The influence of unfunded pension liabilities as a potential risk of financial distress

Stefan Huber
152422164

Dissertation written under the supervision of Professor Ricardo Reis

Dissertation submitted in partial fulfilment of requirements for the MSc in Finance, at the Universidade Católica Portuguesa, April 2024.

Title: The burden of pension liabilities as a potential risk of financial distress.

Author: Stefan Huber

Abstract

This thesis investigates the influence of unfunded pension liabilities on the probability of default for corporations. By employing empirical models like the Altman Z- & Z''-Score and the Ohlson O-Score, the study assesses the effects of unfunded pension liabilities on the probability of default among U.S. corporations listed in the S&P 500 from 2006 to 2022. This period is significant due to the implementation of the Pension Protection Act in 2006, which mandated companies to fully fund their pension obligations within a shortened timeframe. The research methodology includes a fixed-effects regression model with variables indicative of pension management to analyse the impact on corporate default risk. The thesis presents a comprehensive review of corporate pension schemes' history, the Pension Protection Act's regulatory context, and the empirical models employed. The analysis distinguishes the varying impacts of unfunded pension liabilities on the probability of default across industries, providing new insights into this under-researched area. Key findings suggest that while unfunded pension liabilities significantly influence the probability of default in some industries, their overall impact across the broad spectrum of industries is nuanced and varies depending on specific industry characteristics, the viewed model, and financial practices. The study contributes to the existing literature by highlighting the complex relationship between pension liabilities and corporate financial health, offering both theoretical and practical implications for managing financial distress risk in corporations.

Key Words: Financial Distress, Pension Liabilities, Probability of Default, Z-Score, O-Score, Defined Contribution, Defined Benefits

Título: O ónus das responsabilidades com pensões como um risco potencial de dificuldades financeiras.

Autor: Stefan Huber

Resumo

Esta tese investiga a influência das responsabilidades com pensões não financiadas na probabilidade de incumprimento das empresas. Utilizando modelos empíricos como o Altman Z- & Z"-Score e o Ohlson O-Score, o estudo avalia os efeitos das responsabilidades com pensões não financiadas na probabilidade de incumprimento entre as empresas americanas cotadas no S&P 500 de 2006 a 2022. Este período é significativo devido à implementação da Lei de Proteção das Pensões em 2006, que obrigou as empresas a financiarem integralmente as suas obrigações em matéria de pensões num prazo reduzido. A metodologia de investigação inclui um modelo de regressão de efeitos fixos com variáveis indicativas da gestão das pensões para analisar o impacto no risco de incumprimento das empresas. A análise distingue os diferentes impactos das responsabilidades por pensões sem capitalização na probabilidade de incumprimento em todos os sectores, fornecendo novas perspectivas sobre esta área pouco estudada. As principais conclusões sugerem que, embora as responsabilidades com pensões não financiadas influenciem significativamente a probabilidade de incumprimento em alguns sectores, o seu impacto global no vasto espetro de sectores é diferenciado e varia em função das características específicas do sector, do modelo visualizado e das práticas financeiras. O estudo contribui para a literatura existente ao realçar a relação complexa entre as responsabilidades com pensões e a saúde financeira das empresas, oferecendo implicações teóricas e práticas para a gestão do risco de dificuldades financeiras nas empresas.

Palavras-chave: Dificuldades Financeiras, Responsabilidades com Pensões, Probabilidade de Incumprimento, Z-Score, O-Score, Contribuição Definida, Benefícios Definidos

Table of Contents

List of Abbreviations

APO	Accumulated benefit obligations
CAPEX	Capital expenditures
DB	Defined benefit
DC	Defined Contributions
INTEXP	Interest Expense
MDA	Multiple discriminant analysis
PBO	Projected benefit obligations
PD	Probability of default
PDO	Probability of default O-Score
PDZ	Probability of default Z-Score
PDZ2	Probability of default Z"-Score
UNFUND	Unfunded Pension Liabilities

List of Figures

List of Tables

1 Introduction

Pension management remains a crucial facet in attracting and retaining talent, as well as in strategic corporate planning. There has been a discernible shift in recent times from defined benefit plans to defined contribution plans, effectively shifting investment risks from employers to employees (Broadbent et al. 2006). This study approaches the ramifications of this shift from a novel angle, addressing a void in the current literature and empirical studies by probing the influence of unfunded pension liabilities, resultant from defined benefit plans, on corporate default risk.

The research scrutinizes the period following the enactment of the Pension Protection Act of 2006, which mandated companies to fully fund their pension obligations within seven years—a significant reduction from the previously allotted thirty years (LaMonte 2006). Focusing on the years 2006 to 2022, the study focusing on U.S. corporations impacted by the PPA, specifically those within the S&P 500. The objective is to employ empirical models such as the Altman Z- & Z"-Score and the Ohlson O-Score to evaluate the effects of unfunded pension liabilities on the probability of default. It seeks to compare these models against each other to verify consistency in results, and to determine if there is a pervasive influence of unfunded pension liabilities on default risk or, alternatively, to discern their impact on specific industries and default models.

Utilizing a fixed-effects regression model with variables that encompass profitability (tax expenses), leverage (interest expenses), capital expenditures (CAPEX), and unfunded pension liabilities as indicators of pension management. The study aspires to shed light on this relatively uncharted subject in economic literature, thereby establishing a foundation for future research. It also considers the age of the companies and the industries they belong to. In the end, this dissertation underscores the critical importance of adaptable and industry-tailored strategies for businesses and policymakers to enhance decision-making regarding pension scheme allocations.

The dissertation is organized as follows: Section 2 presents a historical overview of corporate pension schemes, the regulatory context of the pension protection act 2006, the structure of the empirical models used for the dependent variables, and the hypotheses of the study. Section 3 delineates the sample structure, its composition, methodology, and the employed models. Section 4 showcases regression outcomes for the full sample and industry-specific sub-samples. Key findings of the research, along with theoretical and practical implications, are expounded

in Section 5. The penultimate section 6 addresses the study's limitations and offers suggestions for future research, paving the way to the concluding remarks in Section 7.

2 Literature Review & Hypothesis Development

2.1 History of corporate pension

In the scientific discussion surrounding the evolution of corporate retirement benefit systems, a few key developments have been critical, especially from the 1980s onward. Legislative shifts, such as the enactment of the U.S. Employee Retirement Income Security Act in 1974 and its later modifications, have been pivotal in dictating the framework within which these benefit systems operate (Asthana, 2008). Additionally, there has been a gradual migration from Defined Benefit to Defined Contribution models, largely attributed to the managerial complexity and financial uncertainty that the former entails (Dennis, 2002). This transition, however, is less evident in some sectors or industries, where companies continue to offer Defined Benefit plans for various strategic and workforce-related reasons (Coronado & Copeland, 2004). Such sector-specific variances highlight the fluid nature of corporate retirement benefit schemes, which continue to adapt in response to a range of influencing factors from regulatory mandates to industry nuances (Clark et al., 2003).

2.2 Pension Protection Act

The Pension Protection Act (PPA) of 2006 marks a significant moment in the regulation of pension funds in the United States, addressing critical issues around the funding of defined benefit pension plans. This act, motivated by the financial distress of several high-profile pension plans and an aging demographic, aimed to shore up the financial health of these plans by ensuring they were adequately funded. Its implications for corporate America have been profound, reshaping the landscape of pension fund management and corporate finance strategy.

Historically, the management of pension funds in the U.S. has oscillated between periods of surplus and deficit, largely influenced by market performance, corporate decisions, and demographic shifts. The PPA of 2006 sought to mitigate these fluctuations by enforcing stricter funding requirements, thus ensuring that pension plans could meet their obligations to retirees. According to the U.S. Department of Labor, the Act introduced mechanisms for quicker funding of pension liabilities, including a seven-year timeline to fully fund pension obligations, a

notable departure from the previously allowed thirty years to fund up to 90% of these obligations (LaMonte 2006). Research preceding and following the enactment of the PPA has provided valuable insights into its impact. Rauh (2006) highlights the Act's role in reducing pension underfunding by compelling companies to adopt more conservative investment strategies and increase their pension contributions. This shift has significant implications for the asset allocation decisions within pension portfolios, with a noticeable trend towards bond investments over equities to match liabilities more closely (Rauh 2006). The strategic responses of firms to the PPA have varied widely, reflecting their financial health, the size of their pension obligations, and their capacity to adjust to the new regulatory framework. Some companies chose to freeze their pension plans, stopping accruals for current employees or closing the plans to new entrants, thus limiting their future liabilities. An analysis by Guerriero (2009) suggests that such decisions were not merely reactions to the regulatory environment but also strategic moves reflecting broader corporate finance considerations, such as tax strategy, liquidity management, and risk exposure (Guerriero 2009). Moreover, the PPA's emphasis on transparency and accountability has led to a more informed dialogue between pension plan sponsors and beneficiaries. By mandating detailed disclosures about the funded status of pension plans, the Act has enhanced the visibility of pension health, enabling employees and retirees to make better-informed decisions regarding their retirement planning (LaMonte 2006).

2.3 Differences in pension plans

Since the early 2000s, the landscape of retirement planning in the United States has significantly shifted, with a noticeable trend of companies moving away from offering Defined Benefit (DB) plans to new employees in favor of Defined Contribution (DC) plans. This transition marks a pivotal change in the allocation of retirement risk, transferring the responsibility from employers to employees and signaling a broader move towards privatizing retirement planning (Broadbent et al. 2006).

Defined Contribution plans, such as 401(k)s, are characterized by individual accounts into which both employers and employees can contribute a predefined amount. These contributions are then invested in a range of financial products, with the employee often having a say in the investment decisions. The eventual retirement payout is largely contingent on the success of these investments, thus placing the bulk of the investment risk squarely on the shoulders of the employee. This system contrasts starkly with the traditional Defined Benefit plans, which promise a specific retirement income based on a formula that considers factors such as tenure

of service and salary history, ensuring a predetermined benefit upon retirement with the employer shouldering the investment risk (Franzoni & Marín 2006).

The DB plans require employers to maintain sufficient financial reserves to meet future pension liabilities, exposing them to considerable financial risk. This risk is magnified by market volatility, demographic shifts, and the longevity of retirees, potentially leading to significant financial strain on the company. In extreme cases, such as bankruptcy, DB plan participants might face the prospect of losing their promised benefits unless these are sufficiently insured or supported by pension guarantee funds (Broadbent et al. 2006).

