices pension information, my secondary aim is therefore to investigate whether one can generate portfolios of corporate bonds which can achieve above average returns on the basis of pensions information. I hope to discover how strong, if at all, this effect is and also whether it is persistent across time periods.

Chapter 2

Background and review of the literature

2.1 Corporate Bonds, Credit Spreads and Capital Structure

Much has been written on the topic of corporate bonds, particularly in relation to their pricing and risk. The most widely respected starting point is that presented by Merton (1974) in a paper in which, following on from the work of Black and Scholes (1973), he relates the pricing of corporate bonds to three major factors: the risk free interest rate, the features of the bond and the likelihood of default. He develops closed form equations for the yield to maturity and thus credit spread of a given bond, and demonstrates in his theoretical framework that *ceteris paribus*, more firm leverage increases the probability of default and hence the credit spread ought to be higher.

Merton is certainly not alone in having developed structural models for credit spreads. Eom et al (2004) in their empirical paper consider five such models. As Cardinale (2007) notes, most models suggest to varying degrees a similar relationship between credit spread and leverage as postulated by Merton. Interestingly, Eom et al conclude that not only are the predicted spreads a poor guide when tested empirically but the deviances themselves do not give additional information. The models tend to understate the spreads on safer bonds and overstate the spreads on more risky bonds.

In light of this evidence, one is tempted to side with Dufresne et al (2001) who suggest that aggregate effects are a greater determinant of credit spreads and "are principally driven by local supply/demand shocks that are independent of both credit-risk factors and standard proxies for liquidity." A pertinent example is the recent 'credit crunch' and subsequent decline in the world economy. The spread on UK AA-rated corporate bonds has increased from around 0.6% to around 2.5% at the time of writing[1].

It is difficult to say with any certainty whether pre or post credit crunch levels of credit spread are more 'normal' and further studies will no doubt shed more light on this. In my view, it is unlikely that this increase has been purely driven by an increased likelihood of default, rather there has been, in the words of the August 2007 Economist Intelligence Unit report "a fundamental

[1] Source: Thomson Datastream

re-pricing of risky assets".

In view of this, one begins to see the difficulties faced by ratings agencies. Standard and Poor's (S&P) Corporate Ratings Criteria (2006) contains a prominent caveat: "Bear in mind, however, that a rating is, in the end, an opinion. The rating assignment is as much an art as it is a science." One positive outcome from the crisis may well be a more thorough understanding about how to price risky assets, particularly in respect of liquidity risk.

Having said all of this, there is still an empirical link between leverage and credit spread which is also theoretically intuitive. S&P explicitly state that leverage is a significant factor in determining credit ratings. The above analysis is instructive for interpreting the results and provides a useful starting point for determining which variables to include in the regression model.

As Cardinale (2007) notes, one problem here is that certain explanatory variables cannot be directly observed, in particular the volatility of a firm's assets. I follow him in using the observable variables that are a closest match and which I think are sufficient for my purposes.

One also needs to be aware of firm or industry specific effects. Cabral (2000) explains that utility companies have a high level of fixed assets and quasi-monopoly power, especially in the water industry. It is likely that this affects how their corporate debt is priced by the market. Diamond (2001) notes that banks (and by extension, insurance companies) often have extremely complex capital structures and investors may be tempted to question whether large institutions in such sectors will be left to go bankrupt, or are deemed 'too big to fail', (cf. 'Fannie Mae' and 'Freddie Mac' in the US, or Northern Rock in the UK). Extensions in my empirical analysis below aim to allow for these effects.

Berk & de Marzo (2007), explain, using previous work by Modigliani and Miller that under specified conditions, firm value is independent of capital structure. In practice, the authors note that clearly market imperfections, transaction costs and informational asymmetries amongst other things mean this result does not hold. Myers (1984) develops a 'pecking order theory' of capital structure, in which firms prefer internal financing, and issuing corporate debt is preferred to equity finance. Although pension deficits rank as unsecure credit, they occupy an unusual place in this analysis because as Sharpe (1976) explains, they are equivalent to a firm borrowing from its employees, as one can see pensions as a form of deferred wages. Studies such as Ippolito (1985) have shown firms will often run the plan in deficit, partly because they avoid the costs associated with satisfying external investors, and they take advantage of the irrationality of their employees in not demanding a reward for the risk being run in the plan.

In view of this, it is tempting to question whether the market will worry to same degree about pension leverage alongside more standard forms of leverage. Legislators have however responded to the plight of those employees left without a pension and recent changes in this area, explained more fully below, mean that in my view the risks being run in private sector pension plans should affect the pricing of corporate debt more than ever before.

2.2 Pension Liabilities: Background and Recent Developments

Avrahampour (2007) notes that the UK has a long and established history of defined benefit pension provision. Thomson Reuters (2008) explains: "Pension contribution holidays were a common feature among UK companies up until the late 1990s, as many heavily equity-invested

funds showed healthy surpluses." This masked the effect of legislation over time, as Avrahampour (2007) goes on to set out, which had served to increase the liabilities, in particular benefits that had often in the past been discretionary, such as revaluation in deferment or pension increases became statutory provision.

As Cardinale (2007) notes, the main question here is whether "pension liabilities arising from defined benefit pension plans should be included in an aggregate measure of firm wide obligations". A useful starting point is the "extended balance sheet" approach of Bodie et al (1985) in which he argues that "companies manage their pension funds as if they are an integral part of total corporate financial policy", implying that any deficit is a burden on the firm's shareholders. Sharpe (1976) argues in contrast that the volatility of pension assets and pension deficits create a 'pension put' and rational workers will demand higher wages to compensate. Since then, however, in both the UK and the US legislation has aimed to make it increasingly harder for firms to run such deficits and there is certainly no easy way for them to simply ditch the plans if they prove to be a financial burden. In the UK the Pensions Act of 1995 introduced the "Section 75" debt rule[2] whereby a debt equal to the pension deficit arose on any employer in the event of their insolvency or the winding up of the plan.

