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Revealing the Black Box of Pension Fund Behavior

An Empirical Analysis of Norwegian Pension Funds in a Reach-for-Yield Environment

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Abstract

After the financial crisis in 2008, low-interest rates, increased life expectancy, and falling birth rates have put pension funds under pressure. In response, pension funds have increased their allocation towards risky assets to meet their return guarantees (the basic interest rate). This thesis analyses the determinants of the asset allocation of Norwegian pension funds. Further, we examine how the increased allocation to risky assets has impacted their relative performance and solvency position.

We provide evidence that the basic interest rate is an important determinant for the allocation to risky assets. Our results suggest that public and private funds react differently to a change in the basic interest rate. Moreover, our analysis showcase that funds with higher buffer capital tend to utilize their risk capacity by investing more in risky assets. Additionally, our evidence indicates that public funds outperform the benchmark when they reach for yield, compared to private funds.

Furthermore, we have examined the solvency position of the funds. Our analysis suggests that the reach for yield has negatively impacted their solvency position, ceteris paribus. However, we find that the building of buffer capital has offset the negative effect of the increased risky allocation. Lastly, our analysis highlights that funds with an inadequate solvency position react to this by reaching for yield.

Contents

1 Introduction **1**

2 Literature Review **5**
2.1 Risky Allocation 5
2.2 Performance 7
2.3 Solvency II 8

3 Norwegian Institutional Setting and Solvency II Regulation **9**
3.1 Norwegian Institutional Setting 9
3.1.1 Balance Sheet Mechanisms 11
3.1.2 Paid-Up Policy Contracts 12
3.2 Solvency II Regulation 13
3.2.1 Modified Stress Test 1 15
3.2.2 Market Risk 17

4 Data **20**
4.1 The Construction of the Dataset 20
4.1.1 Treatment of Missing Values in the Dataset 20
4.2 The Construction of the Benchmark 22
4.3 The Construction of the SCR Ratio 22
4.4 Data Limitations 23

5 Empirical Analysis **25**
5.1 Andonov et al. (2017) 25
5.1.1 The Regulatory Incentive Hypothesis 26
5.1.2 Motivation 27
5.2 Summary Statistics 27
5.3 Findings 31
5.3.1 Pension Fund Maturity and Allocation to Risky Assets 31
5.3.2 Norwegian-Specific Variables and Allocation to Risky Assets . . . 34
5.3.3 SCR Ratio and Allocation to Risky Assets 39
5.3.4 Net Benchmark-Adjusted Return 41
5.3.5 Pension Fund Performance 42
5.3.6 Norwegian Specific Variables and Pension Fund Performance . . . 44
5.3.7 SCR Ratio and Pension Fund Performance 47
5.4 SCR Ratio Dynamics: Exploring Drivers of Change 49
5.4.1 Dynamics on a One-Year Basis 51
5.4.2 Dynamics on a Two-Year Basis 51
5.4.3 Dynamics on a Three-Year Basis 52
5.5 Analyzing Measures Funds Take to Improve their Solvency Position . . . 53

6 Conclusion **57**

References **59**

Appendix **63**
A1 Abbreviations 63

List of Figures

1.1 Evolution of the yield, risky allocation, and the basic interest rate 2
3.1 Solvency II hierarchy. 16

List of Tables

3.1 Correlation matrix 17
5.1 Summary statistics for 2009 and 2021 28
5.2 Development in asset allocation for private and public pension funds . . . 30
5.3 Pension fund maturity and allocation to risky assets 32
5.4 Norwegian-specific variables and allocation to risky assets 35
5.5 SCR ratio and allocation to risky assets 40
5.6 Pension fund performance 42
5.7 Norwegian specific variables and pension fund performance 45
5.8 SCR ratio and pension fund performance 48
5.9 Drivers of change in the SCR ratio in the short and medium-term 50
5.10 Measures funds take to improve their solvency position 54
A1.1 List of abbreviations 63

1 Introduction

In the aftermath of the financial crisis in 2008, major economies experienced low growth, declining inflation rates, and quantitative easing, leading to a prolonged period of low interest rates. Combined with increased longevity expectations and falling birth rates, this has caused significant challenges for the global pension systems. In the next three decades, the gap between retirement savings and retirement income needs is projected to reach USD 400 trillion - more than five times the size of the global economy (Yik, 2019).

The described economic climate has also affected large institutional asset managers, such as life insurance companies and pension funds. Firstly, the value of future pension liabilities is directly affected by the interest rates, as the liabilities (in most jurisdictions) are discounted using long-term government bond yields. In our sample period (2009-2021), the interest rates have been falling, increasing the present value of the pension liabilities. Secondly, the low interest rates have also affected the expected return on low-risk assets. Given that the pension funds have an underlying return guarantee embedded into their pension portfolio, they can no longer meet this guarantee by only holding low-risk assets. Consequently, pension funds and other institutional investors have sought riskier and more illiquid investments to earn their required return. According to International Monetary Fund (IMF), pension funds globally have increased their exposure towards alternative investments with significant embedded leverage and long lockup periods – ultimately increasing the risk of financial instability (IMF, 2019, p. 39). The findings also align with Rauh (2006), who finds that pension funds are encouraged to allocate towards higher-yielding assets in a low-interest-rate environment to meet their long-term return targets. Figure 1 provides a visual representation of the challenges pension funds have faced since the financial crisis in 2008. The figure showcase that the yield has fallen below the return guarantee (the basic interest rate). In response, the pension funds have invested more in risky assets to compensate for the low expected return on low-risk assets.

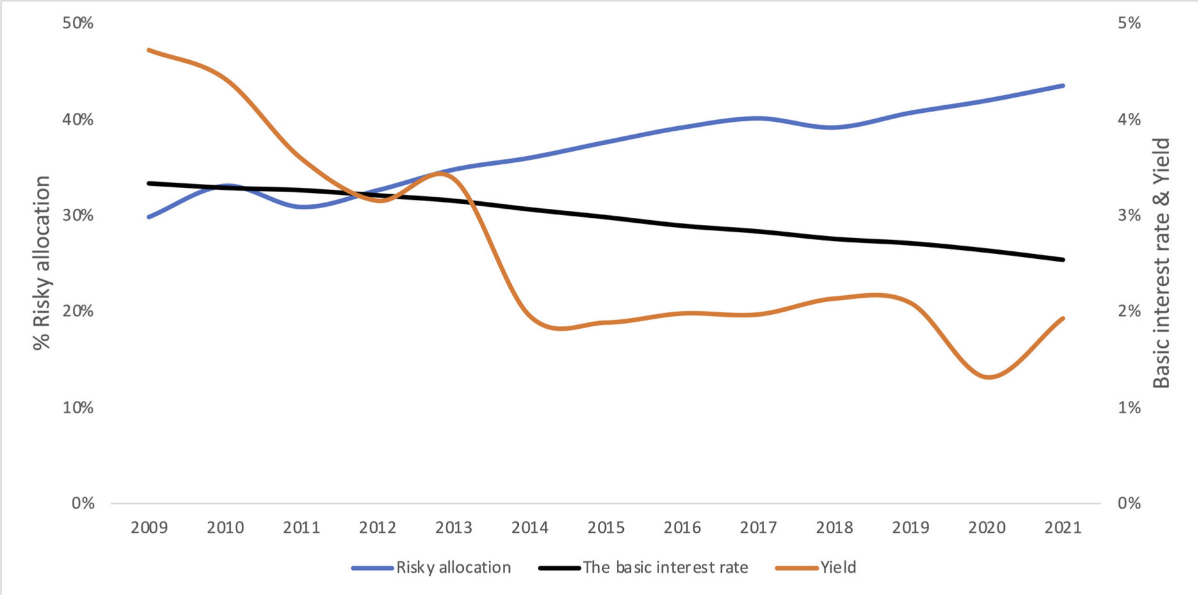


Figure 1.1: Evolution of the yield, risky allocation, and the basic interest rate

As of 2021, the total assets under management for pension funds globally surpassed USD 38 trillion, which makes them among the most influential institutional investors on an aggregated level (OECD, 2019, p. 7). Given their substantial size and systemic importance, the asset composition and risk management in pension funds are of great interest to both the regulatory authorities and the society as a whole. The importance was highlighted in September 2022, when UK pension funds were forced to liquidate their holdings to meet margin calls. The margin calls were triggered because of an urgent 130 basis points rise in the 30-year nominal yield following the announcement of the UK Government's growth plan. In response, the Bank of England intervened by purchasing long-dated government bonds of £19.3 billion over 13 days (Breeden, 2022, p. 3). The UK pension crisis highlights the importance of understanding how pension funds have adapted to prolonged periods with low interest rates. There has also been turmoil in the Norwegian pension market when the pension provider Silver Pensjonsforsikring was put under public administration in 2017. Silver mainly focused on paid-up policy contracts and faced difficulties in effectively managing the challenges associated with low interest rates and demographic trends (Forbrukerrådet, 2018, p. 6). 21 000 pension members with pension claims of NOK 10 billion were affected (Storebrand, 2017).

This paper aims to study the asset allocation of Norwegian pension funds from 2009 to 2021 in a period with falling interest rates. We further analyze how the increased allocation to risky assets has affected their relative performance and solvency position. To facilitate our analyses, we have assembled a comprehensive database with manually collected data on 75 Norwegian pension funds. At the end of 2021, these funds managed approximately NOK 440 billion divided on 620 000 pension contracts[1]. Given the magnitude and extent of pension funds, their significance becomes evident in both the financial market and the pensions of current and former employees of Norwegian businesses.