Adding to the complexity of DB plans are concepts such as Projected Benefit Obligations (PBO) and Accumulated Benefit Obligations (ABO), which represent different methods of valuing pension liabilities (Bodie 1990). ABO reflects the present value of benefits earned to date without accounting for future salary increases, providing a snapshot of the employer's immediate obligation. PBO, on the other hand, includes projections of future salary growth, offering a more dynamic but also more speculative view of pension liabilities. Critics argue that ABO offers a more conservative and therefore reliable assessment of pension obligations, advocating its use over PBO for financial reporting and risk assessment purposes (Bader 2003).

The shift towards DC plans reflects employers' desire to mitigate the financial risks associated with DB plans. By offering DC plans, employers can limit their financial exposure to the contributions made without having to guarantee a specific retirement benefit. This model also aligns with the changing nature of the workforce, offering greater portability and flexibility for employees who may change jobs multiple times over their career. However, the burden of ensuring adequate retirement savings under a DC plan falls on the employees, requiring them to make informed investment choices and manage the risk of market fluctuations effectively.

This evolution from DB to DC plans represents a fundamental shift in the philosophy of retirement planning, emphasizing individual responsibility and the importance of personal financial management in securing a stable retirement. While DC plans offer the potential for higher returns and greater individual control over retirement savings, they also demand a more proactive and knowledgeable approach to investment and risk management from employees. As such, the transition reflects broader economic and societal trends towards individualism and away from collective risk-sharing mechanisms (Broadbent et al. 2006).

2.4 Altman Z-Score

The Altman Z-Score, developed by Edward I. Altman, has been since his development in 1968 one of the main indicators to measure the probability of default. In his seminal 1968 work, Altman questioned the validity of earlier research focused on singular financial metrics, contending that this approach led to imprecise and unreliable forecasts of a company's likelihood of bankruptcy. He advocated for the application of multiple discriminant analysis (MDA) as a method to generate a more dependable and comprehensive predictive framework. MDA aggregates several financial ratios into a unified predictive indicator, offering a more reliable way to classify companies as either on the brink of bankruptcy or financially stable (Altman 1968). In Altman's 1968 study, he analyzed two groups of 33 manufacturing firms each. Group 1 consisted of smaller firms that had filed for bankruptcy between 1946 and 1965, with assets ranging from $0.7 to $25.9 million. Group 2, selected for comparison, included similar but non-bankrupt firms, with assets between $1 and $25 million. This group excluded extremely small and large firms. The firms in Group 2 were slightly larger than those in Group 1. Data for the study was collected from the same period for both groups, with Group 1's data taken from financial statements one period before bankruptcy, averaging a lead time of approximately seven and a half months (Altman et al. 2014).

Altman's (1968) work for publicly traded manufacturing firms led to the formulation of a specific discriminant function as original Z-Score which can be summarized as follows (Xu & Zhang 2009):

$$\text{Z-Score} = 1.2*X_1 + 1.4*X_2 + 3.3*X_3 + 0.6*X_4 + 0.999*X_5$$

Where:

X_1 = Working capital/ Total assets

X_2 = Retained Earnings / Total assets

X_3 = EBIT / Total assets

X_4 = Market value of equity / Book value of total liabilities

X_5 = Sales / Total assets

In 1883 Altman adjusted the original Z-Score model because of his prediction lag for private not-public traded firms and advocated a re-estimation where he changed the value of X_4 from market value of equity into book value of equity (Altman 1983).

Altman´s (1983) work for private manufacturing firms is formulated as Z´-Score which summarized as follows (Altman et al. 2014):

$$Z´\text{-Score} = 0.717*X_1 + 0.847*X_2 + 3.107*X_3 + 0.420*X_4 + 0.998*X_5$$

Where:

X_1 = Working capital/ Total assets

X_2 = Retained Earnings / Total assets

X_3 = EBIT / Total assets

X_4 = Book value of equity / Book value of total liabilities

X_5 = Sales / Total assets

Due to the unavailability of a private firm database, Altman didn't apply the Z'-Score model to a secondary sample. Instead, he evaluated the Z"-Score Model's accuracy, which consists of four variables. This revised model omits the Sales/Total Assets ratio (X5) to address potential industry-related distortions. The exclusion of this industry-sensitive variable, asset turnover, aimed to reduce the influence of industry-specific factors. In 1983, Altman presented this modified four-variable Z"-Score model to enhance its applicability across various industries. The Z" Score is summarized as follows (Altman et al. 2014):

$$Z''\text{-Score} = 3.25 + 6.56*X_1 + 3.26*X_2 + 6.72*X_3 + 1.05*X_4$$

Where:

X_1 = Working capital/ Total assets

X_2 = Retained Earnings / Total assets

X_3 = EBIT / Total assets

X_4 = Book value of equity / Book value of total liabilities

2.5 Ohlson O-Score

The Ohlson O-Score, developed by James A. Ohlson in 1980, represents a significant advancement in bankruptcy prediction, complementing the pioneering work of the Altman Z-Score. Unlike Altman's approach, which leverages MDA to integrate various financial ratios into a composite score, Ohlson's model adopts logistic regression to predict the likelihood of bankruptcy. This methodological shift allows for the inclusion of both continuous and binary variables in the analysis, providing a nuanced view of financial health. Ohlson's seminal study analyzed a dataset comprising 105 bankrupt firms and 2,058 non-bankrupt firms, focusing exclusively on publicly traded or over-the-counter companies within the industrial sector from the years 1970 to 1976. This careful selection ensured a focus on firms for which bankruptcy posed a real and measurable risk, and where financial data was both accessible and relevant for the model's predictive aims. A disadvantage of the model is that it does not incorporate any market transaction of the observed firms (Ohlson 1980).

The O-Score is summarized as follows (Ohlson 1980):

$$\text{O-Score} = -1.32 - 0.407*X_1 + 6.03*X_2 - 1.43*X_3 + 0.076*X_4 - 1.72*X_5 - 2.37*X_6 - 1.83*X_7$$

$$+ 0.285*X_8 - 0.521*X_9$$

Where:

X_1 = log(total assets / GNP price-level index)

X_2 = Total liabilities / Total assets

X_3 = Working capital / total assets

X_4 = Current liabilities / current assets

X_5 = One if total liabilities exceeds total assets otherwise zero

X_6 = Net income / total Assets

X_7 = Funds from operations / total liabilities

X_8 = One if net Income was negative for the last two years otherwise 0

X_9 = (Net income $_t$- Net income $_{t-1}$) / (|Net income $_t$| + |Net income $_{t-1}$|)

2.6 Hypothesis Development

Incorporating a detailed examination of pension liabilities, the implications of regulatory frameworks like the Pension Protection Act of 2006, and default prediction models including the Altman Z-Score, Z"-Score and Ohlson O-Score, this thesis sets out to explore the nuanced relationship between unfunded pension liabilities and the probability of default across industries. Recognizing the complexity of these relationships and the varying effects of unfunded pension liabilities on company default probabilities across sectors, this study adopts a segmented hypothesis approach. This approach facilitates an in-depth investigation across diverse sectors, allowing for a nuanced rejection or acceptance of the alternative hypothesis based on sector-specific findings.

The hypotheses proposed are as follows:

H0 (General Null Hypothesis): *Unfunded pension liabilities do not significantly impact the probability of default across a broad array of industries, indicating the absence of a universal pattern in their effect.*

H1 (General Alternative Hypothesis): *Unfunded pension liabilities significantly influence the probability of default across a broad spectrum of industries, suggesting that the level of unfunded pension liabilities can be indicative of corporate health.*

To delve deeper into the sector-specific dynamics, this study introduces an additional hypothesis:

***H1a (Sector-Specific Alternative Hypothesis*)**: *The impact of unfunded pension liabilities on the probability of default varies significantly across industries, reflecting distinct sector characteristics, economic conditions, regulatory environments, and financial practices.*

Therefore, the formulated hypotheses acknowledge the differential impact of unfunded pension liabilities and facilitate an exploration of inter-industry heterogeneity. This suggests that while certain industries may exhibit a strong correlation between unfunded pension liabilities and the probability of default, others may show little to no such relationship. This emphasis on industry-specific analysis underscores the rationale behind selecting a broad range of industries for this study. With this comprehensive approach, this thesis aims to contribute a deeper understanding of the role unfunded pension liabilities play in influencing corporate default probabilities, offering insights into a gap in the existing literature on this topic.

3 Data & Methodology

This section elucidates the empirical framework employed to scrutinize the interplay between bankruptcy likelihood and unfunded pension liabilities. The methodological approach herein extends and evaluates the research findings of Zhao (2015), while also distinguishing itself by its unique application and analytical perspective, not previously explored in empirical literature. Additionally, this segment furnishes a comprehensive account of the sample selection encompassed in the analysis. It delineates the underpinnings of the statistical models employed, offering a thorough exposition of the variables incorporated.

3.1 Sample composition

This study predominantly utilizes primary data sourced from Thomson Reuters Refinitiv Eikon and Datastream. These platforms provide comprehensive accounting data for publicly listed companies in the United States, encompassing the necessary financial information for this analysis. Additionally, the research incorporates data derived from the annual reports of the selected companies, when available. The variables essential for computing various default probability models were extracted from Refinitiv Eikon and Datastream, including total current assets, total current liabilities, total assets, total liabilities, retained earnings, earnings before interest and taxes, share price, common shares outstanding, net income, funds from operations, working capital, capital expenditures, earnings per share, unfunded pension liabilities, and US gross national product to enrich the dataset.

The temporal scope of this research extends from 2006 to the most recent data point in 2022, with the starting year chosen to account for the implementation of the Pension Protection Act (PPA) in 2006, thereby mitigating potential pre-2006 legislative impacts on the data. The S&P 500 index served as the basis for company selection due to its broad industry coverage, contrasting with other indices like the Nasdaq 100, which is heavily skewed towards technology companies that diverge from traditional retirement planning schemes or lack the necessary pension-related data for this study. After an extensive data cleaning process and ensuring completeness of the requisite data with a particular focus on pension data availability. A final sample of 120 companies was selected for the specified period.

To further categorize the 120 chosen companies into distinct industry segments for analysis, they were classified into 16 industry categories as defined by Refinitiv Eikon, as presented in Table 1. In instances where companies fell into closely related categories, such as Heavy

Machinery & Equipment and Machinery & Vehicles, they were consolidated for clarity. The only exception was industry group 16, which comprises six different sectors due to insufficient data to warrant individual categorization.

This categorization aids in the nuanced examination of industry-specific impacts on the probability of financial distress and pension obligations on the included corporations.