The accounting regulations have formalised the "extended balance sheet" approach. UK Companies reporting under either International Accounting Standards or Financial Reporting Statements rules have for around the last 5 years been forced to disclose the level of their pension liabilities valued on a discount rate linked to corporate bond yields. Previous standards, such as SSAP 24, had nowhere near such onerous requirements - as Avrahampour (2007) states "Lane, Clark & Peacocks (LCP) 1994 survey of pension reporting by FTSE 100 companies notes: 'It is barely possible for an informed pensions specialist to interpret the information currently provided [in SSAP 24] with any confidence. The investment analyst or shareholder stands little chance.' ". For many companies this move caused considerable balance sheet volatility as the CEO of Paternoster, Mark Wood (2006) notes.

Unlike Bulow (1985) I follow Cardinale (2007) and argue that the Projected Benefit Obligation (PBO), which measures the liability assuming the company is a going concern, is the relevant measure here, rather than the Accumulated Benefit Obligation (ABO). In practice, statutory deferred revaluations in the UK combined with the falling proportion of active liabilities within schemes mean that this makes a smaller difference than it appears to at first glance. Unlike the US, the UK does not have a history of 'cliff vesting' where benefits are not crystallised until a certain service period has been reached, another reason the PBO seems more appropriate. Cardinale (2007) notes that even this is a simplification, for example the PBO ignores tax effects and the question of who owns any surplus. It is the easiest measure to observe however and is used for my analysis.

Scottish Life explain that "The PPF was set up to ensure that members of final-salary and hybrid schemes (which are part money-purchase part final-salary schemes) get most of their pension entitlement if their employer becomes insolvent and the pension scheme is underfunded". The PPF exact levies on all companies with defined benefit plans, taking into account the level of underfunding and the credit worthiness of the firm[3]. This can represent a significant burden especially for struggling companies running large pension deficits and provides further evidence as to why such deficits should negatively impact credit spreads.

[2]Source: Explanatory Memorandum to the Occupational Pension Schemes (Employer Debt) Regulations 2005

[3]Source: http://www.ppf.gov.uk/index/pension_protection_levy-2.htm

Allied to this, the Pensions Regulator was set up and, as they explain on their website, were given the task of minimising calls on the PPF. In practice this means improving the funding levels of schemes. Unlike the US, which operates under a different system, trustees of pension schemes in the UK have been given lots of power and the Regulator's Code of Practice states "Trustees should aim for any shortfall to be eliminated as quickly as the employer can reasonably afford", although they go on to explain "what is possible and reasonable, however, will depend on the trustees assessment of the employers covenant". As part of this the Regulator[4] has triggers under the Scheme Specific Funding regulations to ensure that the basis being used to measure the liabilities, known as technical provisions, is not too weak. For many schemes this has led to bases using interest rates closer to gilt yields on governments or corporate bond yields and more prudent mortality assumptions. Often this results in the employer being forced to pump money into the pension scheme that would otherwise have been used to pay dividends or invested in new working capital, surely a concern to bondholders. Of more pressing concern is that Trustees are growing increasingly likely to seek contingent assets, from my experience as a pensions consultant I know of one large client who have sold some of their real estate to their pension scheme and are leasing it back, other schemes have obtained 'letters of guarantee', all of which combines to weaken bondholders' security.

The Regulator has also obtained powers in the areas of Merger & Acquisition activity and other 'notifiable events'. In guidance[5], they state that the explicit aim of this is to improve the status of the pension scheme as a creditor, which must surely be at the expense of other stakeholders, including bondholders.

As if all this were not enough, the last ten years has not, in general, been a good decade for the funded status of UK pension schemes. Doyle (1997) explains that the Government chose to remove the dividend tax credit for pension schemes, costing them billions of pounds in aggregate. Additionally the equity market, which has a large allocation of pension assets, performed poorly from 1999 to 2003[6], although has since staged a recovery. This was followed by a sharp fall in real interest rates[7], increasing the value of liabilities, particularly in conjunction with more prudent longevity assumptions as studies show that the rate of mortality is steadily declining, particularly at older ages, as the CMI have shown[8]. In a low inflation environment, schemes have not benefited from the upside protection they have against inflation.

This analysis leads me to hypothesise that bond markets should carefully consider and incorporate companies' pension information; in particular deficits should have a negative impact. Although the first half of my analysis closely follows that of Cardinale (2007) I have added several new features and focus on the UK using more recent data.

2.3 Pension Information and Market Prices

There is some ambiguity as to how pension information is incorporated by analysts and investors. Franzoni and Marin (2006) find that investors in the US systematically underestimate the effect of poorly funded defined benefit plans and their effects on future profitability and cash

[4]Source: http://www.thepensionsregulator.gov.uk/
[5]Source: http://www.thepensionsregulator.gov.uk/pdf/clearanceGuidance2008.pdf
[6]Source: Bloomberg
[7]Source: Thomson Datastream
[8]Source: http://www.actuaries.org.uk/knowledge/cmi

flow. They find that one can make above average returns by picking a portfolio that is long in stocks with well funded plans, and short stocks with poorly funded plans. Not only is this effect significant, the authorts find it persists for around five years. A possible interpretation of this is that analysts are good at assessing the impact of potential short term problems, such as being unable to cover interest payments, but find it difficult to price in potential longer term problems - as the authors explain particularly pension information, and thus either ignore these or pay insufficient attention.

No study to my knowledge has considered the possibility of achieving above average returns on corporate bonds using pension data. My working hypothesis is that pension information will not be completely assimilated by the market, and I am therefore motivated to investigate the strength of this effect.