The empirical analysis is divided into three parts. Parts one and two are inspired by a study conducted by Andonov et al. (2017). The study investigates potential drivers towards a risky allocation for U.S., European, and Canadian funds and the implications these drivers have on relative performance. We are interested in investigating if the same drivers apply to the Norwegian pension funds and how the drivers affect the relative performance. In the first part of our empirical analysis, we investigate potential drivers of risky allocation through a pooled OLS regression on demographic, financial, and fund-specific variables. We identify that a fund is more likely to increase its risky allocation when the basic interest rate increases. However, when controlling for the difference between public and private funds, we see that public funds respond differently to an increase in the basic interest rate. Further, we find that funds with higher buffer capital tend to allocate more to risky assets. We hypothesize that higher buffer capital increases the risk capacity of the funds, leading to an increase in the risky allocation.

The second part of our empirical analysis investigates potential drivers of benchmark-adjusted returns. We are interested in investigating if the increased allocation towards more risky assets has impacted their benchmark-adjusted returns. We evaluate the performance through a pooled OLS regression on demographic, financial, and fund-specific variables. Our results suggest that public funds outperform the benchmark when they increase the allocation to risky assets. In contrast, we cannot find the same evidence for private funds. Further, our results indicate a persistence in returns on a three-year basis.

In our final empirical analysis, we investigate drivers that influence the solvency position of a fund through a pooled OLS regression. In addition, we provide a difference-in-difference analysis of funds' measures to improve their solvency position. We find that changes in the asset allocation are the greatest influence on the solvency position over time. Further, our

[1] A member can have pension contracts in different funds. Consequently, the number of unique members is likely lower.

difference-in-difference analysis highlights that funds with an inadequate solvency position respond by surprisingly increasing their allocation towards more risky assets, such as real estate. We hypothesize that funds with an inadequate solvency position invest more in risky assets with the rationale of building capital buffers through higher expected returns.

This thesis contributes to the current research of pension funds by constructing a new data set on Norwegian pension funds. In our opinion, we have created the most comprehensive data set on Norwegian pension funds due to its scope and magnitude. The dataset further allows us to study the relationship between risky allocation, performance, and solvency on Norwegian-specific variables. We find this interesting for three reasons. Firstly, previous studies on pension funds have mainly been conducted on data from the U.S. and Europe. Due to the differences in regulation and complexity between countries, the results conducted in the U.S. and Europe may not be representative of Norwegian pension funds. Secondly, to our knowledge, this is the first time anyone has studied the relationship between risky asset allocation, fund performance, and solvency. Most research has looked at pension fund performance and the implementation of Solvency II separately. However, they have not tied the risky allocation to a fund's performance and solvency position. Thirdly, our empirical analysis contributes to the literature by analyzing the factors that influence a change in the solvency position of a fund. In addition, we contribute with an analysis showcasing the measures a fund takes when dealing with an inadequate solvency position.

The proceeding sections of the thesis are structured in the following way: Section two briefly summarizes the existing literature on pension fund asset allocation, performance, and adaptation to Solvency II. Section three describes how pension funds operate in Norway and the theory regarding the Solvency II regulation. Section four will give an in-depth description of how we have constructed the data set and potential data limitations. Section five presents our empirical analysis, and we present the determinants for allocation to risky assets and how this relates to the performance of the funds. This section also addresses the solvency position of a fund and identifies the drivers behind a change in the solvency position. Lastly, we examine the measures taken by a fund with an inadequate solvency position. Section seven summarizes and concludes the thesis.

2 Literature Review

This section briefly overviews the literature on pension fund asset allocation, performance, and the implementation of Solvency II. Despite their systemic importance in the financial market and their ability to facilitate inter-generational risk-sharing (Merton, 1983; Shiller, 1998), pension funds have received limited scholarly attention. The limited attention can be explained by the lack of available data and the complex nature of pension regulations (Andonov et al., 2012; Antolin, 2008). According to Mohan & Zhang (2014), comprehensive and consistent data on individual pension funds over more extended periods are scarce in countries outside the U.S.

We structure this section in the same way as the empirical structure of the thesis. We begin with an overview of the literature on the implications of low interest rates and asset allocation. Afterward, we present research examining the performance of pension funds. Finally, we present literature on how the implementation of Solvency II has affected the asset allocation of life insurance companies and pension funds.

2.1 Risky Allocation

Several studies have examined the consequences of low interest rates and the allocation to risky assets for asset managers. Evidence from Choi & Kronlund (2018) suggests that mutual funds generate greater returns and attract more inflow when they reach for yield, especially in periods with low interest rates. The finding also aligns with the study from Hau & Lai (2016), which examined asset allocation and monetary policies in the eurozone. They found that fund investors in countries with decreasing real-interest rates shifted the allocation from money market funds to riskier equity markets.

Evidence from pension funds and life insurance companies aligns with the findings in mutual funds. Andonov et al. (2017) found that U.S. public pension funds hold more risky assets than their private and European counterparts when the yield is falling. They relate the finding to the regulatory incentives in the U.S., which is discussed more closely in Section 5.1 of the thesis. Lu et al. (2019) find the same results: U.S. public pension funds reach for yield by taking more investment risk in a low interest rate environment. We contribute to the literature by conducting the same analysis on Norwegian pension funds. Our results suggest that both public and private funds in Norway reach for yield when the interest rates are falling. We further contribute to the literature by examining Norwegian-specific variables and the allocation to risky assets. Our results suggest that the return guarantee embedded in the pension contracts is an important variable in explaining the risky allocation in Norwegian pension funds.

Previous literature has studied fund maturity and the allocation to risky assets. Bikker et al. (2012) argue that the age of pension fund participants is crucial in explaining the fund's asset allocation. Further, they argue that the proportion of risky assets invested should decrease over the life cycle of the fund, thereby increasing the proportion of relatively safer bonds. The same result can be found in Novy-Marx & Rauh (2009), where they found a positive correlation between risk-taking and the share of active employees in U.S. private pension plans. We contribute to the literature by examining fund maturity and asset allocation in Norwegian pension funds. Our analysis suggests no relationship between fund maturity and risky allocation. We further argue that the disparity between our findings and previous literature can be attributed to differences in time periods and regulations.

Domanski et al. (2017) suggest that institutional investors take more financial risk when facing a tightening mismatch between assets and liabilities due to low interest rates. Another study by Chodorow-Reich (2014) looked at the implication of quantitative easing and low interest rates on the asset allocation in life insurance companies. He found that life insurance companies have increased their allocation to risky assets as a consequence of quantitative easing.

There is also evidence of reach for yield in the corporate bond market. Becker & Ivashina (2015) found that investors' propensity to buy high-yield bonds increases in periods with low-interest rates. They also find that life insurance companies reach for yield in periods with lower interest rates. The same results are found in a study by Ozdagli & Wang (2019). Life insurance companies, the largest institutional holders of corporate bonds, tilt their portfolios towards high-yield bonds when interest rates decline. This is consistent with our findings in Norwegian pension funds.

2.2 Performance

The empirical literature on pension fund performance is relatively limited. Antolin (2008) provides a comprehensive international summary of pension fund performance by looking at the Sharpe ratio of the funds. The study found that pension funds have generally underperformed the hypothetical portfolio with the highest (mean) return for a given level of risk (i.e., an ex-post efficient frontier). The underperformance was greater in countries with quantitative investment restrictions, such as legal restrictions. Antolin (2008) highlights the difficulties in collecting the performance data as a potential source of bias.

Andonov et al. (2017) have studied the performance of U.S. private and public pension funds. They found that U.S. public funds tend to underperform the benchmark compared to their private and European counterparts. They relate the underperformance of public funds to the Liability Discount Rate (LDR) and "the regulatory incentives hypothesis." A further explanation of this study will be covered in Section 5.1 later in the thesis. The main critique of the study is the importance of benchmark selection, highlighted by Broeders & De Haan (2020), who extend this line of research on Dutch pension funds. We contribute to the literature by studying the performance of public and private Norwegian pension funds. However, our results suggest the opposite of the findings in the U.S. In Norway, public funds tend to outperform private funds when they reach for yield. We hypothesize that the disparity between Norwegian and U.S. public funds can be attributed to the differences in regulation.

Cremers & Pareek (2016) have studied mutual funds and their relative performance to the benchmark. They show that mutual funds that both deviate substantially from their benchmarks and are patient in their strategies can achieve significant outperformance. A higher duration on the invested assets is associated with a significant outperformance of around 2% annually. González et al. (2020) found the same results in pension funds. Funds with higher activity and a longer asset duration tend to outperform the benchmark. The activity is measured as the stock allocation deviation from a typical pension fund behavior. The results from the study indicate that funds with patience to exploit long-term opportunities can outperform the benchmark.

Forbrukerrådet (2018) investigated the potential persistency in returns for Norwegian mutual funds. By comparing actively managed funds with index funds, they find that most actively managed funds underperform the index. In addition, they find limited evidence of any consistent outperformance for the funds outperforming the index in a given year. We contribute to the literature by examining the potential for return persistence in Norwegian pension funds. Our findings point in the same direction, where no consistent return persistency seems to exist.

2.3 Solvency II

The Solvency II directive is the current regulatory framework for European life insurance companies. The directive was implemented in 2016, and its implication on asset allocation has been studied in previous literature. Braun et al. (2017) studied if insurance companies reduced their exposure to risky assets such as stocks, high-yield bonds, and alternative investments because of the implementation of Solvency II. The study found that the new capital requirement, in isolation, reduces the amount of risky assets in life insurance companies. The asymmetrical relationship between risky assets and buffer capital is the main argument for why life insurance companies reduce their allocation to risky assets. For every dollar invested, the life insurance companies need approximately 30-50% in buffer capital, implying that they need inefficiently high levels of buffer capital to maintain the same level of risk exposure.

Bjøru et al. (2016) concluded in the same direction regarding the implementation of Solvency II in Norwegian pension funds. They argue that implementing Solvency II will decrease the risky allocation in pension funds and increase the demand for bonds with the same duration as their commitments. Interest rate movements significantly impact future obligations under Solvency II, and the pension funds desire to immunize the interest rate risk with corresponding assets. This trend has been evident in retrospect of the implementation of Solvency II in life insurance companies. However, we find no evidence that the pension funds have reduced their allocation to risky assets after the implementation of Solvency II in 2019. Additionally, we contribute to the literature by examining the factors that influence the solvency position of a fund and the measures funds take to improve their inadequate solvency position.