	Industry	Number of Companies
Pharmaceuticals	1	5
Oil & Gas	2	8
Electric Utilities	3	15
IT Services & Consulting	4	7
Chemicals	5	7
Medical Equipment	6	10
Telecommunication	7	5
Machinery & Equipment & Vehicles	8	5
Consumer Goods	9	9
Aerospace & Defense	10	6
Multiline Utilities	11	6
Electrical Components & Equipment	12	9
Logistics	13	6
Food & Beverage	14	10
Automotive	15	3
Others	16	9
Insurance & Brokers x2		
Mining & Metals x2		
Real Estate x1		
Semiconductors x2		
Construction Materials x1		
Computer Hardware x1		
		120

Table 1: Industry composition

3.2 Variables

In this section, the work delves deeper into the variables employed in this analysis. Beginning by exploring the three dependent variables: Default Probability Z-Score (PDZ), Default Probability Z"-Score (PDZ2), and Default Probability O-Score (PDO). After this, it will scrutinize the rationale behind choosing the independent variables for this study. Afterwards the control variables will be discussed, specifically chosen to enrich the comprehension of the industrial frameworks within which these variables operate.

Variables are defined as the following:

Probability of default Z-Score	Estimated according to the Z-Score model from Edward I. Altman (1968)[1]
Probability of default Z"-Score	Estimated according to the adopted work to Z"-Score from Altman et al. (2014)[2]
Probability of default O-Score	Estimated according to the O-Score from James A. Ohlson (1980)[3]
Stock returns	Stock prices obtained from Thomas Reuters Datastream at the end of the year t-1
Capital expenditures	Obtained from Thomas Reuters Datastream in year t
Interest expense	Obtained from Thomas Reuters Datastream in year t
Income tax	Obtained from Thomas Reuters Datastream in year t
Unfunded pension liabilities	Obtained from Thomas Reuters Datastream in year t-1
Company age	Retrieved from the Investor Relations webpage from each company separately. Starting year of this research – founding year of the company.

[1,2,3] To get a probability of default for all three methods (Z-Score, Z"-Score, and O-Score) this work used a logistic regression approach (Alam 2022).

Industry	Dummy between 1-16 used on the base of the industry classification from Refinitiv eikon. See Table 1

Table 2: Independent and Dependent Variables

The three dependent variables used in the following regressions are probability of default Z-Score, probability of default Z”-Score, and O-Score. The Altman Z-Score was selected due to its longstanding reputation and validation in the field of financial distress prediction. Developed by Edward I. Altman in 1968, the Z-Score integrates multiple financial ratios into a single metric, offering a comprehensive snapshot of a company's financial health and its likelihood of bankruptcy. This model is particularly valuable for its ability to quantify the subtle nuances of a company's financial stability, combining liquidity, profitability, leverage, and activity ratios. Given its proven predictive power and widespread acceptance in academic and professional spheres, the Altman Z-Score presents an ideal tool for assessing the impact of pension contributions on a company's financial vulnerability. The Altman Z"-Score, an adaptation of the original Z-Score for private firms, was chosen to accommodate the diverse nature of companies within this study. This model revision retains the predictive accuracy of the original while adjusting for the lack of market value data in private companies, making it a versatile tool for evaluating financial distress across different corporate structures. The inclusion of the Z"-Score allows for a more inclusive analysis, ensuring that the study's findings are applicable to a broader spectrum of firms, thereby enhancing the generalizability and practical relevance of the research outcomes. The last approach used in this study is based on the James A. Ohlson O-Score. It was selected for its innovative approach to bankruptcy prediction using logistic regression, which enables the incorporation of both continuous and dichotomous variables. Introduced by James A. Ohlson in 1980, the O-Score extends the analytical framework beyond the financial ratios used in the Altman models, incorporating size and financial condition indicators to predict the probability of failure. This model's inclusion in the study is particularly pertinent for examining how pension contributions, as a specific financial condition, influence the likelihood of default. The O-Score's sensitivity to a range of financial health indicators makes it an essential tool for capturing the multifaceted impact of pension liabilities on company stability. The combination of those three models provides a robust framework for analyzing the potential impact of pension contributions on the probability of default. By employing these diverse yet interconnected financial distress models, the research aims to offer comprehensive insights into the nuanced relationship between pension liabilities and corporate financial stability, contributing new knowledge to the fields. The selection of independent

variables for this investigation was meticulously designed to encompass a broad spectrum of factors impacting corporate stability. Reflective of Zhao (2015), stock returns were incorporated as a pivotal measure, potentially mirroring the market's perception of a company's solidity. These returns not only encapsulate the outcomes of management decisions, including pension scheme preferences, but also echo broader economic forces and investor expectations. Capital expenditures (CAPEX), recognized for its insight into corporate expenditure, was chosen for its implications on a company's growth trajectory and strategic planning. CAPEX's inclusion aims to discern how firms, particularly those burdened by substantial pension liabilities, navigate their investment strategies in ways that might escalate their default risk.

Interest expenses emerge as another critical variable, indicative of borrowing costs that directly influence a firm's cash flows and profitability. Elevated interest expenses could impair a company's capacity to fulfill pension commitments, underscoring the intricate balance between financial obligations and operational sustainability. Similarly, the amount of income tax paid sheds light on profitability and the efficacy of tax strategies, affecting the availability of funds for pension contributions. This analysis extends to understanding how tax liabilities might constrain a company's agility in managing pension duties and forestalling default.

Central to this study is the examination of Unfunded Pension Liabilities. This metric starkly illustrates the divergence between a pension plan's commitments and the assets earmarked to satisfy those obligations, serving as an unequivocal indicator of pension health. The criticality of unfunded liabilities in evaluating the influence of pension management on financial distress is undeniable, with elevated levels potentially heightening default risk. While alternative variables, such as pension & post-retirement benefits and projected pension benefits, were initially considered, they did not demonstrably affect a company's default likelihood and were as a result excluded. Moreover, challenges in accurately accessing comprehensive pension data further underscored unfunded pension liabilities as a pivotal variable within this research.

The inclusion of company age in subsequent analyses aims to explore the proposition that older entities, typically burdened with more substantial pension responsibilities, might exhibit an increased propensity for default. Additionally, an industry-specific dummy variable was integrated to investigate if certain sectors, especially those heavily reliant on labor, face greater financial challenges than others. This nuanced approach, considering both macroeconomic factors and company-specific attributes, strives to offer a comprehensive understanding of the dynamics influencing corporate financial stability and the pivotal role of pension management

therein. Classic variables such as return on assets or return on equity were excluded from this study due to multicollinearity. This is largely because input factors for calculating the above-mentioned dependent variables serve as input for common stability variables.

3.3 Methodology

For this study, a linear regression model was utilized to investigate the impact of unfunded pension liabilities, among other factors, on a company's default probability. Stata 18 software facilitated the analysis, employing the commands -xtset-, -xtreg-, and -fe- for fixed effects. This research incorporated panel data from 120 companies listed in the S&P 500, spanning annual records from 2006 to 2022.

Panel data, characterized by repeated measurements of entities over time, were pivotal in this research for analyzing temporal patterns across companies. This data structure is particularly beneficial for conducting pooled regressions, allowing for the examination of multiple companies over a defined period. A pooled OLS regression within a fixed effect model is crucial for addressing unobserved heterogeneity, as noted by (Cameron and Trivedi 2005).

The fixed effect model for panel data, comprising i companies across t time periods, is represented as follows:

$$y_{it} = X_{it}\beta + \alpha_{it} + \varepsilon_{it}$$

Where:

y_{it} = the dependent variable for company i at time t

α_i = represents time-invariant unobserved characteristics (fixed effect)

X_{it} = is the vector of the independent variable (probability of default) that vary across i and t

β = is the vector of the coefficient that estimated

ε_{it} = error term

The fixed effect model employs a within transformation to eliminate α_i, deducting each individual observed values' time average.

Adjusted expression:

$$\tilde{y}_{it} = y_{it} - \bar{y}_i$$

$$\widetilde{X}_{it} = X_{it} - \overline{X}_i$$

The regression models structured on this foundation are as follows:

Regression 1 – Probability of default Z-Score$_{it}$ $= \beta_0 + \beta_1 Stock\ Returns_{i,t-1} + \beta_2 CAPEX_{i,t} + \beta_3 Interest\ Expense_{i.t} + \beta_4 Income\ Tax_{i,t} + \beta_5 Unfunded\ Pension\ Liabilities_{i,t-1} + \beta_6 Company\ Age_{i,t} + \sum \beta_{i,t}\ Industry\ Dummies_{it} + \varepsilon_{i,t}$

Regression 2 – Probability of default Z''-Score$_{it}$ $= \beta_0 + \beta_1 Stock\ Returns_{i,t-1} + \beta_2 CAPEX_{i,t} + \beta_3 Interest\ Expense_{i.t} + \beta_4 Income\ Tax_{i,t} + \beta_5 Unfunded\ Pension\ Liabilities_{i,t-1} + \beta_6 Company\ Age_{i,t} + \sum \beta_{i,t}\ Industry\ Dummies_{it} + \varepsilon_{i,t}$

The primary goal of these regressions is to assess whether unfunded pension liabilities affect the default probability of publicly traded companies. Subsequently, this study also aims to determine the consistency of default probability models, thereby evaluating the robustness of results across the three regression models. Additionally, by integrating multiple regressions with different industry dummies, the research seeks to uncover how different industries might be variably affected by unfunded pension liabilities.

4 Data Analysis & Results

The subsequent section implements the model, where a total of 51 regressions were performed. This includes three regressions for each Probability of Default model (Z-score, Z''-score, and O-score) across the entire dataset, comprising 120 companies. Additionally, 48 subsample regressions were conducted for each of the 16 specified industries per default model. Further robustness checks were executed to provide additional validation of the implemented methodology.

4.1 Descriptive statistics

Table 3 in this thesis presents a detailed exploration of the sample distribution and illuminates the characteristics of key financial metrics and corporate attributes from 2006 to 2022, spanning

2040 observations. This comprehensive overview is foundational for understanding the impact on default probabilities. The table delineates essential statistics, including the number of observations, mean, standard deviation, and minimum and maximum values, painting a clear picture of the dataset's landscape. Notably, the mean probability of default, as gauged by the Z-Score, stands at 10.26%, with a variability of 11.35%. This ranges from 0% to 87.85% underscoring the vast disparities in default risk across companies. Conversely, the Z"-Score reveals a markedly lower mean default probability of 0.74% and a standard deviation of 3.23%, indicating a tighter distribution of default risks that spans nearly 0% to 94.67%. Similarly, the O-Score model, with an average default probability of 8.16% and a standard deviation of 8.81%, echoes the Z-Score's findings, suggesting a broad spectrum of default probabilities within the dataset. The analysis also highlights the average stock return at 11.07%, reflecting substantial market volatility and divergent perceptions of corporate performance, with returns fluctuating from -76.14% to gains of up to 336.68%. Furthermore, the average capital expenditure (CAPEX) of the firms is reported at $2,022,929, with a significant spread of $3,950,169, illustrating the diverse investment landscapes of the S&P500 constituents. The spectrum of interest expenses, averaging from $551,516 with a variability of $1,284,791, and income tax payments, averaging from $854,755 with a standard deviation of $2,442,793, further underscore the varied financial strategies and profitability levels across firms, ranging from tax refunds or credits between $-11.5 million to $36.5 million.