Chapter 3

Credit Spreads and Pension Liabilities: An Empirical Investigation

3.1 Motivation

To investigate whether pension liabilities are determinants of credit spreads, as the theory suggests they should be.

3.2 Data

For corporate bond data, I made use of iboxx (http://www.iboxx.com) which compiles a wide range of fixed income indices and benchmarks. I restricted my analysis to UK corporate bonds denominated in sterling. I also decided only to look at investment grade bonds, with Standard & Poor's rating BBB or above, to avoid the probability of default becoming too big an issue. The index constructed by iboxx is widely used in the actuarial industry as an indication of the overall yield on investment grade corporate bonds. As a reasonableness check I also looked at Bloomberg data and am confident that the corporate bond data I collected is comprehensive enough to derive meaningful aggregate results. The data included the duration, yield and spread of the bond yield over gilt yields as calculated by iboxx.

Accounting data was downloaded from Thomson Datastream for all FTSE 250 companies going back for 4 years. In particular this included the market value of long term and short term debt as well as the book value of the firm. This represented the balance sheet position of each company at their respective year end date. Pension data (see below) and corporate bond information was also measured at this date so all the data was taken at a consistent point in time for each firm. Thomson Datastream also provides information on the industry sector for each firm, used in the extensions below.

Pension data comprising the market value of the assets and accounting value of the liabilities, the projected benefit obligation, as measured using a corporate bond discount rate consistent with accounting principles was obtained from Hewitt Associates internal database for UK companies. I supplemented this with the database compiled by Punter Southall. There are some irregularities in the data - for example at each quarter end not every firm uses exactly

the same discount rate or mortality assumptions but I expect these differences to be immaterial in the context of the overall results. I have done some analysis on discount rates used and they fall within a very narrow range - as prescribed by accounting standards. There are some small differences in the measures of pension liabilities, particularly in relation to unapproved schemes but these are typically very small in relation to the main scheme and are immaterial in the context of the overall measures.

Finally, I also used Thomson Datastream to download equity prices for all of the FTSE 250 companies for the purpose of calculating equity volatilities.

The data collected runs from 31 December 2005 to 31 March 2008 - the vast majority of UK companies report on either 31 March or 31 December each year, there is a significant minority who report at either 30 September or 30 June and all others can easily be put with one of the earlier groups without losing any material authenticity.

A summary of the data is shown in Tables 3.1 & 3.2.

Date	Number	Average spread (bps)	Average Duration (years)	Average stlev	Average ltlev	Average passlev	Average pdeflev	Average vol
31/12/2005	160	85.7	6.8	27.0%	36.8%	11.5%	2.5%	10.4%
31/03/2006	58	87.0	7.8	8.0%	28.3%	28.5%	3.1%	8.6%
31/12/2006	187	94.1	6.9	29.6%	32.7%	11.9%	1.2%	8.3%
31/03/2007	56	84.4	7.5	8.8%	32.2%	29.6%	1.1%	8.5%
31/12/2007	183	218.8	6.7	27.6%	33.2%	11.5%	0.0%	10.8%
31/03/2008	48	228.5	7.3	9.4%	33.3%	29.9%	-0.7%	10.1%
Total	**692**	**133.1**	**7.0**	**23.6%**	**33.4%**	**15.8%**	**1.2%**	**9.6%**

Table 3.1: Summary of the data

Notes:
1. Bonds of firms reporting nearest the quarter ends 30 June or 30 September have been included in the 31 March or 31 December figures respectively, as there are very few of these.
2. Definitions of *stlev*, *stlev*, *ltlev*, *passlev*, *pdeflev* & *vol* can be found in the **Methodology** section below.

Date	Number	StdDev of Spread	StdDev of Duration	StdDev of stlev	StdDev of ltlev	StdDev of passlev	StdDev of pdeflev	StdDev of vol
31/12/2005	160	38.3	3.8	26.6%	22.7%	13.5%	3.6%	1.9%
31/03/2006	58	34.0	4.1	9.3%	12.7%	19.5%	3.3%	1.5%
31/12/2006	187	40.7	3.7	25.8%	19.5%	14.8%	2.4%	1.5%
31/03/2007	56	28.3	4.0	11.6%	15.7%	20.2%	2.3%	2.1%
31/12/2007	183	143.9	3.4	26.8%	21.6%	14.5%	1.7%	3.7%
31/03/2008	48	93.8	3.9	10.6%	14.4%	20.9%	2.9%	2.4%
Total	**692**	**104.3**	**3.7**	**25.0%**	**19.9%**	**17.5%**	**2.9%**	**2.7%**

Table 3.2: Summary of the data continued

Notes:
1. Bonds of firms reporting nearest the quarter ends 30 June or 30 September have been included in the 31 March or 31 December figures respectively, as there are very few of these.
2. Definitions of *stlev*, *stlev*, *ltlev*, *passlev*, *pdeflev* & *vol* can be found in the **Methodology** section below.

3.3 Methodology

As stated above, the primary objective, following Cardinale (2007) is to investigate whether there is an empirical link between credit spreads and pension leverage. The data collected is arranged in the form of panel data. It is unbalanced because over the 3 years a few bonds mature, some get issued and the pension data is not complete with differing amounts of data available at different times.