3 Norwegian Institutional Setting and Solvency II Regulation

This section describes the Norwegian institutional setting and the Solvency II regulation. We start with an explanation of the objective of a pension fund and the differences between defined benefit and defined contribution plans. Further, we describe the budget equation and the most crucial balance sheet mechanisms before explaining the challenges in the paid-up policy market. Finally, we briefly introduce the Solvency II regulation and the modified stress test from the Norwegian Financial Supervisory Authority. To avoid any ambiguities, we have listed all abbreviations used throughout the thesis in Appendix A1.

3.1 Norwegian Institutional Setting

A pension fund manages pension plans for former and current employees on behalf of a sponsor. The sponsor could be private companies, municipalities, and other public enterprises. The pension funds were initially established as separate legal entities with two objectives: to mitigate the risk of pension assets being adversely affected by a potential bankruptcy in the sponsor and to ensure cost-efficient management of the defined benefit plans. A defined benefit pension plan is a pension scheme where the sponsor guarantees their employees a predefined amount of pension payments at retirement age. The size of future pension disbursements depends on the employee's future earnings, tenure of service, and age. For example, an employee in a public enterprise with 30 years of seniority will receive 66% of their salary in annual pension disbursements at retirement age.

Until 2001, the defined benefit plan was the mandated pension scheme for Norwegian businesses (Sørlie, 2011, p. 50). However, a regulatory change in that year granted businesses the flexibility to opt for either defined benefit or defined contribution plans. The main critique of the defined benefit plans was that they were unpredictable and costly for the sponsors. Consequently, most private sponsors implemented the defined contribution plan for their employees. A defined contribution plan is a pension plan where the risk of the pension disbursements is transferred to the employee. The employer contributes a given amount to the employee's pension account. In Norway, the annual contributions should be at least 2% of the annual salary - up to 12 times the national insurance scheme basic amount (Ministry of Labour and Social Inclusion, 2022). As of today, the defined contribution plans are typically managed by life insurance companies.

One fundamental characteristic of Norwegian pension funds is the return guarantee embedded in their pension contracts - often called the Basic Interest Rate (BIR). The BIR is the weighted average of all historical pension claims and their respective return guarantee. The BIR has two main implications for the pension funds. The first implication is that the return guarantee requires them to make asset allocations that expose them to market fluctuations. In our sample period, the declining interest rates have caused most funds to have a BIR higher than the current interest rate level. Consequently, this has created a situation where the underlying return guarantee cannot be met by only investing in low-risk assets. This has pressured the pension funds to reach for yield in risky assets, such as equities, high-yield bonds, and alternative investments. As we will see in the empirical analysis, the level of the BIR is an essential determinant when explaining the asset allocation in Norwegian funds.

The second implication is that the BIR is a part of the budget equation for the pension funds. Equation 3.1 expresses the relationship between the basic interest rate, premium payments, and future pension disbursements:

$$\text{Premium income} + \text{Financial income} = \text{Pension disbursements} \tag{3.1}$$

The budget equation states that the premium payments and financial income must be sufficient over time to cover the future pension disbursement. The sponsor calculates the future disbursements of pensions by estimating the tenure of service, future earnings, and life expectancy of the employee. Further, the sponsor calculates the financial income using the BIR. Consequently, the premium payments from the sponsor are calculated as a plug number, covering the difference between future pension disbursement and the expected financial income. If any imbalances in the equation were to occur, the legislation allows the funds to either draw on their additional reserves or their premium fund (Bjøru et al., 2016, p. 21). This will be described in more detail in the following subsection.

3.1.1 Balance Sheet Mechanisms

This section briefly explains a pension fund's main balance sheet items and mechanisms. The balance sheet of a pension fund is complex and difficult to comprehend. To enhance the understanding of the empirical analysis, we find it important to give an overview of the main balance sheet items and how they work. Going forward, we present the premium reserve before presenting the premium fund, additional reserves, and the value adjustment fund.

Premium Reserve

The premium reserve constitutes the largest part of the liability side of the balance sheet. The premium reserve is the present value of all future pension disbursements to the pension members, discounted with the BIR. When fund members retire, the pensions are paid from the premium reserve - ultimately reducing the present value of future pension obligations. If the economical and demographical assumptions of future pension disbursements remain unchanged, the premium reserve will represent the exact value of future pension disbursements (Bjøru et al., 2016, p. 21). However, if the assumptions were to change, the actual value of the pension liabilities would deviate from the estimated premium reserve. For example, in our sample period, the life expectancy of the pension members has increased, consequently increasing the premium reserve.

Premium Fund

In periods where the realized return exceeds the BIR, the funds get a positive interest result. In such instances, the funds can distribute the surplus towards a premium fund. However, if the interest result is negative, the funds can draw on the premium fund to ensure balance in their liquidity budget.

Additional Reserves

Another way of distributing the surplus from the interest result is to the additional reserves. The additional reserves can also cover a negative interest result like the premium fund. However, an important difference is that the additional reserves cannot exceed 12% of the premium reserve (The Financial Supervisory Authority, 2019, p. 5).

Value Adjustment Fund

The value adjustment fund comprises the aggregated unrealized returns in the investment portfolio. The value adjustment fund gives the flexibility of realizing returns in periods with a negative interest result.

Common for the premium fund, additional reserves, and the value adjustment fund is that they allow pension funds to smooth the underlying volatility of their returns. In years with strong performance, the pension funds accumulate buffer capital which can be utilized in periods with poor performance.

3.1.2 Paid-Up Policy Contracts

A paid-up policy contract is the pension entitlements you acquire from a previous employment engagement. Put differently, the rights you have earned through previous employment are gathered in a paid-up policy contract as proof of the pension rights you are entitled to. In addition, a paid-up policy contract can also be issued when an enterprise transfer its employees from a defined benefit to a defined contribution plan. The latter has been observed in the Norwegian pension market after the implementation of defined contribution plans in 2001. As an example, Equinor Pensjon closed its defined benefit pension plan for new members and transferred the employees with more than 15 years until retirement to a defined contribution plan in 2015. 13 000 employees were given a paid-up policy contract for their earned rights in the defined benefit plan up to this point (Equinor Pensjon, 2016, p. 4). As of 2018, more than 700 000 people have paid-up policy pension rights, mainly managed by life insurance companies. The total value of these paid-up policy contracts is estimated to be over NOK 350 billion, with claims projected to reach over NOK 500 billion in 2028 (Hippe & Lillevold, 2018, p. 7). In comparison, the pension funds in our sample have Assets Under Management (AUM) of NOK 440 billion. The numbers highlight the increasing importance of paid-up policy contracts in the Norwegian pension market.

Previously, paid-up-policy contracts were typically transferred from pension funds to life insurance companies. However, in recent years life insurance companies have been reluctant to take on these contracts. This has mainly been attributed to three factors. Firstly, the low interest rate environment has increased the liabilities' present value and made it harder to achieve the embedded return guarantee in the pension contracts at a desired risk level. Secondly, the increased life expectancy has also increased the true value of the pension liabilities. Ultimately leading to a greater cost for the life insurance companies. Lastly, since no premiums are paid into these contracts, it is harder to be compensated for the increased risk through premium payments (Bjøru et al., 2016, p. 18). The challenges described above are some of the reasons why Silver Pensjonsforsikring was put under public administration, as explained in the introduction. Consequently, the market for the transfer of paid-up policy contracts has been non-existing in recent years. Most life insurance companies have been unwilling to take the risk associated with paid-up policy contracts. The pension funds, therefore, have started to manage their paid-up policy contracts on the same balance as their defined benefit pension plans.

The asymmetrical return distribution in private paid-up policy contracts has been amongst the most discussed topics in the Norwegian pension market. In private plans, a positive interest result is distributed by a 20/80 rule, where the pension fund gets 20% of the excess return, and the owner of the paid-up policy contract gets 80%. However, if the interest result is negative, the fund is responsible for 100% of the downside. This distribution mechanism causes an asymmetrical relationship, where the funds are responsible for 100% of the downside but only get 20% of the upside. Overall, this incentivizes the funds with paid-up policy contracts to be more risk-averse with their asset allocation. Bjøru et al. (2016) find the allocation towards risky assets in paid-up policy contracts to be remarkably low and further argues that a long-term risk-reward consideration cannot justify this. Compared to a "traditional" pension plan with retirees and active employees, Bjøru et al. (2016) estimates that the holders of private paid-up policy contracts will earn 15% less on a 15-year time horizon - ultimately losing their purchasing power over time. In contrast, for public funds, the regulation of paid-up policy contracts is determined by the general development in prices and salaries over time, avoiding the same type of asymmetry. The asymmetrical return distribution will be central for our empirical analysis later on. For an in-depth analysis of the criticism and potential solutions for the “Paid-up policy problem,” we refer to Hippe & Lillevold (2018).

3.2 Solvency II Regulation

The European Commission has introduced a new directive, Solvency II, to enhance financial stability in the life insurance market. Solvency II has replaced the old Solvency I directive, which was deemed outdated and insufficient in light of the financial crisis in 2008. The directive was implemented on January 1st, 2016, and has significantly changed how insurance companies in the European economic area manage and report their risk. A key feature of Solvency II is the update of the capital adequacy requirements, introducing a new Solvency Capital Requirement ratio (SCR ratio). The new requirement intends to help life insurance companies withstand potential losses from various sources, such as market risk, particularly during extreme market downturns (EIOPA, 2014, p. 30). Solvency II builds on the same three pillars as the Basel framework, and are the following:

Pillar 1: Quantitative Requirements - This pillar includes the quantitative requirements for insurers, such as the amount of capital they must hold to cover their risks. The pillar requires insurers to undertake a risk assessment concerning their assets and liabilities, including different stress test scenarios. Pillar 1 also establishes guidelines for the valuation of assets and liabilities.