Moreover, unfunded pension liabilities average at $1,637,778 with a variance of 3,626,080, highlighting the disparity in companies' pension funding statuses, from fully funded schemes to liabilities up to $86.3 million. This variance reflects the absence of unfunded pension liabilities in certain years within the observation period for some companies. Considering the tenure of firms listed in the index, the average company age is 91 years, with a variation of 44.5 years. This spans a history from 4 to 216 years at the outset of the observed period in 2006, showcasing a blend of established entities with extensive histories and emerging players with innovative business models. This mix offers a nuanced view of the evolving dynamics of corporate America and its implications on financial stability and risk.

2006-2022	No. of Obs.	Mean	Std. Dev.	Min	Max
PD Z-SCORE	2040	0.1026115	0.1134653	0	0.8785246
PD Z"-SCORE	2040	0.0074074	0.0322748	1.60e-07	0.9466791

PD O-SCORE	2040	0.0815699	0.0881151	0.0002923	0.9377559
Stock Returns	2040	0.1106875	0.2889495	-0.7614213	3.366812
CAPEX	2040	2022929	3950196	8601	3.80e+07
Interest Expense	2040	551515.6	1284791	689	2.38e+07
Income Tax	2040	854754.5	2442793	-1.15e+07	3.65e+07
Unfunded Pension Liabilities	2040	1637778	3626080	0	8.63e+07
Company Age	2040	91.275	44.52532	4	216
No. of Obs.	2040				

Table 3: Descriptive Statistics

Table 4 showcases the Pearson correlation matrix, which examines the pairwise correlation between the variables under study. The Pearson correlation coefficients range from 1 to -1, where values at either extremity indicate a strong linear relationship. Consequently, an increase or decrease in one variable will lead to a change in the same or opposite direction in another variable, as signified by the coefficient's sign. Correlations exceeding 0.8 may signal multicollinearity, shedding light on the compatibility of chosen variables with the model. Conversely, a value near 0 implies a no-linear association among the variables within the regression framework (Pearson 1894).

In this study, the correlations derived from the Pearson matrix do not surpass +0.5931 or fall below -0.1502, suggesting only moderate correlations among the independent variables. This moderate correlation level speaks to the robustness of the results obtained. However, certain variable pairs exhibit more pronounced linear dependencies than others.

The dependent variables PDZ and PDZ2 demonstrate a moderate positive correlation of +0.4770, indicating a proportional but less intense increase of PDZ2 with PDZ. This outcome aligns with expectations, given both models derive from similar principles and utilize accounting data to compute respective default probabilities. This correlation between PDZ and PDZ2, relative to their correlation with PDO (which is notably lower at +0.2411 and +0.2315), emphasizes the distinctiveness of the three models employed in this research, thereby highlighting the impact of model selection on the investigation of the relationships in question.

Stock returns exhibit a negative correlation with all three PD measures, particularly with PDO at -0.1209, suggesting that higher stock returns may correlate with a reduced risk of default. Contrasting correlations with CAPEX further underscore the differences among the selected models. CAPEX shows a positive correlation with Altman's PD measures (+0.2280 and +0.0397) and a negative correlation with Ohlson's model (-0.1209), suggesting that while increased capital expenditure may heighten default risk in Altman's models, it decreases in Ohlson's model.

The positive correlation between Interest Expense (INTEXP) and PDZ (+0.3207) implies that companies with substantial interest obligations may face an elevated default risk. This relationship indicates that higher interest expenses could signal larger debt or unfavorable credit conditions, potentially leading to financial instability and increased default risk. Moreover, the notable correlation between INTEXP and Unfunded Pension Liabilities (UNFUND) of +0.4920 highlights a complex financial structure, suggesting that companies with significant interest expenses—and thereby, possibly higher debt levels—may also exhibit larger UNFUND, indicating the use of debt financing not only for operational and development purposes but also for pension liabilities.

Income Tax displays a negative correlation with all PD measures, especially PDO at -0.1660, implying that higher taxes, potentially indicative of greater revenue, are associated with lower default risks. UNFUND's minimal linear relationship with all three PD measures (+0.0799; +0.0020; -0.0052) suggests its limited impact on a company's default risk.

The analysis of PDZ, PDZ2, and PDO in relation to company age presents mixed findings. While there is a slight positive correlation between company age and PDO (+0.0603), negative correlations are observed with PDZ and PDZ2. This indicates that older companies may have a marginally increased risk of default according to the PDO model, yet a decreased risk according to PDZ and PDZ2.

These findings not only confirm consistent outcomes across Altman's models but also reveal distinctions from Ohlson's model. This suggests that the selected PD measurement significantly influences the analysis results, with correlations between the models sometimes diverging.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1)PDZ	1.0000								
(2)PDZ2	0.4770	1.0000							
(3)PDO	0.2411	0.2315	1.0000						
(4)STRE	-0.0660	-0.0996	-0.0962	1.0000					
(5)CAPEX	0.2280	.0397	-0.1209	-0.0833	1.0000				
(6)INTEXP	0.3207	0.0733	-0.0079	-0.0478	0.5088	1.0000			
(7)INCTAX	-0.1125	-0.0741	-0.1660	0.0127	0.5931	0.1623	1.0000		
(8)UNFUND	0.0799	0.0020	-0.0052	-0.0458	0.4703	0.4920	0.3043	1.000	
(9)AGE	-0.0711	-0.0348	0.0603	-0.0308	-0.1502	-0.0544	-0.1168	-0.0290	1.000

Table 4: Pearsons´ Correlation Matrix

4.2 Regression for the entire sample

The study commenced with the execution of three regressions, each predicated on distinct models for assessing the probability of default (PD Z-Score, PD Z"-Score, PD O-Score) across a comprehensive sample spanning from 2007 to 2022. Owing to the incorporation of lagged

variables such as stock returns and unfunded pension liabilities (t-1), data from 2006 were excluded from the analysis. Each coefficient delineates the variation in PD scores attributable to a unit change in the respective predictor, holding other variables constant. The t-statistics, presented beneath the coefficients, ascertain the statistical significance of the predictors, with significance levels denoted by asterisks (* for 10%, ** for 5%, *** for 1%).

The regression outcomes, summarized in Table 5, reveal modest R^2 values across all models, with the PDZ model achieving the highest at 0.112. This suggests that the chosen variables and the volume of observations offer limited explanatory power for default probability. The F-statistics and corresponding p-values, particularly notable in the PDZ score model with a p-value of 1.70e-43, validate the collective statistical significance of the model variables on the PDZ score. However, this level of significance is not mirrored in the PDZ2 and PDO models. The analysis indicates that prior-year stock returns exert a negative impact on PDZ and PDO scores, with coefficients of -0.0343 and -0.0197 respectively, both significant at the 1% level. This implies that an uptick in stock returns correlates with a diminished default risk as gauged by these models. These findings support the results of Zhao 2015. Conversely, for PDZ2, the effect is positive but not statistically significant, suggesting that the relevance of stock returns might vary across different PD models. Capital Expenditure shows a positive correlation with default probability across all models, yet it is only statistically significant for PDZ, indicating that increased CAPEX is linked to heightened default risk specifically within the Z-score framework. Interest expenses, similarly, positive across all models, achieve statistical significance solely in the PDZ model at the 1% level, hinting that higher interest burdens, suggestive of greater indebtedness, may elevate default risk, though this assertion does not uniformly apply across all models. Income Tax presents a consistently negative and statistically significant impact across all PD models, suggesting that higher tax liabilities are associated with lower default risk. This could imply that more profitable entities, which invariably pay more taxes, exhibit reduced default propensity. The examination of unfunded pension liabilities reveals their statistically insignificant influence on default risk across all models, underscored by non-significant t-statistics. This suggests that variations in unfunded pension liabilities do not directly affect companies' default probabilities within the confines of the analyzed models. Lastly, the coefficient for Company Age, while not statistically significant across any model, is uniformly negative, implying a potential for older firms to exhibit marginally lower default risks compared to their younger counterparts, albeit without definitive statistical evidence to support this observation.

2007-2022			
	PD Z-Score	PD Z"-SCORE	PD O-SCORE
Stock Returns $_{t-1}$	-0.0343***	0.000306	-0.0197***
	(-9.26)	(0.13)	(-4.21)
CAPEX	4.32e-09***	7.01e-10	-1.09e-10
	(5.68)	(1.44)	(-0.11)
Interest Expense	9.43e-09***	9.30e-10	2.61e-09
	(5.95)	(0.91)	(1.30)
Income Tax	-4.41e-09***	-1.75e-09***	-2.98e-09***
	(-6.55)	(-4.04)	(-3.51)
Unfunded Pension Liabilities $_{t-1}$	-3.48e-10	-2.26e-10	1.87e-10
	(-0.66)	(-0.67)	(0.28)
Company Age	-0.000154	-0.000221	-0.000344
	(-0.68)	(-1.51)	(-1.20)
Constant	0.112***	0.0277**	0.117***
	(5.38)	(2.07)	(4.45)
No. of Obs.	1920	1920	1920
R^2	0.112	0.0113	0.0195
F-Statistics	37.90	3.409	5.946
P	1.70e-43	0.00239	0.00000366

t statistics in parentheses
* p<0.10, ** p<0.05, ***p<0.01

Table 5: Regression output full sample

4.3 Regression for the industry subsample

To enhance the comprehension of how various factors impact the overall dataset, the regressions were reanalyzed, this time incorporating 16 industry-specific dummies. This method aimed to unveil the nuanced effects of industry characteristics on default risk, as depicted in Table 6.