As per Cardinale (2007) I need to isolate the effect of pensions leverage, so I split out leverage into short term, long term, funded pensions liability (i.e. the value of the pension asset) and unfunded pensions liability (i.e. the deficit on an accounting basis, which of course may be negative if the fund is in surplus). Although Cardinale focuses on US bonds, I am able to use a consistent approach, namely a linear regression. The following specification is used:

$$\begin{aligned} spread_{it} = \alpha &+ \beta_1 stlev_{it} + \beta_2 ltlev_{it} + \beta_3 passlev_{it} + \beta_4 pdeflev_{it} + \beta_5 vol_{it} \\ &+ \beta_6 dur2_{it} + \beta_7 dur3_{it} + \beta_8 dur4_{it} \\ &+ \beta_9 wave0_{it} + \beta_{10} wave1_{it} + \beta_{11} wave2_{it} + \beta_{12} wave3_{it} + \beta_{13} wave4_{it} \\ &+ u_i + \epsilon_{it} \end{aligned} \tag{3.1}$$

Leverage is used as an explanatory variable due to its presence in all major theoretical structural models of credit spreads. Another ideal explanatory variable would be the volatility of the firm's assets, as this is not directly observable the volatility of a firm's equity price is used in its place. Table 3.3 gives the meaning of each of these variables and the predicted signs for the variables of interest.

Variable	**Description**	**Predicted Sign**
stlev	Short Term Borrowings / (Net Asset Value + Total Borrowings)	positive
ltlev	Long Term Borrowings / (Net Asset Value + Total Borrowings)	positive
passlev	Funded Pension Obligations / (Net Asset Value + Total Borrowings)	positive
pdeflev	Unfunded Pension Obligations / (Net Asset Value + Total Borrowings)	positive
vol	Annualised three year equity price volatility (or a shorter period if three years unavailable)	positive
dur	Dummy variable for duration	N/A
wave	Dummy variable for reporting quarter	N/A

Table 3.3: Desciption of explanatory variables

Notes:
1. Net Asset Value is defined as Total Assets *less* Total Liabilities, equivalent to Shareholder Equity
2. Total Borrowings is defined as Short Term Borrowings *plus* Long Term Borrowings *plus* Pension Liabilities
3. Definitions of Short Term Borrowings, Long Term Borrowings, Total Assets and Total Liabilities are as per Thomson Datastream
4. The dummy duration and wave variables are explained in detail in the Appendix, Table 6.1. Note that one variable of each type is not included in the regression equation for reasons of multicollinearity, as per Cardinale (2007)

As opposed to Cardinale, I use the pension leverage in its value form rather than using it as a dummy variable to subdivide the firms, I do not, however, expect this to make a big difference

in practice. In the last part of this section, I consider the effect of removing bonds where the firm has a pension plan in surplus.

Theory as set out in Greene (2003) indicates that simply using Ordinary Least Squares estimation will not provide a consistent estimator because of the 'individual' effects, in particular we must allow for the differences over time in individual bonds and firms. One way of doing this is to use generalized least squares (GLS) estimation, combined with either the fixed effects of random effects correction techniques. I have chosen to use random effects, as per Cardinale (2007) who explains that the bonds in the regression are a subset rather than the total universe of all bonds.

3.4 Results

Table 3.4 shows the results of running the regression specified in 3.1 using GLS and random effects.

Variable	Coefficient	Std. Error
stlev	32.81***	12.83
ltlev	80.40***	15.18
passlev	30.50*	19.38
pdeflev	-55.42	101.90
vol	2017.63***	104.69
dur2	25.20***	7.01
dur3	37.79***	7.12
dur4	35.54***	7.11
wave0	151.33***	12.09
wave1	127.03***	7.62
wave2	40.23***	11.18
wave3	51.63***	7.53
wave4	45.42***	10.77
intercept	-189.07***	16.42

Table 3.4: Initial regression results

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.45$, within $R^2 = 0.68$, overall $R^2 = 0.58$

There are a few key points to notice:

- As predicted by all the literature on the structural makeup of credit spreads, the explanatory variables of long term leverage and equity volatility (a proxy for asset volatility) are highly significant.
- Unfunded pension leverage appears to have no effect on the credit spread. In fact, it even enters the equation with a negative sign - opposite to what was predicted, but in any case the effect is not significant.

- Surprisingly in light of the above the level of funded pension leverage does appear to increase credit spreads. The effect is significant at the 5% level and although not large, is material - companies with the largest pension funds could see their spreads increase by around 10%. This possibly reflects the view that pension liabilities are somewhat of an unknown and the market value is not trivial to calculate - Cardinale (2007) reaches a similar conclusion.
- As expected, the dummy variables for time and duration have some effect and help to improve the regression. The overall R^2 is quite high, although I am mindful of the existing literature, commented on in the introduction, which emphasises the difficulty of modelling credit spreads.

3.5 Results - Extensions

One effect considered here is that banks, insurers and utility companies have very complex capital structures, therefore we cannot expect that the spreads on their bonds react in the same way to those of other companies. To allow for this effect I introduce three more dummy variables for companies in each sector. The new regression specification is as follows:

$$\begin{aligned} spread_{it} =& \alpha + \beta_1 stlev_{it} + \beta_2 ltlev_{it} + \beta_3 passlev_{it} + \beta_4 pdeflev_{it} + \beta_5 vol_{it} \\ &+ \beta_6 dur2_{it} + \beta_7 dur3_{it} + \beta_8 dur4_{it} \\ &+ \beta_9 wave0_{it} + \beta_{10} wave1_{it} + \beta_{11} wave2_{it} + \beta_{12} wave3_{it} + \beta_{13} wave4_{it} \\ &+ \beta_{14} bankind + \beta_{15} utilind + \beta_{16} insind + u_i + \epsilon_{it} \end{aligned} \tag{3.2}$$

Note: *bankind*, *utilind* and *insind* are indicator variables taking the value 1 if the bond is issued by a bank, a utility company or an insurance company respectively

The results are reported in Table 3.5 below (only the variables of significance are included).