Pillar 2: Supervisory Review - This pillar focuses on the supervisory review and evaluation process. The pillar involves that the regulatory authorities must asses the internal risk management of the insurer and review their financial condition. The supervisory authorities may also come with recommendations or impose corrective actions on insurers to ensure compliance with the Solvency II requirements.

Pillar 3: Market Discipline - The third pillar ensures transparency and accountability in the insurer's reporting. Insurers are required to disclose information on their risk exposures, capital adequacy, and governance arrangements. The insurer must ensure that the information is publicly available so that stakeholders can make informed decisions about the insurer's financial stability and risk profile.

Together, these three pillars form a comprehensive and integrated approach to insurance regulation under Solvency II, promoting financial stability, transparency, and consumer protection in life insurance companies (EIOPA, 2014, p. 45).

The Solvency II framework pertains exclusively to life insurance companies, while pension funds are governed by the Institutions for Occupational Retirement Provision Directive, also known as the IORP directive. While Solvency II and IORP are different regulatory frameworks, they fall under the European Insurance and Occupational Pensions Authority

(EIOPA) supervision. EIOPA ensures that Solvency II and IORP are implemented consistently across the EU and that life insurance companies and pension funds comply with the relevant regulations.

The main difference between the two directives is that the IORP directive allows the regulatory authorities to apply the capital requirements they see fit, implying that the pension funds operate independently from the Solvency II guidelines. However, in 2018, the Financial Supervisory Authority of Norway decided to implement the Solvency II regulation for pension funds, implicating that pension funds are now subject to similar capital requirements as life insurance companies. Improved financial stability and protection for pension fund members were the main arguments for implementing the Solvency II directive in Norwegian pension funds (Bjøru et al., 2016, p. 30).

3.2.1 Modified Stress Test 1

The Financial Supervisory Authorities of Norway have created the modified stress test 1 to calculate the Solvency Capital Requirement Ratio (SCR Ratio) in Norwegian pension funds. The stress test is based on Solvency II's first pillar but with simplifications and adaptations for the Norwegian pension funds. The SCR ratio is a crucial part of our empirical analysis, and therefore we find it important to explain the mechanisms of the stress test. The Solvency II regulation and the stress test are quite extensive. Hence, this section aims to give a brief overview of the most critical factors in the regulation and the calculation of the SCR ratio rather than explaining every detail.

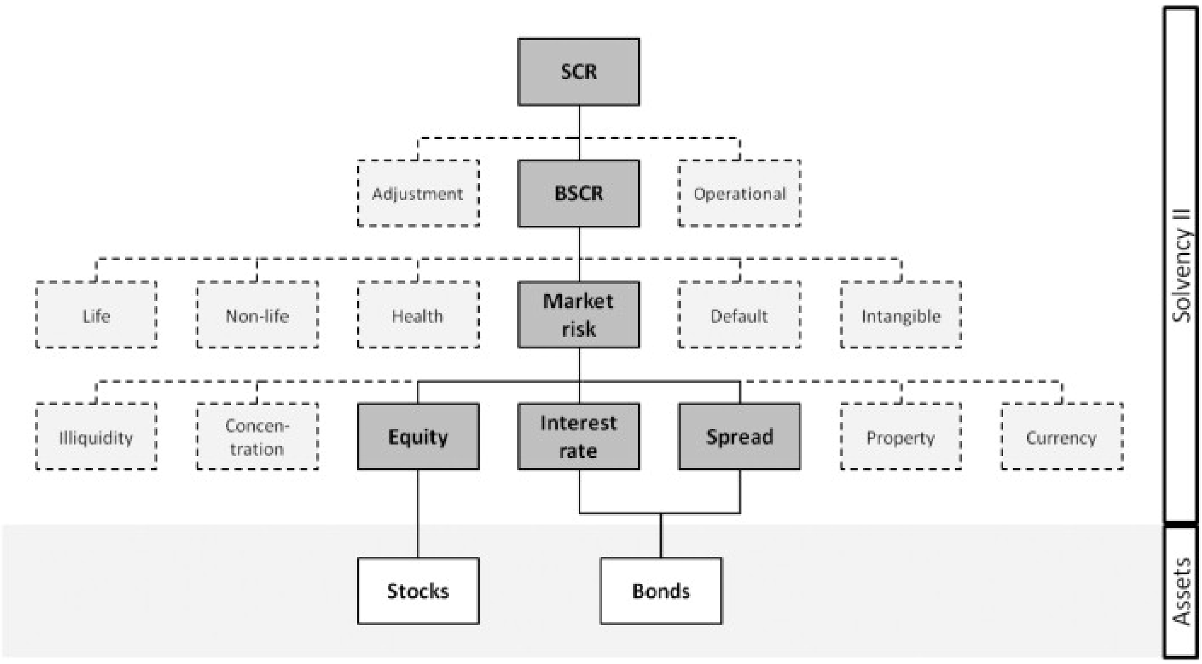
The SCR ratio is the ratio between the eligible capital and the solvency capital requirement, expressed in Equation 3.2.

$$\text{SCR ratio} = \frac{\text{Eligible capital}}{\text{Solvency capital requirement}} \tag{3.2}$$

The solvency capital requirement is calculated using the Net Asset Value (NAV) principle. NAV is calculated by taking the asset value and subtracting the value of the liabilities. The central concept behind the regulation is to measure the assets and liabilities at fair value and then compare the regular balance sheet to the stressed balance sheet. The balance sheet is stressed using a value at risk of 99.5%, and the difference between the unstressed and stressed balance sheets is the solvency capital requirement. The pension funds must always ensure that the eligible capital exceeds the solvency capital requirement.

If the eligible capital falls below the solvency capital requirement, this implies that the funds do not have enough capital to withstand a potential loss on a 99.5% value at risk level. The eligible capital comprises the fund's equity, additional reserves, and the value adjustment fund. The NAV calculation method also considers the possibility of future income streams. A pension fund that has active members of defined benefit plans will have future premium income, which contributes to reducing the solvency capital requirement. For example, a public pension fund with an active pension scheme could consider future income streams from the sponsor. However, a pension fund that no longer has active members (only paid-up policy capital) will be unable to include such income streams because no further premiums are paid for new entitlements (EIOPA, 2014, p. 136).

Figure 3.1 illustrates the Solvency II hierarchy. The regulation has six risk modules - market, non-life, life, health, default, and intangible risk. The stress test has simplified the Solvency II risk modules by not including the risk of intangible assets and default risk. Each risk module contains different risk factors; for example, the market risk module contains equity, interest rate, property, spread, currency, and concentration risks. Each risk factor is then stressed with a given parameter stated in the regulation. The individual stress test amounts are combined across the risks within the module using a specified correlation matrix and matrix multiplication.



Retrieved from (Gatzert & Martin, 2012, p. 652).

Figure 3.1: Solvency II hierarchy.

As illustrated, the Solvency Capital Requirement (SCR) can be decomposed into the Basic Solvency Capital Requirement (BSCR), adjustment, and operational, as shown in equation 3.3.

$$SCR = BSCR + Adjustment + Operational \tag{3.3}$$

The BSCR is calculated by aggregating the risk per risk module with a prescribed correlation matrix, as illustrated in Equation 3.4 and Table 3.1. The adjustment is the loss-absorbing capacity of deferred taxes, and the operational risk module is designed to capture the risk the other modules have not captured.

$$BSCR = \sqrt{\sum_{i,j} Corr_{i,j} * SCR_i * SCR_j} \tag{3.4}$$

Table 3.1: Correlation matrix

Corr SCR	SCR_{Market}	SCR_{Health}	SCR_{Life}	$\text{SCR}_{Non-life}$
SCR_{Market}	1	0.25	0.25	0.25
SCR_{Health}	0.25	1	0.25	0.25
SCR_{Life}	0.25	0.25	1	0.25
$\text{SCR}_{Non-life}$	0.25	0.25	0.25	1

3.2.2 Market Risk

In this subsection, we give an overview of the market risk module in the stress test. Market risk is the risk of volatility in market prices and interest rates. The module is divided into five different subcategories of risk; interest rate, equity, currency, spread, and concentration risk (The Financial Supervisory Authority, 2018, p. 7). The market risk module is important for two reasons. The first reason is that most of the solvency capital requirement stems from the market risk module. According to Bjøru et al. (2016), this risk accounts for 50-70% of the total solvency capital requirement. The second reason is that the market risk module is possible to calculate with publicly available information, unlike the other modules, which to a greater extent, require fund-specific information. A more in-depth discussion on the construction of our SCR ratio can be found in Section 4.3.

Interest Rate Risk

Interest rate risk is related to changes in the yield curve. Positions in interest-bearing financial instruments, derivatives with interest instruments as underlying, and insurance obligations are subject to interest rate risk. An essential part of the interest rate risk is the measurement of future insurance obligations to fair value. Equation 3.5 illustrates how the fair value is calculated:

$$\text{Fair value of liabilities} = \text{BV} \times \frac{(1 \times \text{BIR})^{D_p}}{(1 \times \text{Yield})^{D_p}} \tag{3.5}$$

Where:

D_P = Duration of the obligations in the portfolio

BV = Book value of liabilities

$Yield$ = The current yield curve

If the BIR is higher than the yield, the fair value of liabilities surpasses the book value. Conversely, if the BIR is lower than the yield, the fair value of liabilities is lower than the book value. The Solvency II framework further stresses the fair value of liabilities through a positive shift in the yield curve of 35% and a negative shift of 28%. Holding all other things equal, a positive shift in the yield curve will decrease the solvency capital requirement. The fixed-income portfolio is also subject to interest rate risk. The portfolio is stressed by shifting the yield curve up 59% and down 50%. The solvency capital requirement of the fixed-income portfolio depends on how much the pension fund has invested in the fixed-income portfolio and the investment duration (The Financial Supervisory Authority, 2018, p. 12).