The impact and significance of stock returns diverge across different models, manifesting as negative and statistically significant across most sectors except for chemicals, telecommunications, multiline utilities, and automotive. This pattern mirrors the outcomes from the primary regressions and associated correlation analyses, possibly indicating disparate market expectations and investment sentiments. Yet, this trend is not consistently observed across all three PD models. Specifically, within the PDZ model, the effect of stock returns exhibited substantial variability; however, logistics maintained statistical significance, albeit with a reduced significance from 1% to 10%, marked by t-statistics of -2.76 and -1.78. Meanwhile, Machinery & Equipment & Vehicles and Food & Beverage sectors showed negative and statistically significant effects under the PDO model. Moreover, the impact of stock returns on default risk exhibited variation by industry and model, with sectors such as Pharmaceuticals, Electric Utilities, IT Services & Consulting, Machinery & Equipment & Vehicles, Consumer Goods, Aerospace & Defense, Logistics, Food & Beverage, and

Automotive demonstrating negative correlations across all three models. This indicates that market performance is a critical indicator of financial health within these industries, albeit with model-dependent variations.

Capital Expenditure (CAPEX) presented inconsistent outcomes across all three regression analyses, with variability in both sign and statistical significance. Nonetheless, certain industries like Pharmaceuticals, IT Services, and Consumer Goods showed statistical significance for PDZ at levels of 5%, 5%, and 1%, respectively, with Pharmaceuticals experiencing a negative CAPEX impact while the latter two exhibited positive significance. For PDZ2, Chemicals, Consumer Goods, and Automotive were notable at significance levels of 5%, 1%, and 5%, respectively, with varying impacts—positive for Chemicals and Consumer Goods, and negative for Automotive. Electric Utilities stood out as the sole sector to show a negative and significant impact at the 1% level under PDO.

Interest Expense demonstrated a positive correlation with default risk under PDZ across most sectors, signifying a clear indicator of its influence on default probability. For instance, in Pharmaceuticals, a robust positive correlation was evident at the 1% level, marked by a coefficient of 6.38e-08 and a t-statistic of 4.60. Similar observations were made across other sectors, though with varying levels of significance. Notably, Consumer Goods differed with a negative sign, suggesting a contrary impact. The PDZ2 model also highlighted a significant positive relationship between interest expenses and default risk across various industries, albeit with distinct coefficients and significance levels. This positive linkage between PDZ2 and Interest Expenses was consistently observed across sectors such as Pharmaceuticals, Chemicals, Machinery & Equipment & Vehicles, Food & Beverage, and Automotive, emphasizing the critical role of interest expenses in default risk prediction. In the PDO context, the correlation between interest expense and default risk remained positive in several industries but exhibited a varied significance pattern.

Income tax serves as an indicator of company profitability, with its relationship to the PD models predominantly negative across the board. This observation supports the premise of the primary regressions that higher income tax payments, indicative of greater profitability, correlate with reduced default risk. For instance, within the PDZ model's examination of the Electric Utilities sector, a starkly negative coefficient of -3.71e-08 (t-statistic of -8.06) showcases a pronounced inverse relationship at the 1% significance level. This trend is apparent across multiple sectors, albeit with varying coefficients and significance levels, underscoring

the overarching theme that elevated profitability, as inferred from higher tax obligations, diminishes default risk. The PDZ2 model mirrors these negative associations, though with distinctions in magnitude and significance when juxtaposed with the PDZ model. Notably, Electric Utilities exhibit a significantly negative coefficient of -3.61e-08 (t-statistic of -9.67), a pattern consistent within the PDO model, where, for instance, Electric Utilities again demonstrate a negative coefficient of -5.83e-08 (t-statistic of -9.83). The persistence of this negative correlation across models challenges the fundamental assumption that operational success mitigates financial distress.

Conversely, the outcomes related to unfunded pension liabilities showcase considerable variability. In the PDZ model, certain industries like Electric Utilities, Medical Equipment, Multiline Utilities, and Logistics report notably positive coefficients—1.42e-08 (t-statistic of 3.56), 1.94e-08 (t-statistic of 2.22), 1.95e-08 (t-statistic of 2.65), and 3.79e-09 (t-statistic of 1.83) across various levels of significance (1%, 5%, 1%, 10%, respectively). This suggests that in these sectors, unfunded pension liabilities may elevate default risk. Conversely, other industries exhibit no significant correlation, with results spanning both positive and negative signs, indicating that the impact of unfunded pension liabilities on default risk is industry specific. This nuanced understanding of the PDZ model does not extend to the PDZ2 and PDO models, where significant correlations between unfunded pension liabilities and default risk are largely absent. Notably, only the Consumer Goods and Automotive sectors within PDZ2 show significance, with coefficients of -2.86e-10 (t-statistic of -4.72) and -9.53e-10 (t-statistic of -2.24) at the 1% and 5% significance levels, respectively. In an intriguing contrast to prior findings, Consumer Goods uniquely displays statistically significant negative coefficients in both models at the 1% significance level, suggesting a scenario where higher unfunded pension liabilities could potentially confer advantages within this sector.

The inclusion of the Company Age variable was initially hypothesized to either confirm or refute the implications of unfunded pension liabilities. Yet, the regression outcomes present a spectrum of both positive and negative statistically significant results across all models. Consistency in results is observed solely within the Oil & Gas, Chemicals, and Logistics industries across all three models, albeit with varying significance and industry-dependent effects. In some cases, the longevity and accrued experience of older firms may endow them with a competitive edge, potentially mitigating default risk. Conversely, other scenarios highlight older companies grappling with innovation and adaptability challenges, thus heightening their susceptibility to financial duress.

This variability in findings illuminates the multifaceted influence of diverse variables across different industry landscapes within the models. The lack of uniformity and occasional stark contrasts between industries and models accentuate the complex dynamics at play in determining default risk.

5 Discussion

This section of the thesis delves into an in-depth discussion of the outcomes derived from the conducted regressions and the empirical analysis findings, with a particular focus on unfunded pension liabilities and their impact across different industries. The objective is to decipher the complex and varied results, examine the underlying dynamics and relationships, and enhance our understanding of their effect on a company's default risk.

5.1 Key findings

After scrutinizing the regression outputs, we can distill the following insights: The influence of unfunded pension liabilities on the probability of default (PD) does not exhibit uniformity across different PD models and sectors, illustrating the nuanced and complex nature of the relationships under investigation. Specifically, the impact of unfunded pension liabilities on PD significantly hinges on the PD model employed and the industry in question. In sectors where significant relationships are discerned, the findings hint at heightened unfunded pension liabilities correlating with an increased PD, underscoring the criticality of adept pension fund management and strategic planning to mitigate associated risks, albeit primarily within the industries identified.

For sectors notably impacted by pension liabilities, adopting proactive strategies such as ensuring sufficient funding and deliberating over pension strategy choices (e.g., Defined Benefit vs. Defined Contribution plans) can markedly influence the long-term PD. Moreover, the observed data variability and the sparse significant relationships across the models and industries suggest that unfunded pension liabilities should not be isolated and evaluated but rather considered within the context of industry-specific dynamics and their interaction with key financial indicators.

Further, the regression analyses reveal that in certain industries, such as Electric Utilities and Logistics, unfunded pension liabilities demonstrably affect company PD, aligning with initial hypotheses. Notably, these industries exhibit positive coefficients across all three industry-specific regressions, suggesting a unit increase in unfunded pension liabilities parallels a rise in

PD. This effect is statistically significant for Electric Utilities in the PDZ model at the 1% level and for Logistics across PDZ and PDO at 10% and 5% levels, respectively. Conversely, sectors like Consumer Goods and Telecommunications deviate from this assumption, albeit with Consumer Goods showing statistical significance in PDZ and PD2 models, indicating a scenario where unfunded pension liabilities positively impact PD, potentially even reducing it.

This variability accentuates the differential impacts that unfunded pension liabilities may have across various PD models. While significant findings in the PDZ model are occasionally mirrored in PDZ2 and PDO, this is not consistently the case, highlighting the crucial role of model selection in financial distress research. The divergent impacts captured by different models emphasize the multifaceted relationship between unfunded pension liabilities and PD.

The R^2, F-statistics, and P-values mirror these insights. The R^2 values across industries and models indicate varying degrees of explanatory power, suggesting that factors influencing default risk, including unfunded pension liabilities, differ across industries. The F-statistics and associated P-values attest to the regression models' statistical significance, validating the models' capacity to explain variations in PD to some extent, albeit not uniformly across every industry and model.

When considering the regression results for the entire sample without delving into industry-specific factors, unfunded pension liabilities appear to wield no significant influence on PD overall. Yet, the aggregate results resonate with Zaho's 2015 findings regarding stock returns' impact on PD within the Z-score context, as evidenced by significant outcomes in the O-score analysis. Here, an uptick in stock returns correlates with a diminished PD.

Another notable discovery or Co-founding pertains to the consistent significance of income tax across all models in the overall regression analysis, which emerges as one of the most compelling findings of this study. Predominantly negative coefficients across models highlight a pivotal financial principle: companies exhibiting higher profitability, inferred from increased income tax payments, generally face a lower risk of default. This not only solidifies the inverse relationship between income tax payments and default risk but also underscores the consistency and robustness of these findings across varied methodologies and models. Additionally, the discrepancies in income tax impacts may reflect differences in operational margins among industries, with higher margins typically seen in less capital-intensive sectors. This analysis unequivocally suggests that profitability, as inferred from income tax payments, plays a pivotal role in mitigating default risk across the board.

5.2 Theoretical implications

Incorporating the findings of this research into the chapter on theoretical implications, it is discernible that the variances between defined benefit and defined contribution plans exert a minimal influence on the default probability of the observed companies, barring a few exceptions previously noted. This observation challenges the prevalent assumption that defined contribution plans inherently provide a more stable foundation for companies by transferring investment risks from the employer to the employee, as posited by Broadbent et al. (2006). The theoretical takeaway here is that the intricacies of pension investment systems have implications for corporate financial stability that transcend the mere reallocation of investment risks.

Furthermore, the varied effects of unfunded pension obligations across different industries highlight the significance of industry characteristics, economic and macroeconomic conditions, and regulatory frameworks. This suggests a need for a segmented theoretical approach to examining default risks, where industry-specific models might yield more granular insights.

The utilization of Altman and Ohlson models and their resulting disparate outcomes reiterate the critical importance of model selection. Theoretical frameworks going forward should accommodate the particular financial structures and risk profiles of industries to enhance their predictive accuracy.

Despite the lack of analysis for periods before 2006 in this work, a pattern is discernible post-enactment of the Pension Protection Act (PPA) in 2006 across the entire sample. Pension liabilities appear to decrease approximately every six to seven years and subsequently increase in the years that follow, as depicted in Figure 2. This aligns with insights from the literature that delve into the repercussions of PPA on pension strategies, such as the works of Rauh (2006) and Guerriero (2009), underscoring the theoretical relevance of regulatory impacts on pension management.