Variable	Coefficient	Std. Error
stlev	42.77***	13.87
ltlev	95.13***	15.85
passlev	37.45*	19.42
pdeflev	-69.50	101.60
vol	1964.89***	106.12
bankind	-11.61*	6.80
insind	4.89	11.14
utilind	-26.20***	9.75

Table 3.5: Regression results with indicator variables for industry

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.57$, within $R^2 = 0.70$, overall $R^2 = 0.62$

We can see that the effect of being an insurance company is insignificant, whilst both banks and utility companies have lower credit spreads on average (although the result is only marginally

significant for banks). Again I do not find that unfunded pension liabilities have any effect. Similar results are obtained when data excluding banks and utility companies is used in the regression (see Table 3.6 below).

Variable	Coefficient	Std. Error
stlev	66.61**	28.81
ltlev	110.16***	31.84
passlev	44.33	31.11
pdeflev	-132.90	153.38
vol	2225.63***	180.14

Table 3.6: Regression results with bonds of banks and insurance companies excluded

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.48$, within $R^2 = 0.66$, overall $R^2 = 0.55$

We must also consider the effect of endogeneity. In particular, I try and correct for the possible endogenous effects of equity volatility and pension deficit (Cardinale (2007) only considers volatility). If both of these variables, together with credit spread, are themselves the effect of an unrelated cause, the estimation will no longer be consistent or efficient. The most common method of allowing for this effect is the use of instrumental variables. In the following regression I therefore substitute for the above two variables with their lagged values. The coefficient of equity volatility is slightly reduced but is still highly significant. There is a big change in the unfunded pension leverage variable and in particular it now enters the equation with a positive sign, as predicted. The effect is still not significant, however as one can see in Table 3.7.

Variable	Coefficient	Std. Error
stlev	57.27**	22.42
ltlev	114.00***	25.96
passlev	42.62	33.22
pdeflev	253.91	257.15
vol	1454.27***	309.79

Table 3.7: Regression results with correction for potential endogeneity

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.48$, within $R^2 = 0.66$, overall $R^2 = 0.55$
3. *pdeflev* and *vol* have been instrumented by their one year lagged variables
4. Earlier bonds are excluded from this regression due to the need to use lagged variables

Finally, I consider the effect of splitting the data between bonds whose firms have surpluses at that time and those which have deficits, as there is evidence to suggest that pension surpluses are not priced in the same way as pension deficits. The results are reported in Tables 3.8 and 3.9.

These results come the closest to suggesting a link between pension deficits and spreads, although again the effect is not significant at the 5% level, and is still far less significant com-

Variable	Coefficient	Std. Error
stlev	-10.5567	9.143317
ltlev	42.69478***	9.787457
passlev	-4.09511	15.07999
pdeflev	132.556*	72.83478
vol	686.7779***	86.49896

Table 3.8: Regression results using only bonds of firms with pension deficits

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.69$, within $R^2 = 0.86$, overall $R^2 = 0.75$

Variable	Coefficient	Std. Error
stlev	157.6214***	58.30688
ltlev	113.8256*	65.90286
passlev	103.9847	82.98457
pdeflev	-773.578	622.5793
vol	2880.706***	276.4699

Table 3.9: Regression results using only bonds of firms with pension surpluses

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. Between $R^2 = 0.56$, within $R^2 = 0.83$, overall $R^2 = 0.54$

pared to standard long term leverage. Interestingly the effect of funded pension liabilities is now completely insignificant. The results for firms with surpluses show that pension surplus is insignificant, whilst funded pension liabilities are penalised, although again the effect is only marginally significant at best.

These results are consistent with those found by Cardinale for UK data, which is different to that found for US data, where pension deficits were shown to be a significant predictor of spreads.

Chapter 4

Corporate Bond Returns and Pension Liabilities: An Empirical Investigation

4.1 Motivation

The results in the previous section were somewhat surprising; in particular there does not seem to be an effect of unfunded pension liabilities on credit spreads, certainly compared to other forms of long term leverage. Additionally pension surpluses also do not seem to be valued at all by the market, and there is some evidence that funded pension liabilities are penalised. This leads us to question whether one can make an economic profit based on this information. As large amounts of schemes' assets are invested in equities, such surpluses provide a buffer against poor stock returns dragging down funding levels and resulting in cash contributions, often when businesses can least afford it. Finally I also wish to investigate whether the fact that funded pension liabilities seem to be more heavily penalised than unfunded pension liabilities has also resulted in mispricing.

I formulate this part of the investigation on the basis that there is a lag before analysts correctly price pension information; alternatives are possible, for example that pensions information is completely ignored and will only show up when looking at defaults.

4.2 Data

The data is essentially the same as that used in the first empirical investigation, however I make some changes.

Firstly, I restrict the analysis to only looking at one bond per firm. I do this to avoid skewing the investigation towards any particular sectors or companies - here the original data is somewhat uneven in this respect, as the data is heavily weighted towards larger companies and financial firms. I also want to specifically isolate differences in firms rather than just in bonds.

Secondly I pick the bonds with longest duration for each firm. This is because the longer dated bonds have durations that will typically be closer to the durations of their pension schemes, and the nature of pension liabilities is that they take a long time to unwind and are therefore more

likely to affect the longer dated corporate debt.

I also remove bonds which expire or are not present in the index throughout the period of the investigation. Again I make use of pension data and firm value, information on durations and coupon rate is included in the corporate bond data from iboxx.

4.3 Methodology

As discussed above we want an empirical test to provide evidence as to whether corporate bond prices do not reflect up to date pension information or misinterpret it. An easy way to do this is to pick two portfolios and examine their relative performance.