It is essential to understand that a shift in the yield curve will affect the present value of the obligations and the fixed-income portfolio differently. A positive shift in the yield curve will lower the obligations' fair value, making the solvency capital requirement lower, all things equal. However, an increase in the yield curve will decrease the value of the fixed-income portfolio, increasing the solvency capital requirement, all things equal. This hedge mechanism is one of the main arguments why the Solvency II regulation will increase the demand for bonds with the corresponding duration as the commitments, as stated in the literature review (Bjøru et al., 2016, p. 30).

Equity Risk

Equity risk consists of market risk linked to positions in equity instruments, including derivatives with underlying equity instruments. There is a distinction between type 1 and 2 shares. Type 1 shares are listed in countries that are members of the European economic area and states within the OECD area. In contrast, type 2 shares could either be shares listed in countries outside the European economic area and OECD or alternative investments and commodities. Alternative investments include all forms of private equity and hedge funds. The standard stress parameter is 39% and 49% for type 1 and 2 shares, with a symmetric adjuster of 10%, depending on how the stock market has performed in the last 36 months.

Real Estate, Currency, Spread, and Concentration Risk

Real estate risk consists of the market risk of direct investment, equity positions, and derivatives with real estate as an underlying instrument. Real estate exposures are stressed with a stress parameter of 25%.

Currency risk comes from the volatility of the currency rates. This risk category includes all financial instruments and other positions with foreign exchange risk. Currency risks are also stressed with a stress parameter of 25%.

Spread risk is the risk of changes in the market value of the fixed-income portfolio due to changes in credit spreads. If the credit spreads in the fixed-income portfolio of the fund deteriorate, this implies a higher solvency capital requirement.

Finally, the concentration risk is the risk of a change in market values due to a significant concentration towards a counterparty. In other words, it is the risk of not being well diversified. Concentration risk is calculated for equities, fixed income, and other interest-rate exposures (The Financial Supervisory Authority, 2018, p. 23).

Having presented an overview of Norwegian pension funds, the mechanism behind the balance sheet, the basic interest rate, and the Solvency II regulation, we describe our data sample in the next section.

4 Data

In this section, we describe our dataset and the construction of it. Further, we present the treatment of missing variables. We also discuss some potential data limitations with the construction of the dataset.

4.1 The Construction of the Dataset

The Norwegian pension funds data set contains 75 active pension funds in 2021, with a sample period from December 31st, 2009, to December 31st, 2021[2]. We have gathered the sample of pension funds by analyzing The Financial Supervisory Authority registry of licensed companies. We have collected a total of 922 annual reports from The Brønnøysund Register Centre, and the dataset was created by manually collecting the relevant information from the annual reports of each pension fund. In total, we extracted approximately 30 000 variables from these reports. Some funds had not filed their annual reports with The Brønnøysund Register Centre in certain instances. Consequently, we resorted to direct communication with the fund administrators, requesting the annual reports. For funds with both public and private pension plans, we have placed the fund in the category where most of its liabilities were related. After categorizing the sample into public and private funds, we ended up with 23 public and 52 private funds.

After spending a significant amount of time extracting the necessary variables from the annual reports, we ended up with what we believe to be the most detailed and comprehensive dataset on Norwegian pension funds.

4.1.1 Treatment of Missing Values in the Dataset

The quality of reporting in the sample has been challenging during the construction of the dataset. Information disclosure and consistency have varied between funds, years, and regulations resulting in some variables missing. Examples are the average BIR and the fixed-income portfolio's duration.

Some funds have not reported the average BIR in their annual reports, and some have

[2]Due to differences in reporting, nine funds were excluded from the final sample.

only sporadically reported it. Fortunately, the average BIR disclosure increased after the implementation of Solvency II and the modified stress test 1 in 2019. However, since the variable is a crucial part of our analysis, we replace the missing values with a proxy. The proxy calculations have been conducted in two ways:

1. For funds that have not reported the BIR in any given year
2. For funds that have reported the BIR but not for the entire sample period

In the first case, we took the average of the peers at the start of the sample and then adjusted for the trend in the sample in the coming years. E.g., if the average of peers in 2009 was 3% and the trend from 2009 to 2010 decreased by 0.05%, then the average BIR used is 2.95%. The peer group in this context refers to public and private funds. Three pension funds did not report the BIR, making it a total of 39 missing observations. In the second case, we took the reported BIR by the fund and then adjusted the missing years with the trend of peers. E.g., if the fund were missing the BIR in 2010 and reported a BIR of 3% in 2009, given a trend decrease of 0.05% for peers, the average BIR would be 2.95%. We have applied the proxy on a total of 72 observations. The proxy method has been developed based on advice from industry professionals, and the method utilizes the declining basic interest rate trend and low variation in the BIR amongst funds. Fallen interest rates in our sample period have contributed to a lower intrinsic guaranteed interest rate in the new pension contracts entered. In combination with the expiration of older contracts (with a higher embedded BIR), this has led to an overall decrease in the average BIR during the sample period. Consequently, we can confidently conclude that our proxy method captures the overall trend in the BIR.

We have also estimated a proxy for the duration of the fixed-income portfolio. The duration of the fixed-income portfolio is essential for calculating the SCR ratio in the empirical analysis. We have calculated the overall average duration for peer pension funds each year and inserted the average for peers in the years where the duration was missing. A total of 91 observations were missing. Given that the duration seems relatively equal across funds, we do not think this has materially biased our results.

4.2 The Construction of the Benchmark

In this subsection, we present a brief overview of how the dependent variable "Net Benchmark-Adjusted Return" (NBAR) is created. In line with Andonov et al. (2017), we adjust the value adjusted returns for both investment costs and benchmark performance to evaluate their relative performance. The benchmark return is calculated on an individual fund basis by multiplying the allocation weight in each asset class with an appropriate benchmark return for the respective asset classes. Since the pension funds in our sample report their returns in Norwegian Krone (NOK), benchmark returns for their global investments are converted to NOK.

Unfortunately, no relevant index exists for the Norwegian High-Yield (HY) market from 2009 to 2012 (Ruud & Nordlid, 2017, p. 47). Consequently, we used the returns in European HY indices as a proxy for the return in these years. It can be argued that the Norwegian HY market was more stable in the period compared to the European HY market. If this is the case, the returns in these years might be biased to the upside, making it harder for the funds to beat the benchmark. Finding a representative index for the Norwegian Investment-Grade (IG) market was another challenge. From 2009 to 2014, we used the Norwegian Government bond index with a three-year duration (ST4X) as a proxy for IG returns after consulting industry professionals. In the same period, ST4X seems to be the preferred reference index for the fixed-income portfolio of the pension funds (Bergen Kommunale Pensjonskasse, 2013, p. 7). A potential downfall with using ST4X is that the index does not account for the credit spread IG bonds are issued with. This could potentially cause the benchmark return to be biased to the downside.

4.3 The Construction of the SCR Ratio

The SCR ratio is an essential part of our empirical analysis. However, the funds were not legislated to report the SCR ratio before the implementation of Solvency II in 2019. Ultimately, we had to calculate each fund's SCR ratio manually. After meeting with industry professionals, we received invaluable input on the actuarial aspects of the modified stress test. With some simplifications, we were able to calculate the SCR ratio based on publicly available information. For information not publicly available, we have relied our calculations on industry averages provided by industry professionals.

Because of the complexity of the stress test model and the absence of fund-specific demographic information, we had to focus on the two most important risk modules in the stress test – market risk and eligible capital. Consequently, our estimates of the SCR ratio may deviate from what industry professionals are familiar with. For example, our analysis excludes the life and health insurance risk modules, which conventionally contribute approximately 30% to the overall solvency capital requirement (EIOPA, 2022, p. 14). Ultimately, our simplification may lead to an overstatement of the solvency position of the funds. In 2021, the average reported SCR ratio for Norwegian pension funds was 178%, according to The Financial Supervisory Authority (2022). In contrast, we have calculated the SCR ratio in the same period to be 192%.

The modified stress test employs the EIOPA yield curve to discount the pension obligations to fair value, and it is an essential part of calculating the SCR ratio. However, the yield curve was not published before 2015. In line with the EIOPA guidelines, we constructed a yield curve for the years before 2015 based on the Smith-Wilson extrapolation method (EIOPA, 2017, p. 14). The reason for extrapolating the yield curve is to estimate a proper discount rate for the pension liabilities with a duration beyond the Last Liquid Point (LLP). Two assumptions were made to extrapolate the yield curve. The first assumption is related to the LLP on the yield curve, which we assumed to be ten years following the findings of Evjen et al. (2017). The second assumption is related to the Ultimate Forward Rate (UFR). The UFR is the sum of an expected real rate and an expected inflation rate and represents the theoretical interest rate the yield curve will converge towards. In line with Michelsen (2018), we assumed the yield curve to converge towards a UFR of 4.2% over a period of 50 years.

4.4 Data Limitations

This subsection will briefly discuss the data limitations of our dataset and how this may have affected the results.

Firstly, the manual plotting has led us to make discretionary decisions that could affect the findings. An example is the allocation of risky assets, where we had to make discretionary decisions if an investment was risky or not. This process was particularly difficult for funds with low-quality reporting because of the inadequate disclosure of their investments. Some funds also chose to pool their investments, making it practically impossible to separate the different asset classes. The discretionary flexibility could cause the risky assets to be either overstated or understated, leading to biased results in the empirical analysis.

Secondly, the treatment of missing values could be another potential downfall. For the funds that were missing values for most of the sample period, there is substantial uncertainty regarding their actual values. Our proxies could potentially affect the empirical analysis, both positively or negatively. However, we believe the method utilized should be representative based on previous discussions.

Thirdly, the construction of the benchmark could be another potential downfall. Where there was an absence of reference indices, proxies were chosen based on guidance from industry professionals. However, it is important to emphasize that this could either overstate or understate the benchmark returns. Benchmark selection vulnerability is also something Broeders & De Haan (2020) have highlighted in their research as a potential downfall.