5.3 Practical implications

This thesis illuminates that strategic pension management holds a marginal role in mitigating default risks. It appears that only select industries, where unfunded pension liabilities tangibly affect default risk, should engage in comprehensive financial risk management strategies concerning pension liabilities. This focus, however, should not be universally applied across all companies.

One salient insight from this research is that the prevalent shift from defined benefit to defined contribution plans does not markedly impact default risk. In the context of this study, this shift may not warrant consideration when evaluating failure probability. Instead, individual companies should weigh the specific objectives, benefits, and drawbacks of changing pension schemes, independent of their effect on default risk. For instance, continuing to offer defined benefit plans could foster long-term employee retention if adequately communicated, despite the commonly cited investment risk—which this study did not substantiate.

Regulatory efforts might be more productively channeled into refining existing pension frameworks. Policymakers could contemplate the introduction of more stringent transparency and funding standards, alongside harmonized reporting, paralleling the objectives behind the enactment of the Pension Protection Act.

Moreover, the research indicates that a blanket evaluation of unfunded pension liabilities is unfeasible without a granular, industry-specific analysis. Firms within industries more susceptible to the repercussions of unfunded pension liabilities ought to explore alternative financing sources or investment strategies to alleviate this risk.

Enhanced transparency, coupled with effective communication between corporations and stakeholders regarding the implications of unfunded pension liabilities, can also foster a deeper understanding and align expectations, thereby bolstering trust. For example, clear disclosure practices can mitigate potential stock price impacts associated with significant unfunded pension liabilities.

6 Limitations and further research

This thesis illuminates that strategic pension management holds a marginal role in mitigating default risks. It appears that only select industries, where unfunded pension liabilities tangibly affect default risk, should engage in comprehensive financial risk management strategies concerning pension liabilities. This focus, however, should not be universally applied across all companies.

One salient insight from this research is that the prevalent shift from defined benefit to defined contribution plans does not markedly impact default risk. In the context of this study, this shift may not warrant consideration when evaluating failure probability. Instead, individual companies should weigh the specific objectives, benefits, and drawbacks of changing pension

schemes, independent of their effect on default risk. For instance, continuing to offer defined benefit plans could foster long-term employee retention if adequately communicated, despite the commonly cited investment risk—which this study did not substantiate.

Regulatory efforts might be more productively channeled into refining existing pension frameworks. Policymakers could contemplate the introduction of more stringent transparency and funding standards, alongside harmonized reporting, paralleling the objectives behind the enactment of the Pension Protection Act.

Moreover, the research indicates that a blanket evaluation of unfunded pension liabilities is unfeasible without a granular, industry-specific analysis. Companies within industries more susceptible to the repercussions of unfunded pension liabilities ought to explore alternative financing sources or investment strategies to alleviate this risk.

Enhanced transparency, coupled with effective communication between corporations and stakeholders regarding the implications of unfunded pension liabilities, can also foster a deeper understanding and align expectations, thereby bolstering trust. For example, clear disclosure practices can mitigate potential stock price impacts associated with significant unfunded pension liabilities.

Future research endeavors could expand upon this study by exploring alternative default prediction models, such as the KMV model or the Jarrow-Turnbull model, providing a more comprehensive understanding of the subject. Furthermore, there is a wide array of opportunities for subsequent investigations to build upon the preliminary findings presented herein. To validate or challenge these results, it would be prudent to adopt a more expansive geographical scope, extending beyond the confines of the United States. This could involve assessing the influence of various political regulations, such as Basel II, or employing different indices to verify the outcomes observed in U.S. firms, or global indices.

An additional avenue of research could involve a temporal analysis of pension liabilities, examining periods before and after the implementation of new regulatory frameworks. Moreover, selecting a diverse sample that includes both companies that have defaulted due to substantial liabilities and those that have remained solvent despite similar financial strains could yield insightful distinctions. Such an approach would offer a richer, more nuanced understanding of the interplay between pension liabilities and corporate financial distress.

7 Conclusion

This research sought to explore the link between default risk and its potential association with unfunded pension liabilities, aiming to discern the effects of transitioning pension systems. It questioned whether the shift from defined benefit to defined contribution schemes and their resultant unfunded pension liabilities correlates with an elevated default risk—a query that extends the findings of existing literature and provides a more nuanced understanding of these connections.

To gauge default probability, the study employed esteemed, scientifically grounded models, such as the Altman Z and Ohlson O scores. Yet, the comprehensive results revealed no significant impact—neither negative nor positive—of the unfunded pension liabilities on default risk across the board for the companies and the period post-Pension Protection Act (PPA) from 2006-2022. Despite this, the research uncovered sector-specific susceptibilities to retirement-related financial instability and shed light on the intricate dynamics that influence corporate financial well-being.

While unfunded pension liabilities as an aggregate do not sway company default risk, industry-specific effects were identified and substantiated. Notably, the energy utilities sector displayed a marked sensitivity to unfunded pension liabilities, indicating a significant uptick in default probability in tandem with rising levels of such liabilities. These findings emphasize the extensive economic and regulatory challenges that disproportionately impact certain sectors. Conversely, in the consumer goods sector, the opposite effect was observed. The study accentuates the critical intersection between sector-specific operational dynamics and broader financial frameworks within enterprises.

Merging theoretical paradigms with empirical analyses, this thesis also contributes new insights into financial distress management. The varied efficacy of the Altman and Ohlson models across sectors reveals that a simplistic application of these models is not universally valid, with outcomes largely contingent on the chosen model. This underscores the complexity of applying theory in practice and the necessity for a multifaceted approach to predicting the factors influencing financial emergencies.

The insights offered here can enrich practical implications for corporate and policy realms concerning differentiated and sector-specific pension management. The findings advocate for a tailored approach to pension liability management, especially in sectors more vulnerable to pension-related distress, which might benefit from conservative financial strategies or

alternative pension arrangements. For policymakers, these insights could guide the creation of nuanced regulatory frameworks that reflect industry-specific risk profiles, potentially enhancing the stability of occupational pension systems.

Yet, this study has its constraints, focusing on U.S. companies within the S&P 500, which restricts the global applicability of its findings. This limitation presents an opportunity for further research to examine the impacts across various industries on a more expansive geographical scale.

Moreover, the study unearthed interconnected co-founding's. Collectively considering the Altman Z-Score and the Ohlson O-Score, stock returns significantly influence the failure probability of the examined companies, corroborating literature such as Zhao (2015)—wherein higher stock returns mitigate default risk. Furthermore, this research established that Income Taxes produce significant results across numerous observations, suggesting that companies paying higher taxes, indicative of superior profitability, face reduced default risk. These revelations further inform theory and practice, encouraging future examination within a broader context.

In conclusion, this thesis not only clarifies the intricate interplay between unfunded pension liabilities and default risk but also charts a course for future inquiries. It calls for a wider exploration of alternative default probability models and deeper dives into international pension practices. Ultimately, this work underscores the necessity for both corporations and legislators to engage with the dynamic complexity and embrace contextual strategies in pension liability management, ensuring the enduring security of employee pensions and the fiscal health of companies across all sectors.