Portfolio 1 contains bonds whose firms have a high level of funded pension leverage but a low level of unfunded pension leverage, whilst portfolio 2 contains the rest of the bonds in the sample, and the two portfolios have an equal amount of bonds. I ranked the bonds on the basis of:

$$\phi = passlev - pdeflev$$

where $passlev$ and $pdeflev$ are as defined in the initial investigation. I form four pairs of portfolios:

- one at 31 December 2005, considering two one year holding periods, *Portfolio Pair 1*
- one at 31 March 2006, considering two one year holding periods, *Portfolio Pair 2*
- one at 31 December 2006, considering a single one year holding period, *Portfolio Pair 3*
- one at 31 March 2007, considering a single one year holding period, *Portfolio Pair 4*

A summary of the data is shown in Table 4.1.

	High ϕ		Low ϕ	
Portfolio	**Number of Bonds**	**Average Duration**	**Number of Bonds**	**Average Duration**
Portfolio Pair 1	16	8.0	16	11.1
Portfolio Pair 2	7	10.2	7	11.5
Portfolio Pair 3	20	7.2	20	9.4
Portfolio Pair 4	8	8.0	8	11.5

Table 4.1: Summary of data used in second empirical investigation

The calculation is straightforward; I simply derive the internal rate of return for each bond over the next year. The return allows for coupons, their amount and timing (although the timing effect is small). I assume coupons are reinvested, and use the average of the yield to maturity at the start and end of each year as a proxy for the interest rate with which to roll up the coupon

payments to the year end. The calculation of the raw return is set out in Equation 4.1:

$$return = \frac{price_1 + coupons}{price_0} - 1 \tag{4.1}$$

$$\tag{4.2}$$

where $price_0$ is the price at the outset, $price_1$ is the price at the end of the holding period and $coupons$ are the total coupon payments over the holding period rolled up with interest to the end of the period.

I must also allow for two further effects. Firstly the coupon rate of bonds can (and often does) affect their holding period return - for example bonds with a high coupon rate can suffer in times of high inflation and high interest rates. I do not expect this effect to be that big, and there is not a huge variety in coupon rates in the portfolios. Secondly the duration of the bond has an effect on the internal rate of return. I expect this to be a much bigger effect, and also do not expect this effect to be linear across durations, especially at the shorter end of the term structure.

To adjust the calculation for these factors, I perform a simple linear regression on the entire universe of iboxx sterling denominated corporate bonds across the relevant holding periods. I allow for the potential non-linearity of the duration effect by assigning dummy variables to bonds based on duration intervals, shown in Table 6.2 in the Appendix. As always, one of the dummy variables is omitted from the regression to avoid multicollinearity. The regression equation is as shown in Equation 4.3.

$$return_i = \alpha + \beta_1 dur1_i + \beta_2 dur2_i + \beta_3 dur3_i + \beta_4 dur4_i + \beta_5 coupon_i \tag{4.3}$$

This formulation assumes, of course, that one can perfectly hedge the duration and coupon risk; I suspect this is unlikely but is beyond the scope of this investigation!

Table 4.2 reports the result of the regression.

Variable	31 Dec 05 to 31 Dec 06		31 Mar 06 to 31 Mar 07		31 Dec 06 to 31 Dec 07		31 Mar 07 to 31 Mar 08	
	Coefficient	*Std. Error*	Coefficient	*Std. Error*	Coefficient	*Std. Error*	Coefficient	*Std. Error*
Intercept	-0.0121***	0.0026	-0.0126***	0.0024	-0.0401***	*0.0079*	-0.1041***	*0.0131*
dur1	0.0379***	*0.0028*	0.0396***	*0.0050*	0.0841***	*0.0094*	0.1546***	*0.0170*
dur2	0.0297***	*0.0015*	0.0333***	*0.0017*	0.0851***	*0.0053*	0.1452***	*0.0090*
dur3	0.0162***	*0.0016*	0.0198***	*0.0015*	0.0573***	*0.0049*	0.0852***	*0.0083*
dur4	0.0074***	*0.0016*	0.0078***	*0.0016*	0.0242***	*0.0052*	0.0167*	*0.0086*
coupon	0.0020***	*0.0004*	0.0021***	*0.0004*	0.0009	*0.0012*	0.0015	*0.0020*

Table 4.2: Correction coefficients for bond returns

Notes:
1. * indicates signifance at the 10% level, ** at the 5% level and *** at the 1% level
2. $R^2 = 0.48, 0.48, 0.35$ and 0.40 respectively

As expected, the coupon effect is relatively small (and is in some cases not statistically significant), whereas the duration effect is very significant. Each pair of portfolios does not differ too much in terms of duration or coupon rate, so I do not believe this has a material effect on the conclusions.

I have also considered how to weight the returns; the main choices being value-weighted or equal-weighted. I have chosen to use equal-weighted returns, as with a small sample using

value weights can distort the results without adding to the authenticity of the conclusions, and it is also difficult to decide on a fair weighting factor as there are other issues of liquidity and availability.

4.4 Results

The main results are reported in Table 4.3 below. I have included both the raw returns and the returns adjusted for the factors discussed above.

	High ϕ		Low ϕ	
Portfolio	**Average Raw Return**	**Average Adjusted Return**	**Average Raw Return**	**Average Adjusted Return**
Portfolio Pair 1	3.68%	-4.19%	-5.07%	-9.88%
Portfolio Pair 2	0.74%	-5.55%	-3.20%	-9.24%
Portfolio Pair 3	1.52%	-4.15%	-4.12%	-7.63%
Portfolio Pair 4	-0.17%	-6.03%	-4.25%	-8.04%

Table 4.3: Results of empirical investigation into corporate bond returns

At first glance, the high ϕ portfolios seem to have outperformed the low ϕ portfolios. To reach a more definitive conclusion, however, I must perform t-tests, the results of which are reported in Table 4.4. I only consider the adjusted returns.