Finally, the calculation of the SCR ratio may be another downfall. As mentioned previously, we had to make several simplifications in constructing the SCR ratio. Our SCR ratio is mainly based on publicly available data, and our method does not account for fund-specific demographic risk. Therefore, our estimates may be biased to the upside.

5 Empirical Analysis

This section presents our empirical analysis of Norwegian pension funds. We have used the study "Pension Fund Asset Allocation and Liability Discount Rates" conducted by Andonov et al. (2017) as inspiration for the empirical analysis. We first present the study and the motivation behind using the study as an inspiration. Afterward, we present summary statistics and a descriptive analysis showcasing the increasing trend in risky allocation. Moreover, we present our empirical findings and conclusions.

The empirical findings are divided into three subsections. In the first subsection, we study determinants of the risky allocation in Norwegian pension funds. We have conducted three regressions examining the relationship between the risky allocation and variables we believe are essential in explaining the allocation. The second subsection looks at the performance of the pension funds. We have two main motivations; the first is to test the relationship between risk-taking and the performance of the funds. The second motivation is to see if Norwegian-specific variables can explain the net benchmark-adjusted returns. The third subsection is divided into two analyses. The first analysis examines the drivers of a change in the SCR ratio in the short and medium term. The second analysis examines the measures taken by pension funds with an SCR ratio lower than the board directors' predetermined level.

5.1 Andonov et al. (2017)

This thesis has gathered inspiration from the study "Pension fund asset allocation and liability discount rates" conducted by Andonov et al. (2017). The study examines the allocation of risky assets in pension funds in the U.S., Europe, and Canada and investigates how the increased risky allocation affects fund performance.

An underlying regulatory motivation behind the study is that public pension funds in the U.S. are subject to a unique regulatory framework that ties their liability discount rate (LDR) to the expected return on assets. According to the study, this unique regulation incentivizes these funds to allocate more of their portfolio to riskier investments to improve their funding status. Defined benefit retirement schemes typically pool the assets of multiple generations together and allow for intergenerational risk-sharing. The risk-sharing can create a conflict of interest between the different generations (stakeholders), particularly when the pension plan is underfunded – when the value of assets is lower than the future promised benefits. Underfunding can, in the worst case, result in a generation not receiving the pension they are entitled to, even if they have contributed with premium payments toward the pension plan. Andonov et al. (2017) believe that there may be incentives for current pension fund stakeholders to use a higher liability discount rate to reduce the probability that a low reported funding level triggers regulatory increases in the contribution payments from the sponsor. This could trigger public discussions on reductions in future (or even already accrued) pension benefits.

5.1.1 The Regulatory Incentive Hypothesis

Andonov et al. (2017) argue that the contrasting results between U.S. public funds and the other funds in the sample are due to differences in the LDR. The Governmental Accounting Standards Board (GASB) allows U.S. public funds to discount their liabilities using the expected returns on their assets. In contrast, the regulation for U.S. private, European, and Canadian funds requires the LDR to be based on high credit quality interest rates. For instance, European funds must follow the EIOPA and the IORP regulation and discount their liabilities with a yield curve that converges towards the UFR. U.S. corporate pension plans are subject to a similar regulation where they can use a combination of the upper-medium and high-grade long-term corporate bonds as their discount rate (Rauh, 2006, p. 34). Both regulations imply that the discount rate is exogenous and cannot be modified by changing the allocation to risky assets.

According to Andonov et al. (2017), the GASB regulation has two significant consequences. First, public pension funds in the U.S. tend to understate their liabilities because they discount their liabilities with a too high discount rate. The second consequence is that the link between the LDR and the expected return on their assets gives U.S. public pension funds considerable discretion to manage their LDR. Since the expected return depends on the historical return, the funds can change their discount rate by changing the allocation across asset classes. Andonov et al. (2017) refer to this as "the regulatory incentives hypothesis," meaning that there is a link between the LDR and the expected return on assets, giving U.S. public funds an incentive to increase their allocation to risky assets. A higher allocation to risky assets will give a higher expected return and, consequently, a higher LDR and lower reported value of liabilities. Ultimately, this will increase the reported funding status of the pension plan, such that the fund may seem more well-funded than it is.

5.1.2 Motivation

There are three main motivations behind using the study of Andonov et al. (2017) as an inspiration for our study. The first motivation is to employ a valid methodology that captures the specific aspects we aim to study. By adopting the same methodology used by research professionals studying the same topic, we can confidently employ the appropriate method – ultimately increasing our results' credibility and trustworthiness.

The second motivation is that we intend to utilize the same variables they have examined. To our knowledge, there is limited research conducted on pension funds' asset allocation and performance in Norway. Even though Norwegian pension funds do not have the same regulatory incentives as the U.S. public funds, we are still interested in examining the relationship between the variables and Norwegian pension funds. E.g., can we examine the exact relationship between fund maturity and risky allocation as they found in the study? Furthermore, what are the implications of increased risky allocation on the performance of the funds? We will likely have different results in the Norwegian pension funds compared to public pension funds in the U.S. due to differences in regulation. However, we find it intriguing to demonstrate the similarities and differences between the study's results and the result of Norwegian pension funds.

The final motivation is to add Norwegian-specific variables to see if we can better understand what drives the risky allocation and the performance of Norwegian funds. Because of the complexity of Norwegian pension funds, we will likely see that other variables explain the allocation of risky assets and the relative performance of the funds.

5.2 Summary Statistics

Table 5.1 presents the summary statistics for our sample of Norwegian pension funds. Panel A presents the number of funds and observations in our sample. Panel B and C showcase the mean and standard deviation (in parentheses) of our variables at the beginning and the end of the sample period. From panel A, we can see that the total number of funds has increased during our sample period. A total of eight public and three private funds emerged during the period. Our sample consists of 75 funds, where 52 are private and 23 are public.

Table 5.1: Summary statistics for 2009 and 2021

	Public	Private	All funds
Panel A: The total number of pension funds and observations			
Funds	23	52	75
Obs. [funds × year]	268	654	922
Panel B: Summary statistics in 2009			
Funds	15	49	64
%Retired	0.249	0.344	0.322
	(0.039)	(0.180)	(0.164)
%Risky	0.231	0.318	0.298
	(0.066)	(0.147)	(0.137)
Returns (NBAR)	0.092	-0.002	0.019
	(0.025)	(0.056)	(0.064)
Basic interest rate (BIR)	0.030	0.034	0.033
	(0.001)	(0.003)	(0.003)
SCR ratio	1.22	1.88	1.73
	(0.419)	(0.920)	(0.874)
Duration	3.18	2.77	2.87
	(0.64)	(0.91)	(0.87)
Fund size (NOK millions)	2 694	2 457	2513
	(2 596)	(6 183)	(5 535)
Panel C: Summary statistics in 2021			
Funds	23	52	75
%Retired	0.222	0.407	0.351
	(0.072)	(0.407)	(0.2146)
%Risky	0.467	0.420	0.435
	(0.057)	(0.153)	(0.132)
Returns (NBAR)	0.072	-0.011	0.015
	(0.012)	(0.032)	(0.047)
Basic interest rate (BIR)	0.024	0.026	0.025
	(0.001)	(0.003)	(0.003)
SCR ratio	1.73	2.01	1.92
	(0.212)	(0.534)	(0.478)
Duration	2.69	3.47	3.23
	(0.91)	(1.23)	(1.19)
Fund size (NOK millions)	7 589	4 796	5 652
	(7 854)	(12 126)	(11 016)

This table provides descriptive statistics for pension fund maturity, asset allocation, performance, basic interest rate, solvency, duration, and fund size. In Panel A, rows *Funds* and *Obs.* present the number of funds and observations through the entire sample period. In Panels B and C, we show the means of the variables in 2009 and 2021. Standard deviations are in parentheses.*%Retired* shows the fund's average percentage of retired members. *%Risky* presents the average percentage allocated to risky assets, which includes equities, alternative investments (i.e., hedge funds, private equity, and real estate), and high-yield bonds. The returns show the net benchmark-adjusted returns reported in percentage points. The *Basic interest rate* shows the weighted average of the fund's return guarantee. The *SCR ratio* presents the average solvency ratio reported in percentage points. The *Duration* measures the average duration in the fixed-income portfolio. The *Fund size* presents the average total asset under management (in NOK millions). All statistics are reported for both public and private funds. In addition, the table includes statistics for all funds.

In Panels B and C, we document the differences in the allocation of risky assets between public and private pension funds. The allocation to risky assets in public funds has increased from 23.1% in 2009 to 46.7% in 2021. In the same period, private funds have increased their allocation to risky assets from 31.8% to 42%. Consequently, our data suggest that the risk-taking in Norwegian pension funds has increased during the sample period for both private and public funds. An interesting finding is that the public funds have increased their allocation to risky assets relatively more than the private funds in our sample period.

Furthermore, we observe different trends in the fund maturity between public and private pension plans. The percentage of retired members in private pension plans increased from 34.4% in 2009 to 40.7% in 2021. In contrast, public funds' maturity decreased from 24.9% in 2009 to 22.2% in 2021. Most private pension funds have transitioned from defined benefit to defined contribution plans, which can explain the difference between maturity in private and public pension plans. Our data also suggest that the funds have increased their average AUM from NOK 2 513 million in 2009 to NOK 5 652 million in 2021. On average, we observe that public funds have a higher AUM than private funds.

The BIR for both private and public funds has fallen in the sample period. In 2009, the BIR was 3.0% in public funds and 3.4% in private funds. However, 13 years later, the rate has fallen by 0.6 percentage points for public and 0.8 percentage points for private funds. We see that the BIR has been falling in line with the overall decrease in the yield curve. Lastly, we observe that the SCR ratio has strengthened from 173% in 2009 to 192% in 2021. Consequently, the funds seem to be more well-funded in 2021 than in 2009. An interesting finding is that our results suggest that private pension funds are more well-funded than public funds.