Words: 9,682

8 Appendix

8.1 Table 6: Regression output subsample

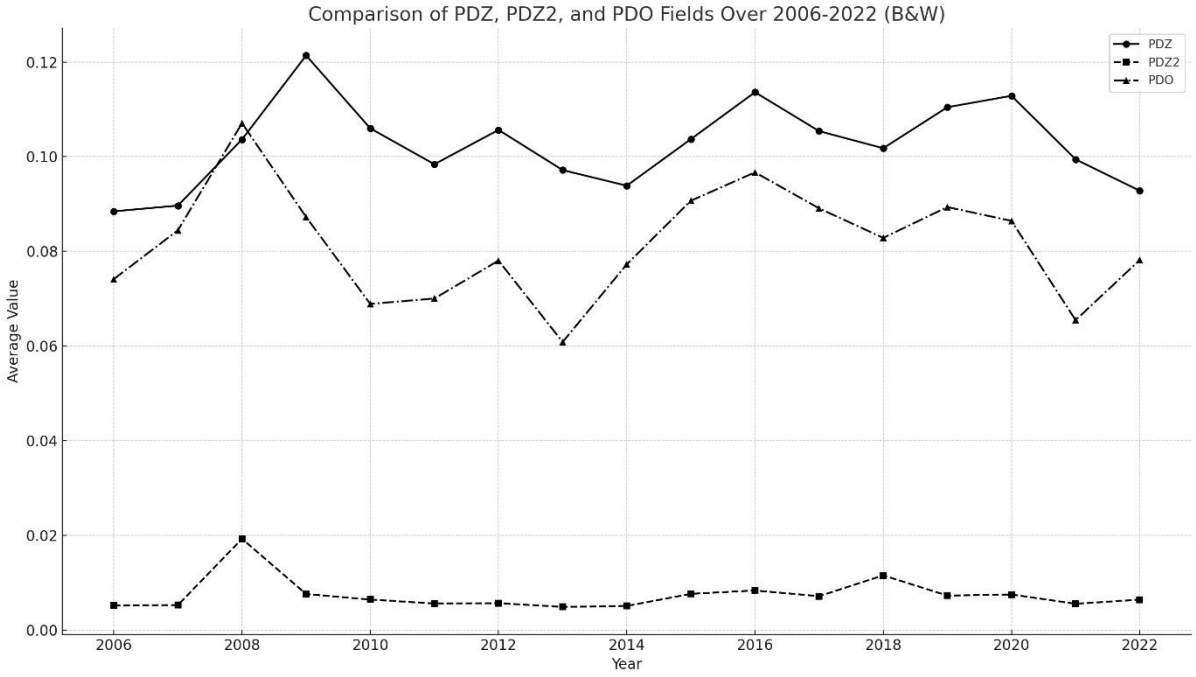
PD Z-Score	Pharmaceuticals	Oil & Gas	Electric Utilities	IT Services & Consulting	Chemicals	Medical Equipment	Telecommunication	Machinery & Equipment & Vehicles	Consumer Goods	Aerospace & Defense	Multiline Utilities	Electrical Components & Equipment	Logistics	Food & Beverage	Automotive	Others
Stock Returns $_{t-1}$	-0.0640***	-0.0413**	-0.0415***	-0.0295***	-0.00996	-0.0157*	-0.0137	-0.0331***	-0.0216***	-0.0242***	-0.0132	-0.0209**	-0.0248***	-0.0314**	-0.0153	-0.0305***
	(-3.36)	(-2.53)	(-3.28)	(-3.50)	(-0.96)	(-1.76)	(-0.41)	(-2.89)	(-3.02)	(-2.76)	(-1.10)	(-2.13)	(-2.76)	(-2.27)	(-1.63)	(-3.06)
CAPEX	-2.82e-08**	3.27e-09**	6.27e-09	1.89e-08**	2.99e-09	-1.36e-09	5.22e-09	-3.86e-09	9.96e-09***	-2.69e-09	1.05e-09	1.69e-08	4.46e-09	-9.31e-09	-4.62e-09	1.30e-08**
	(-2.02)	(2.31)	(1.55)	(2.00)	(0.29)	(-0.10)	(0.72)	(-0.43)	(8.45)	(-0.58)	(0.23)	(1.25)	(0.74)	(-0.67)	(-0.41)	(2.27)
Interest Expense	6.38e-08***	4.86e-08*	8.54e-08***	6.04e-08***	0.000000197***	0.000000149***	3.33e-08***	0.000000142***	-2.13e-09**	5.77e-08***	3.07e-08*	0.000000142***	0.000000100***	0.000000103***	1.27e-08***	0.000000220***
	(4.60)	(1.87)	(5.36)	(2.71)	(4.83)	(7.72)	(2.71)	(4.13)	(-2.12)	(6.44)	(1.86)	(3.27)	(2.90)	(5.42)	(3.49)	(5.49)
Income Tax	1.04e-09	4.87e-10	-3.71e-08***	-1.25e-09	-3.65e-08	-1.16e-08	-8.65e-09	-3.13e-08***	7.11e-09***	-1.20e-08**	-5.91e-08***	-1.04e-09	-1.07e-08	-1.80e-08	2.88e-09	-7.16e-08***
	(0.20)	(0.42)	(-8.06)	(-0.39)	(-1.61)	(-0.84)	(-1.34)	(-3.42)	(3.50)	(-2.60)	(-5.95)	(-0.12)	(-1.63)	(-1.18)	(0.92)	(-11.76)
Unfunded Pension Liabilities $_{t-1}$	-1.52e-09	-4.08e-09	1.42e-08***	-8.41e-10	1.83e-09	1.94e-08**	-1.25e-09	3.30e-09	-1.71e-09***	1.26e-09	1.95e-08***	1.65e-08	3.79e-09*	4.39e-09	-8.50e-10	1.10e-09
	(-0.49)	(-0.83)	(3.56)	(-0.30)	(0.41)	(2.22)	(-0.24)	(0.89)	(-5.71)	(1.22)	(2.65)	(1.52)	(1.83)	(0.48)	(-0.33)	(0.20)
Company Age	0.00173*	0.00612***	-0.00174**	0.000715	-0.00150**	-0.00259***	-0.0107***	0.0000612	-0.00142***	-0.00138**	0.000595	-0.00271***	-0.00358***	0.00238***	0.0000272	-0.00334***
	(1.67)	(4.81)	(-2.23)	(1.15)	(-2.07)	(-4.99)	(-4.03)	(0.10)	(-3.73)	(-2.05)	(0.72)	(-4.23)	(-5.53)	(4.13)	(0.02)	(-4.02)
Constant	-0.152	-0.390***	0.347***	-0.0321	0.188**	0.196***	0.881***	0.0127	0.201***	0.169***	0.225***	0.348***	0.287***	-0.240***	0.0872	0.397***
	(-1.40)	(-4.26)	(5.78)	(-0.96)	(2.54)	(5.77)	(4.83)	(0.24)	(4.27)	(3.41)	(3.81)	(4.50)	(6.69)	(-3.64)	(0.71)	(4.99)
No. of Obs.	80	128	240	112	112	160	80	80	144	96	96	144	96	160	48	144
R^2	0.433	0.279	0.512	0.239	0.255	0.387	0.223	0.470	0.592	0.583	0.467	0.272	0.441	0.302	0.375	0.700
F-Statistics	8.798	7.343	38.36	5.183	5.661	15.16	3.293	10.20	31.25	19.54	12.27	8.030	11.06	10.41	3.907	50.13
P	0.000000402	0.00000119	1.14e-31	0.000113	0.0000434	2.07e-13	0.00658	4.69e-08	5.67e-23	3.86e-14	7.22e-10	0.000000225	4.68e-09	1.44e-09	0.00377	2.10e-31

PD Z"-Score	Pharmaceuticals	Oil & Gas	Electric Utilities	IT Services & Consulting	Chemicals	Medical Equipment	Telecommunication	Machinery & Equipment & Vehicles	Consumer Goods	Aerospace & Defense	Multiline Utilities	Electrical Components & Equipment	Logistics	Food & Beverage	Automotive	Others
Stock Returns $_{t-1}$	-0.000121	0.000880	-0.00345	-0.000835	0.000271	0.0167	-0.0128	-0.000293	-0.00162	-0.00124	0.00210	0.0000318	-0.00217*	-0.00149	-0.00187	0.0218***
	(-0.08)	(0.32)	(-0.34)	(-0.61)	(0.83)	(1.13)	(-0.34)	(-1.04)	(-1.12)	(-1.92)	(0.77)	(0.05)	(-1.78)	(-1.00)	(-1.23)	(2.69)
CAPEX	7.62e-10	2.27e-10	-3.87e-09	8.28e-10	8.35e-10**	1.78e-09	3.26e-09	-7.21e-11	1.66e-09***	-3.27e-10	-1.49e-10	8.90e-10	5.00e-10	-2.32e-09	-3.80e-09**	-7.51e-09
	(0.72)	(0.94)	(-1.18)	(0.54)	(2.57)	(0.76)	(0.39)	(-0.32)	(6.98)	(-0.96)	(-0.14)	(0.96)	(0.61)	(-1.54)	(-2.08)	(-1.62)
Interest Expense	3.41e-09***	5.54e-09	4.19e-09	3.78e-09	7.46e-09***	5.23e-09	1.85e-08	5.32e-09***	-4.99e-11	6.55e-10	3.35e-09	4.26e-09	7.17e-09	4.69e-09**	1.62e-09***	-2.32e-09
	(3.23)	(1.26)	(0.32)	(1.05)	(5.81)	(1.64)	(1.31)	(6.31)	(-0.24)	(0.99)	(0.89)	(1.44)	(1.52)	(2.29)	(2.72)	(-0.07)
Income Tax	-3.63e-10	1.91e-10	-3.61e-08***	-2.75e11	1.36e-10	-1.84e-09	-4.25e-09	-7.21e-10***	5.49e-10	-1.07e-09***	-7.25e-09***	-9.59e-11	-1.96e-09**	-3.86e-09**	6.74e-10	-6.40e-08***
	(-0.91)	(0.96)	(-9.67)	(-0.05)	(0.19)	(-0.81)	(-0.57)	(-3.20)	(1.34)	(-3.15)	(-3.19)	(-0.16)	(-2.19)	(-2.34)	(1.33)	(-12.91)
Unfunded Pension Liabilities $_{t-1}$	-8.32e-11	2.83e-13	2.41e-09	-1.11e-11	-5.77e-11	-2.64e-10	-1.15e-09	-2.01e-11	-2.86e-10***	-1.12e-10	-3.28e-10	-6.68e-10	3.91e-10	5.71e-10	-9.53e-10**	-6.40e-08***
	(-0.35)	(0.00)	(0.75)	(-0.02)	(-0.41)	(-0.18)	(-0.19)	(-0.22)	(-4.72)	(-1.46)	(-0.20)	(-0.90)	(1.39)	(0.58)	(-2.24)	(-0.37)
Company Age	-0.0000296	0.000474**	0.000306	-0.0000954	-0.0000821***	-0.000124	-0.00792**	0.0000102	-0.0000883	-0.00000438	0.000272	-0.0000453	-0.000212**	0.000288***	-0.000315*	-0.000942
	(-0.38)	(2.19)	(0.48)	(-0.95)	(-3.61)	(-1.44)	(-2.60)	(0.71)	(-1.15)	(-0.09)	(1.44)	(-1.03)	(-2.41)	(4.63)	(-1.75)	(-1.39)
Constant	0.00270	-0.0352**	0.00843	0.00615	0.00832***	0.00893	0.568**	-0.00130	0.0111	0.00525	-0.00303	0.00650	0.0161***	-0.0280***	0.0481**	0.134**
	(0.33)	(-2.26)	(0.17)	(1.14)	(3.57)	(1.59)	(2.71)	(-0.99)	(1.17)	(1.44)	(-0.23)	(1.23)	(2.76)	(-3.94)	(2.39)	(2.07)
No. of Obs.	80	128	240	112	112	160	80	80	144	96	96	144	96	160	48	144
R^2	0.153	0.0574	0.323	0.0228	0.339	0.0397	0.0993	0.502	0.440	0.283	0.246	0.0375	0.242	0.185	0.389	0.573
F-Statistics	2.081	1.157	17.45	0.386	8.476	0.993	1.267	11.60	16.87	5.524	4.570	0.838	4.480	5.459	4.136	28.86
P	0.0666	0.334	1.75e-16	0.887	0.000000198	0.432	0.284	6.15e-09	2.62e-14	0.0000731	0.000464	0.543	0.000554	0.0000408	0.00262	1.06e-21