Portfolio	**Test Statistic**	**Critical Value**
Portfolio Pair 1	2.259	1.729
Portfolio Pair 2	2.113	1.833
Portfolio Pair 3	1.530	1.692
Portfolio Pair 4	1.087	1.761

Table 4.4: Results of t-test for corporate bond portfolios

Notes:
1. I am testing the following:
H_0: The returns on the high ϕ and low ϕ portfolios are the same vs.
H_1: The returns on the high ϕ portfolios are greater than those on the low ϕ portfolios.
2. I use an unpaired t-test assuming unequal variances.
3. Critical values are at the 1-tailed 5% level

The key findings of these results are therefore:

- For the first two portfolios with the two year holding period, the portfolio of bonds of firms with well funded, large pension schemes outperform those of firms with poorly funded, smaller pension schemes
- For the second two portfolios with the one year holding period, there is some evidence of outperformance in the high ϕ portfolios, but this is not statistically significant at the 5% level (but it is at the 10% level)

- Adjusting for any duration or coupon effects make a significant difference to the actual returns calculated, but a much smaller difference to the relative returns between pairs of portfolios, strengthening the validity of the conclusions.

4.5 Results - Extensions

Clearly these results are influenced by the economic circumstances we are witnessing stemming from the 'credit crunch' which started in the summer of 2007. To help check the robustness of the conclusions, I first adjust Portfolio 1 to try and allow for this, then I perform a similar analysis on bonds over the period 31 December 2002 to 31 December 2005.

For the first extension I remove the four worst performing bonds from both portfolios in Portfolio Pair 1. This is to avoid the results being potentially skewed by a few very poorly performing bonds. The resulting t-test is shown in Table 4.5 and demonstrates that the original conclusions are robust to this analysis.

Portfolio	**Test Statistic**	**Critical Value**
Portfolio Pair 1	2.581	1.746

Table 4.5: Results of t-test for Portfolio Pair 1 with four worst performing bonds removed from each portfolio

Notes:
1. I am testing the following:
H_0: The return on the high ϕ and low ϕ portfolio is the same vs.
H_1: The return on the high ϕ portfolio is greater than that on the low ϕ portfolio.
2. I use an unpaired t-test assuming unequal variances.
3. The critical value is at the 1-tailed 5% level

For the second extension, the bonds used cover an entirely different period in which pension liabilities first started to be reported on the balance sheet - if there was ever a time when analysts and investors were making insufficient use of pension data, this would be the time. In addition, over this period pension liabilities became more of an issue for firms as long term interest rates declined, stock markets performed moderately at best and longevity assumptions tightened, significantly increasing the value of firms' pension liabilities. Table 4.6 reports the results.

	High ϕ		Low ϕ	
Holding Period	**Average Raw Return**	**Average Adjusted Return**	**Average Raw Return**	**Average Adjusted Return**
1 year	8.85%	1.14%	9.01%	1.30%
2 years	19.20%	2.55%	18.98%	1.90%
3 years	35.84%	6.47%	34.48%	4.01%

Table 4.6: Results of empirical investigation into corporate bond returns, sample from 31 December 2002 to 31 December 2005

At first glance these results seem to confirm the key findings of the initial calculations, namely that high ϕ bonds seems to outperform low ϕ bonds, especially over two and three year hold-

ing periods, however looking at the resulting t-tests shows that the results are not statistically significant, as showin Table 4.7.

Holding Period	**Test Statistic**	**Critical Value**
1 year	- 0.049	1.833
2 years	0.104	1.860
3 years	0.209	1.860

Table 4.7: Results of t-test for additional corporate bond portfolio

Notes:
1. We are testing the following:
H_0: The returns on the high ϕ and low ϕ portfolios are the same vs.
H_1: The returns on the high ϕ portfolios are greater than those on the low ϕ portfolios.
2. I use an unpaired t-test assuming unequal variances.
3. Critical values are at the 1-tailed 5% level

Looking more closely at the data I find that the apparent outperformance of the high ϕ portfolio is driven largely by one corporate bond returning more than 60% over the three years. There is therefore insufficient evidence to conclude that this portfolio outperforms the other, but it certainly does not suggest the opposite. The finding is essentially stymied by a lack of data, as there are only seven bonds in each portfolio. The returns are also far most unstable in terms of sensitivity to the coupon rate, the effect of this is shown in the Appendix, Table 6.3.

The overall finding is therefore that there is some evidence that we can use pension information to generate above average returns on corporate bonds, but further work is needed to enforce the strength of this conclusion. The results are consistent with those found by Franzoni & Marin (2006) for stock market returns in the US but apply to corporate bond returns in the UK.

Chapter 5

Extensions

This investigation has reached a number of interesting conclusions, which can be improved and extended by further research and study.

An obvious starting point is to look at other countries - Cardinale (2007) and Franzoni & Marin (2006) have already looked at plans in the US, whilst the reality is that very few countries fund (or even have) corporate defined benefit pension plans in a similar way to the UK. It would be interesting to see the effects on countries which reserve for pensions using their book value (e.g. Germany).

Rather than purely looking at spreads it would be interesting to look at actual defaults to see if these can be better predicted using pension data, the problem here is likely to be that defaults are both rare and highly correlated, making any empirical investigation trying to isolate the effect of pension liabilities very difficult. It is possible to increase the scope of the investigation, thus utilising more data, by also considering re-ratings.

A recent interesting development has been the explosion (certainly in the UK) of specialist insurers offering to 'buy out' (or 'buy in') part or all of companies defined benefit pension plans, essentially taking the risks of the balance sheet in return for a premium. Conducting such a transaction may reduce corporate bond spreads due to the decreased leverage of such firms; alternatively spreads may increase because the insurance is seen as too expensive and damaging to the companies' future profitability by reducing investment.