In table 5.2, we have deconstructed the risky allocation of public and private funds. Panel A shows the allocation to risky assets for private funds, and panel B for public funds. The most evident finding is that both public and private funds have decreased their allocation to IG bonds (low-risk assets) and increased their allocation to equities, HY bonds, and alternative investments (risky assets). It should be emphasized that the disclosure and distinction between risky and non-risky assets increased substantially during our sample period. This has potentially led to an overstatement of the change towards risky assets.

During our sample period, public and private funds decreased their allocation to IG bonds by 21 and 6 percentage points, respectively. The low interest rate environment can explain the decrease in IG bonds during our sample period. Since the returns obtained in the IG market have not been sufficient to cover the BIR, the pension funds have reallocated to asset classes with higher expected returns, such as equities. Public funds have increased their exposure to equities by over 14 percentage points, while private funds have increased their allocation by 4 percentage points. The reallocation to real estate has also been evident, where public funds have increased their exposure by roughly 6 percentage points compared to 4 percentage points in private funds.

Table 5.2: Development in asset allocation for private and public pension funds

	Avg. Cash & Equivalents	Avg. IG Bonds	Avg. HY Bonds	Avg. Equities	Avg. Real Estate	Avg. Hedge Funds	Avg. Private Equity	Avg. %Risky
Panel A: Private funds:								
2009	8.50%	59.68%	1.07%	26.49%	2.88%	0.39%	0.99%	31.82%
2010	6.38%	58.35%	1.67%	28.07%	3.93%	0.44%	1.16%	35.27%
2011	7.22%	60.14%	2.48%	24.18%	4.39%	0.54%	1.05%	32.64%
2012	6.68%	59.10%	2.97%	25.22%	4.63%	0.49%	0.90%	34.22%
2013	5.47%	58.48%	3.08%	27.11%	4.45%	0.50%	0.91%	36.05%
2014	6.06%	57.02%	3.07%	28.05%	4.37%	0.53%	0.91%	36.92%
2015	5.49%	56.37%	3.39%	27.90%	4.95%	0.90%	1.00%	38.14%
2016	5.51%	55.11%	3.58%	28.76%	5.10%	0.96%	0.98%	39.38%
2017	4.61%	55.36%	3.20%	29.03%	5.62%	1.09%	1.11%	40.04%
2018	4.27%	57.11%	2.65%	27.86%	5.97%	1.15%	1.00%	38.62%
2019	5.05%	55.43%	1.77%	29.04%	6.22%	1.38%	1.11%	39.53%
2020	4.81%	54.42%	2.13%	29.70%	6.38%	1.12%	1.43%	40.76%
2021	4.17%	53.78%	2.09%	30.80%	6.56%	0.90%	1.69%	42.05%
Total average	5.71%	56.95%	2.55%	27.86%	5.03%	0.80%	1.10%	37.34%
Panel B: Public funds:								
2009	8.02%	68.85%	0.24%	16.60%	5.36%	0.38%	0.57%	23.14%
2010	4.93%	68.16%	0.29%	19.98%	5.83%	0.28%	0.52%	26.91%
2011	5.56%	68.49%	0.25%	17.29%	7.30%	0.32%	0.78%	25.95%
2012	7.14%	64.57%	0.49%	19.29%	7.63%	0.28%	0.61%	28.29%
2013	6.71%	61.83%	0.85%	22.00%	7.71%	0.27%	0.64%	31.46%
2014	8.24%	58.08%	1.70%	22.88%	7.98%	0.28%	0.84%	33.68%
2015	5.33%	58.17%	1.55%	23.72%	9.77%	0.35%	1.12%	36.50%
2016	4.51%	56.88%	1.50%	24.85%	10.67%	0.40%	1.20%	38.61%
2017	4.49%	55.29%	1.05%	25.90%	11.44%	0.43%	1.41%	40.22%
2018	4.57%	55.24%	1.67%	24.65%	12.08%	0.28%	1.51%	40.19%
2019	4.59%	52.03%	2.46%	27.71%	11.08%	0.53%	1.60%	43.38%
2020	4.49%	50.70%	2.24%	29.23%	11.13%	0.51%	1.71%	44.82%
2021	4.96%	48.29%	1.89%	30.26%	11.78%	0.41%	2.41%	46.75%
Total average	5.66%	58.97%	1.25%	23.41%	9.21%	0.36%	1.15%	35.38%

This table provides an overview of how the average allocation weights to each asset class have evolved throughout our sample period. In Panel A, we present the asset allocation for private pension funds. In panel B, we present the asset allocation for public pension funds. We have separated their allocation into the following asset classes: *Cash & Equivalents*; consisting of cash and money market funds; *IG Bonds*, bonds with investment grade credit quality (rated BBB- or higher); *HY Bonds*, bonds with high-yield credit quality, (rated below BBB-); *Equities*, publicly listed companies, mutual funds, and index funds; *Real Estate*, investments into real estate (both direct and indirect); *Hedge Funds*, allocation to hedge funds; *Private Equity*, allocation towards private equity (both direct and indirect through fund-of-funds); *%Risky*, the sum of investments to HY bonds, Equities, Real Estate, Hedge Funds, and Private Equity. The total average rows show the average over the sample period. The numbers may not add up to 100% due to roundings.

As mentioned in the literature review, Ozdagli & Wang (2019) found evidence of reach for yield in the corporate bond market during a period with falling interest rates. Our dataset suggests this may also be true for the Norwegian pension funds. Both public and private funds have increased the allocation to HY bonds by 1.7 and 1 percentage points, respectively. However, it is more evident that pension funds have prioritized the reach for yield in other asset classes over HY bonds. In conclusion, public funds have increased their risky allocation relatively more than private funds in the sample period. Furthermore, we present our empirical analysis and findings in the next subsection.

5.3 Findings

5.3.1 Pension Fund Maturity and Allocation to Risky Assets

In this section, we have gathered inspiration from the study by Andonov et al. (2017), where they examine the relationship between fund maturity and risky allocation. The study states that funds with higher maturity are generally more likely to face worsening future funding status prospects. "The regulatory incentive hypothesis" implies that U.S. public funds with higher maturity are expected to face increased incentives to maintain a high LDR (Andonov et al., 2017). Even though Norwegian pension funds do not have the same regulatory incentives as the U.S. public funds, we still find the relationship between fund maturity and risk-taking worth investigating.

After implementing the defined contribution plans in 2001, most private companies have gradually converted to defined contribution plans. As a result, most private funds have closed the defined benefit pension scheme for new members. Consequently, the fund maturity in private funds has increased during our sample period and is expected to increase even more in the coming years, highlighted in Table 5.1. We present two hypotheses on fund maturity and risky allocation based on the following discussion.

The first hypothesis is that the pension funds will decrease the risky allocation when the fund maturity increases. In line with asset-liability matching theory, it is common to decrease the allocation of risky assets when the obligations are closer in time. This rationale was studied by Bikker et al. (2012), who found that risk-taking evolved with the life cycle of the funds. We hypothesize that an increasing fund maturity is associated with a decrease in the allocation of risky assets since the disbursement of the promised benefits is closer in time. The second hypothesis is that private funds are more sensitive to increased fund maturity than public funds. As discussed earlier, most private funds have closed for new members during the sample period. In contrast, public funds have kept their funds open for new members, and consequently, the percentage of retired members depends on the inflow and outflow of members. Given this difference, we posit that private funds will respond more to increased fund maturity.

The allocation to risky assets is the total percentage of AUM invested in equities, alternative investments, and HY bonds. Alternative investments are categorized into Private Equity

(PE), real estate (direct and indirect investments), and hedge fund investments. The percentage of retired members is used as a measurement for fund maturity, meaning that funds with a higher percentage of retired members are more mature. We have included two control variables; the yield in $year_{t-1}$ and fund size. The motivation behind utilizing the yield in $year_{t-1}$ is to better express the relationship between last year's yield and the investment decisions in $year_t$. Reallocating the portfolio takes time since most of the fund's investment decisions are proposed to the board by an outside counsel, such as Gabler and Grieg Investor. The yield is the Norwegian 10-year swap rate and is exogenous to all individual pension plans. The fund size is the logarithm of the AUM.

Table 5.3 presents our findings. We start with a simple specification in column (1) where we include *%Retired*, $Yield_{t-1}$, and *Fund size*. We then add a dummy variable for public funds and an interaction variable of *%Retired × Public* in column (2). In column (3), we add the interaction between $Yield_{t-1}$ × *Public* and *Fund size × Public*.

Table 5.3: Pension fund maturity and allocation to risky assets

	(1)	(2)	(3)
Dependent variable: Percentage allocated to risky assets			
%Retired	-0.008	-0.047	-0.030
	(0.059)	(0.064)	(0.063)
$Yield_{t-1}$	-2.275**	-2.164**	-2.017*
	(0.868)	(0.834)	(0.974)
Fund size	0.079*	0.084**	0.033
	(0.037)	(0.036)	(0.049)
Public		-0.092	-0.432
		(0.108)	(1.164)
%Retired × Public		0.343	0.234
		(0.208)	(0.171)
$Yield_{t-1}$ × Public			-2.896**
			(1.089)
Fund size × Public			0.020
			(0.052)
Constant	-1.316	-1.401	-0.321
	(0.824)	(0.807)	(1.091)
Observations	922	922	922
Adjusted R-squared	0.816	0.820	0.834
Year FE	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the percentage allocated to risky assets for all pension funds in our sample. Risky assets are defined as allocations to equities, alternative assets, and high-yield bonds. As independent variables, we include *%Retired*, the percentage of retired members in the pension funds; $Yield_{t-1}$, the 10-year swap rate in the previous year; *Fund size*, the logarithm of the AUM of the pension funds; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of last year‘s swap rate on public pension funds; *Fund size × Public*, an interaction term capturing the effect of fund size on public pension funds. We include year dummies and fund-fixed effects in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

The results in column (1) suggest no relationship between fund maturity and risk-taking. In columns (2) and (3), we have added an interaction term to see if there is a difference between fund maturity in public and private funds on risky allocation. According to our regression, there is no difference between fund maturity in private and public funds, even though the coefficients in the regression indicate that public funds are more sensitive to fund maturity. We, therefore, reject our hypotheses and conclude that we cannot find evidence that fund maturity has a relationship with risky allocation. In contrast, Andonov et al. (2017), found that for all funds, except the U.S. public, a 10% increase in the percentage of retired members was associated with a 1.61% decrease in risky allocation. However, when including an interaction term for public funds, they find that a 10% increase in retired members is associated with a 5.9% increase in risky allocation.