PD O-Score	Pharmaceuticals	Oil & Gas	Electric Utilities	IT Services & Consulting	Chemicals	Medical Equipment	Telecommunication	Machinery & Equipment & Vehicles	Consumer Goods	Aerospace & Defense	Multiline Utilities	Electrical Components & Equipment	Logistics	Food & Beverage	Automotive	Others
Stock Returns $_{t-1}$	-0.000993	-0.0121	-0.0216	-0.0587*	0.00909	-0.00496	0.000340	-0.0205**	-0.0191	-0.0154	0.0253	-0.0144	-0.0178	-0.0617***	-0.00667	-0.0122
	(-0.05)	(-1.53)	(-1.33)	(-1.76)	(0.59)	(-0.37)	(0.01)	(-2.30)	(-0.76)	(-0.90)	(1.36)	(-1.60)	(-0.89)	(-2.90)	(-0.50)	(-0.98)
CAPEX	1.19e-08	1.17e-09*	-1.46e-08***	-1.57e-08	2.30e-08	-8.16e-09	-8.60e-10	-3.58e-09	4.09e-09	-4.74e-09	3.75e-09	-5,64e-09	-3.06e-10	-8.64e-09	-5.88e-10	-6.63e-09
	(0.80)	(1.70)	(-2.81)	(-0.42)	(1.49)	(-0.38)	(-0.13)	(-0.51)	(0.99)	(-0.53)	(0.54)	(-0.45)	(-0.02)	(-0.40)	(-0.04)	(-0.93)
Interest Expense	2.01e-08	2.72e-08**	1.93e-08	5.84e-0.8	0.000000139**	6.34e-08**	-6.81e-09	8.10e-08***	1.09e-09	-3.23e-08*	-8.27e-09	4.47e-09	7.48e-08	1.22e-08	9.26e-09*	2.77e-08
	(1.37)	(2.16)	(0.94)	(0.66)	(2.27)	(2.20)	(-0.59)	(3.04)	(0.31)	(-1.85)	(-0.32)	(0.11)	(0.97)	(0.42)	(1.78)	(0.55)
Income Tax	-5.48e-09	2.06e-10	-5.83e-08***	-1.49e-08	-7.27e-08**	-1.11e-08	2.22e-09	-4.11e-08***	-3.09e-09	-1.24e-08	-5.61e-08***	-3.00e-09	-5.48e-08***	-4.99e-08**	-7.00e10	-4.69e-08***
	(-0.99)	(0.36)	(-9.83)	(-1.17)	(-2.15)	(-0.54)	(0.37)	(-5.78)	(-0.43)	(-1.39)	(-3.63)	(-0.37)	(-3.72)	(-2.13)	(-0.16)	(-6.14)
Unfunded Pension Liabilities $_{t-1}$	2.15e-09	-1.86e-09	5.30e-09	-3.42e-09	-1.71e-08**	-4.21e-09	-2.09e-09	-4.02e-09	-1.36e-10	1.02e-09	5.99e-09	-7.90e-09	1.18e-08**	-2.85e-09	1.93e-09	-1.19e-09
	(0.65)	(-0.78)	(1.03)	(-0.31)	(-2.56)	(-0.32)	(-0.43)	(-1.40)	(-0.13)	(0.50)	(0.52)	(-0.79)	(2.54)	(-0.20)	(0.52)	(-0.17)
Company Age	-0.000298	0.00159**	0.000417	-0.00836***	-0.00446***	0.0000629	0.00494*	-0.00114**	0.00648***	0.000620	-0.00303**	0.000682	-0.00118	-0.00175*	0.00372**	-0.00397***
	(-0.27)	(2.57)	(0.42)	(-3.40)	(-4.13)	(0.08)	(1.99)	(-2.51)	(4.85)	(0.47)	(-2.37)	(1.16)	(-0.82)	(-1.98)	(2.35)	(-3.80)
Constant	0.0434	-0.106**	0.120	0.640***	0.550***	0.0356	-0.259	0.153***	-0.677***	0.0759	0.356***	-0.0341	0.172*	0.336***	-0.364**	0.471***
	(0.38)	(-2.39)	(1.55)	(4.86)	(4.97)	(0.70)	(-1.51)	(3.68)	(-4.10)	(0.78)	(3.89)	(-0.48)	(1.79)	(3.32)	(-2.06)	(4.72)
No. of Obs.	80	128	240	112	112	160	80	80	144	96	96	144	96	160	48	144
R^2	0.0561	0.142	0.330	0.174	0.293	0.0480	0.0656	0.547	0.162	0.0645	0.218	0.0322	0.217	0.126	0.209	0.320
F-Statistics	0.684	3.137	17.96	3.483	6.852	1.210	0.807	13.89	4.159	0.965	3.908	0.715	3.874	3.460	1.713	10.14
P	0.663	0.00698	6.55e-17	0.00363	0.00000420	0.304	0.568	2.77e-10	0.000744	0.454	0.00172	0.638	0.00184	0.00318	0.144	3.62e-09

t statistics in parentheses * p<0.10, ** p<0.05, *** p<0.01

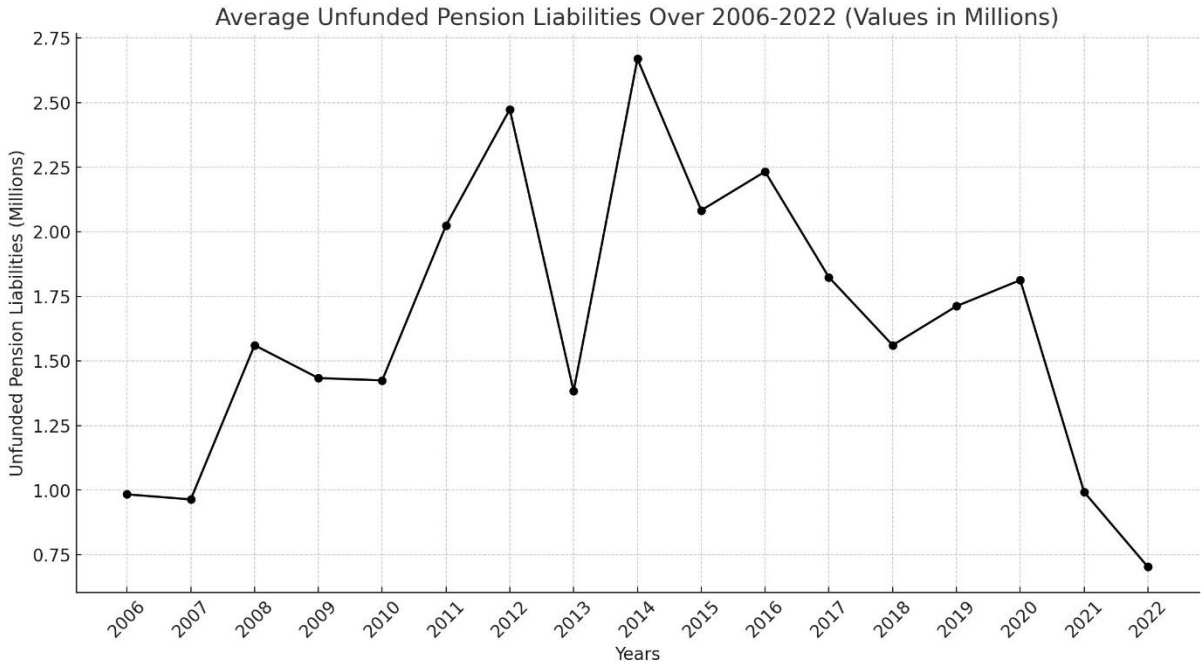
8.2 Figure 1: Comparing probability of default by model 2006-2022



8.3 Table 7: Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
CAPEX	2.29	0.436848
Income Tax	1.65	0.604963
Interest Expense	1.54	0.647659
Unfunded Pension Liabilities $_{t-1}$	1.40	0.712083
Company Age	1.03	0.971182
Stock Returns $_{t-1}$	1.02	0.978184
Overall	1.49	

8.4 Figure 2: Evolution of average unfunded pension liabilities



8.5 Table 8: LASSO Coefficient

active	PDZ	PDZ2	PDO
Stock Returns $_{t-1}$	X	X	X
CAPEX	X	X	X
Interest Expense	X	X	X
Income Tax	X	X	X
Unfunded Pension Liabilities $_{t-1}$	X	X	X
Company Age	X	X	X
Constant	X	X	X

Legend:

b – base level

e – empty cell

o – omitted

x – estimated

9 References

Alam, S. M. I. (2022). *James Ohlson O-Score for Predicting Corporate Bankruptcy*. https://doi.org/10.13140/RG.2.2.13601.28005

Altman, E. I. (1968). Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy. *The Journal of Finance*, *23*(4), 589–609. JSTOR. https://doi.org/10.2307/2978933

Altman, E. I. (1983). *Corporate financial distress: A complete guide to predicting, avoiding, and dealing with bankruptcy*. https://api.semanticscholar.org/CorpusID:166991892

Altman, E. I., Malgorzata, I.-D., Erkki, K. L., & Suvas, A. (2014). *Distressed Firm and Bankruptcy Prediction in an International Context: A Review and Empirical Analysis of Altman's Z-Score Model*. 1–47.

Asthana, S. (2008). *Factors affecting corporate choices of postretirement benefits in the USA*. Accounting Research Journal.

Bader, L. N. (2003). Treatment of Pension Plans in a Corporate Valuation. *Financial Analysts Journal*, *59*(3), 19–24. https://doi.org/10.2469/faj.v59.n3.2527

Bodie, Z. (1990). The ABO, the PBO and Pension Investment Policy. *Financial Analysts Journal*, *46*(5), 27–34. JSTOR.

Broadbent, J., Palumbo, M., & Woodman, E. (2006). *The Shift from Defined Benefit to Defined Contribution Pension Plans—Implications for Asset Allocation and Risk Management*. https://www.bis.org/publ/wgpapers/cgfs27broadbent3.pdf

Clark, R. L., Craig, L. A., & Wilson, J. W. (2003). *A History of Public Sector Pensions in the United States*.

Coronado, J. L., & Copeland, P. C. (2004). Cash Balance Pension Plan Conversions and the New Economy. *Journal of Pension Economics and Finance*, *3*, 297–314. https://doi.org/10.1017/S1474747204001684

Dennis, H. (2002). *The Retirement Planning Specialty*. American Society on Aging.

Franzoni, F., & Marín, J. M. (2006). Pension Plan Funding and Stock Market Efficiency. *The Journal of Finance*, *61*(2), 921–956. JSTOR.

Guerriero, E. J. (2009). Pension Protection Act of 2006: Effects on Defined-Benefit Plans. *Journal of Financial Service Professionals*, *Vol. 63*, p58-70.

LaMonte, M. (2006). *Pension Reform Will Increase Funding Requirements for Under-funded U.S. Pension Plans*. http://dx.doi.org/10.2139/ssrn.979819

Ohlson, J. A. (1980). Financial Ratios and the Probabilistic Prediction of Bankruptcy. *Journal of Accounting Research*, *18*(1), 109–131. JSTOR. https://doi.org/10.2307/2490395

Pearson, K. (1894). Contributions to the Mathematical Theory of Evolution. *Philosophical Transactions of the Royal Society of London. A*, *185*, 71–110. JSTOR.

Rauh, J. D. (2006). Investment and Financing Constraints: Evidence from the Funding of Corporate Pension Plans. *The Journal of Finance*, *61*(1), 33–71. JSTOR.

Xu, M., & Zhang, C. (2009). Bankruptcy prediction: The case of Japanese listed companies. *Review of Accounting Studies*, *14*(4), 534–558. https://doi.org/10.1007/s11142-008-9080-5

Zhao, T. (2015). The Relationship between Z-Score and Stock Prices. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2595600