The effect of the third party insurer, the PPF, is also worth considering. Some plans may be so poorly funded, with such a weak employer, that they will inevitably fall into the PPF. An event study could discover whether the price of such firms increased as there is now little point in them putting more money in the scheme. Such a study could also cover the effect of the Pensions Regulator, and whether the regulatory changes caused a step shift in the price of corporate debt. The suspicion is that the change will have been gradual rather than sudden; hence it will be difficult once again to highlight the effect of pensions in differentiating from global macroeconomic factors of higher significance.

My study has focused exclusively on companies with defined benefit pension plans; it would also be interesting to investigate companies without any pension liabilities. In particular this would highlight whether the simple presence of a pension plan increases corporate bond spreads. Previous studies have demonstrated such a link, but there are increasing numbers of larger companies in such a position now, particularly in the UK; investigations of this nature

therefore become easier to carry out.

The second empirical investigation would benefit from a longer term study; it is limited at the moment as pension liabilities were only disclosed to the market from 2003 in the UK, so it is difficult to derive conclusive results. Studies in the future will have the benefit of considering longer term holding period returns.

Finally there is also the question of accounting practice. My study has assumed that the Projected Benefit Obligation measures quoted in accounts are consistent across all firms, in practice firms assumptions can differ in areas such as longevity improvements, withdrawal decrements and the use of an inflation risk premium. Now that the mortality assumption (or certainly life expectancy) has to be disclosed, it would be interesting to see if the market adjusts for these and whether this would affect the conclusions of my report.

Chapter 6

Conclusions

The aim of the investigation, as stated at the outset, was to discover an empirical link between credit spreads on corporate bonds and pension leverage for UK companies; then to investigate whether one could obtain above average returns by exploiting any mispricing by investors and analysts in view of pension information.

The results of the first investigation show that there is no significant link between credit spreads and pension deficits, there is very limited evidence that pension deficits increase spreads, whilst pension surpluses have little impact. There is also a suggested link between credit spreads and funded pension liabilities, although again the evidence is somewhat inconclusive. The results are reasonably robust to changes in the specification and econometric methodology and at no stage can a strong empirical effect of pension deficits on credit spreads be found. The results are consistent with theory that more routine forms of leverage, such as long term bank loans, do increase credit spreads.

These results are strikingly different to those found by Cardinale for US companies; they are however consistent with his results for UK companies. In my view a potential reason for this that pension liabilities were not disclosed in UK companies accounts until relatively recently, certainly compared to the US so it possible investors in UK corporate bonds cannot easily process pension information.

Another possibility is that the market does not believe that pensions are an expensive form of leverage, possibly because of the great improvement in funding levels since 2004 due to the improvement in real interest rates, higher stock market returns and deficit contributions may also have convinced the market that pension deficits are not something to be too worried about.

The results of the second investigation provide some evidence that one can make an economic profit by making use of pension information in corporate bond selection, and that the effect seems to be persistent over time. Using data from an earlier period does not conclusively back up this result. The potential return exploits the fact that funded pension liabilities do seem to affect credit spreads, whilst unfunded pension liabilities do not (in particular surpluses do not seem to have any effect), which appears to be inconsistent. I am unable to make the conclusions too definitive in this regard unfortunately; this is largely based on quite a small sample size over a very short period of time, relative to the total time to maturity of the bonds. This result is however consistent with that of the earlier investigation, and in particular supports

a view that pension information does affect firms' profitability and cash flow, whilst not being immediately incorporated into corporate bond prices.

Future studies over a longer time period will be very valuable in determining the strength of this conclusion. Additionally further studies will demonstrate whether UK markets become better at assimilating pension information, similar to the US markets. My view is that this is likely, particularly if the currently prevailing poor economic outlook continues; weakening the funding level of many corporate pension plans. Although most defined benefit pension plans in the UK are closed, the nominal value of the liabilities is still increasing with interest and there are still a large number of employees actively accruing benefits.

Overall the investigation demonstrates that the relationship between pension liabilities and the prices of corporate debt in the UK is a complex one; there are almost certainly inefficiencies which may disappear over time. Future work in this area will help further our understanding of credit spreads and how the market responds to current and new information.

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Appendix

Variable	Explanation
dur1	Duration less than or equal to 4 years
dur2	Duration greater than 4 years, less than or equal to 7 years
dur3	Duration greater than 7 years, less than or equal to 9.5 years
dur4	Duration greater than 9.5 years
wave0	Closest reporting quarter 31 March 2008
wave1	Closest reporting quarter 31 December 2007
wave2	Closest reporting quarter 31 March 2007
wave3	Closest reporting quarter 31 December 2006
wave4	Closest reporting quarter 31 March 2006
wave5	Closest reporting quarter 31 December 2005

Table 6.1: Additional desciption of explanatory variables for first empirical investigation

Notes:
As reported in Section 3.3, *dur1* and *wave5* are omitted from the regression specification for reasons of multicollinearity, following Cardinale (2007)

Variable	Explanation
dur1	Duration less than or equal to 2 years
dur2	Duration greater than 2 years, less than or equal to 4 years
dur3	Duration greater than 4 years, less than or equal to 8 years
dur4	Duration greater than 8 years, less than or equal to 12 years
dur5	Duration greater than 12 years

Table 6.2: Additional desciption of explanatory variables for second empirical investigation

Notes:
As reported in Section 4.3, *dur5* is omitted from the regression specification for reasons of multicollinearity

Variable	Coefficient	Standard Error
Intercept	-0.0870	0.0025
dur1	0.0700	0.0020
dur2	0.0587	0.0018
dur3	0.0366	0.0015
Coupon in %	0.0137	0.0004

Table 6.3: Correction coefficients for the final portfolio considered in Section 4.5

Notes:
As noted in Section 4.5, the coefficient relating to the coupon payment is an order of magnitude higher than previously possibly impacting the results