Further, column (1) indicates that Norwegian pension funds allocate more to risky assets when the yield in year_{t-1} declines. A one percentage point increase in the yield in year_{t-1} is associated with a roughly 2 percentage points decrease in risky allocation, significant in all regressions. We have added an interaction term to capture the effect on public funds in columns (2) and (3). Our results indicate that public funds are more sensitive to a change in the yield in year_{t-1}. In column (3), a one percentage point increase in the yield in year_{t-1} is associated with a roughly 4.9 percentage points decrease [-2.01 + (-2.89)] in risky allocation, significant at a 5% level. We introduce two novel hypotheses that we believe could elucidate this finding:

The first hypothesis is called "the reach for yield" hypothesis and states that the falling interest levels have pressured the pension funds to allocate more to risky assets. In the sample period, the yield fell from 4.72% in 2009 to 1.92% in 2021, lowering the expected returns on low-risk assets. Since pension funds have a required return embedded in their pension obligations, the lower expected returns have forced them to allocate more to risky assets to meet their required return. This is a potential explanation of why pension funds have allocated more to risky assets during a period with falling interest rates. The second hypothesis is called "the misalignment of incentives" hypothesis. As previously discussed, the transition from defined benefit to defined contribution plans has caused an increase in paid-up policy contracts in private funds. Given that paid-up policy contracts in private pension funds have a different return distribution (the 80/20 rule), this has incentivized the funds with a higher percentage of paid-up policy contracts to be more risk-averse, as highlighted in Table 5.2 above, where we observed a stronger increasing trend to risky assets in public funds. We believe that "the misalignment of incentives" hypothesis is one possible explanation for the difference in sensitivity between public and private funds.

Lastly, we have tested the relationship between fund size and the allocation to risky assets. The primary motivation is to test whether an increase in fund size is related to a higher risky allocation. Funds with higher AUM tend to have an in-house investment team, and we hypothesize that they can respond more quickly to changes in market conditions. The regression results are ambiguous. Fund size is significant in columns (1) and (2) but not significant in column (3). A one-unit increase in fund size is associated with an 8.4 percentage points increase in risky allocation in column (2). When controlling for interaction variables, the significance disappears, and we cannot conclude that the fund size affects the allocation to risky assets.

5.3.2 Norwegian-Specific Variables and Allocation to Risky Assets

This section expands the previous specifications with Norwegian-specific variables in Table 5.4. Firstly, we add a new Norwegian-specific variable on fund maturity to capture a potential relationship between fund maturity and risky allocation. Further, we investigate the relationship between the BIR and the risky allocation. We hypothesize that the BIR is an essential variable due to its critical function in Norwegian pension funds. Finally, we investigate the relationship between the funds' risk capacity and allocation to risky assets.

We continue to investigate the relationship between fund maturity and risk-taking. However, as a measurement of fund maturity, we now include the variable years since closed in addition to the percentage of retired members. The variable captures the number of years since a pension fund closed for new members. We hypothesize that there is a relationship between funds that are closed and risk-taking for two reasons. The first reason is the same as presented in the last section. Due to the disbursement of the promised benefits being closer in time, we expect to see a lower allocation to risky assets. The second reason is that the closed private funds will have a higher proportion of paid-up policy contracts in their portfolio. As described in section 3.1.2, the asymmetrical return distribution of the paid-up policy contracts incentivizes the private funds to be more risk-averse. Hence, we expect private funds to be more sensitive to fund maturity.

Table 5.4: Norwegian-specific variables and allocation to risky assets

	(1)	(2)	(3)	(4)
Dependent variable: Percentage allocated to risky assets				
%Retired	0.011	0.028	-0.024	-0.018
	(0.049)	(0.051)	(0.059)	(0.058)
Yield_{t-1}	-2.105**	-2.886***	-0.709	-0.309
	(0.926)	(0.915)	(1.184)	(1.242)
Fund size	-0.010	0.005	0.025	0.026
	(0.042)	(0.031)	(0.052)	(0.052)
Active	0.050	0.056**	0.121	0.105
	(0.033)	(0.025)	(0.071)	(0.067)
Basic interest rate	6.579*	6.694**	9.379***	9.092***
	(3.067)	(2.973)	(2.724)	(2.743)
Buffer capital	0.084***	0.049*	0.047*	0.059**
	(0.022)	(0.023)	(0.022)	(0.024)
Funding ratio		0.082	0.049	0.002
		(0.063)	(0.053)	(0.059)
$\text{Interest result}_{t-1}$		0.120	0.109	0.100
		(0.110)	(0.103)	(0.101)
Years since closed		-0.004	0.004	0.004
		(0.003)	(0.003)	(0.003)
Equity contribution		0.000	0.000	-0.000
		(0.001)	(0.001)	(0.001)
Interest rate guarantee premium		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Public			1.522	1.608
			(1.222)	(1.175)
%Retired × Public			0.124	0.106
			(0.135)	(0.137)
Yield_{t-1} × Public			-0.232	-0.526
			(0.930)	(0.932)
Fund size × Public			-0.016	0.002
			(0.064)	(0.062)
Basic interest rate × Public			-24.193***	-22.285***
			(6.346)	(5.577)
Buffer capital × Public			-0.028	-0.063
			(0.030)	(0.036)
Funding ratio × Public				0.165*
				(0.088)
Equity contribution × Public				0.001
				(0.001)
Constant	-1.300	-0.980	-1.468	-1.698
	(0.761)	(0.588)	(1.074)	(1.075)
Observations	922	847	847	847
Adjusted R-squared	0.832	0.851	0.867	0.868
Year FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the percentage allocated to risky assets for all pension funds in our sample. Risky assets are allocations to equities, alternative assets, and high-yield bonds. As independent variables, we include *%Retired*, the percentage of retired members in the pension funds; $\textit{Yield}_{t-1}$, the 10-year swap rate in the previous year; *Fund size*, the logarithm of the AUM of the pension funds; *Active*, a dummy variable taking the value of one if the fund has its own internal investment team; *Basic interest rate*, the weighted average of the return guarantee; *Buffer capital*, the logarithm of total buffer capital; *Funding ratio*, the ratio between assets in the collective portfolio and the premium reserve; $\textit{Interest result}_{t-1}$, the realized returns in year_{t-1} adjusted for the basic interest rate in year_{t-1}; *Years since closed*, a variable measuring the number of years since the pension plan was closed for new members; *Equity contribution*; the logarithm of equity contributions from sponsor in that year; *Interest rate guarantee premium*, the logarithm of the interest rate guarantee premium collected that year; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; $\textit{Yield}_{t-1}$ *× Public*, an interaction term capturing the effect of last year's swap rate on public pension funds; *Fund size × Public*, an interaction term capturing the effect of fund size on public pension funds; *Basic interest rate × Public*, an interaction term capturing the basic interest rate for public pension funds; *Buffer capital × Public*, an interaction term capturing the effect of buffer capital on public pension funds; *Funding ratio × Public*, an interaction term capturing the effect of the funding ratio on public pension funds; *Equity contribution × Public*, an interaction term capturing the effect of equity contributions on public pension funds. We include year dummies and fund-fixed effects in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

The variable years since closed are insignificant in columns (2)-(4), indicating no relationship between the number of years since the pension fund was closed and the risk-taking. The finding does not align with our hypothesis that funds decrease their allocation to risky assets when the fund matures. The percentage of retired members is still insignificant in all columns, indicating no significant relationship between the proportion of retired members after controlling for our Norwegian-specific variables. Ultimately, we cannot conclude that there exists a relationship between fund maturity and risky allocation in Norwegian pension funds. Our findings contradict the findings of Andonov et al. (2017), who found that fund maturity was important in explaining the allocation to risky assets in U.S. public funds.

Furthermore, we now investigate the relationship between the BIR and risky allocation. The BIR is an essential variable in pension funds because it is the minimum required return embedded in their pension contracts. We uphold our "reach for yield" hypothesis that an increase in the BIR corresponds to a higher allocation to risky assets due to the need for higher returns. The BIR is significant in columns (1)-(4), and our results indicate that a one percentage point increase in the BIR is associated with an increase in risky allocation of 6.5-9 percentage points. However, we see a surprising effect when adding an interaction term to capture the BIR effect on public funds. According to the regression, public funds react differently to an increase in the BIR. A one percentage point increase is associated with a 13.1 percentage points [9.092 + (-22.285)] decrease in the risky allocation in column (4). We believe there could be two explanations for this discrepancy.

The first explanation for the discrepancy could be the variation in regulatory frameworks when the yield falls below the BIR. In a scenario where the yield falls below the BIR, the legislative framework allows pension funds to compensate for the difference with increased premium payments. However, the legislative framework introduces differential treatment between private and public funds, granting public funds the authority to offset up to 90% of the disparity through increased premium income. In comparison, private funds are constrained to offset merely 50% (Heilund, 2021). We hypothesize that the differential treatment in the legislation between public and private funds can explain the discrepancy. Given that the yield has been lower than the BIR during our sample period, public funds have to a greater extent, been able to compensate with higher premium payments than private funds. Reflecting on the budget equation, an increase in the premium payments will lower the fund's minimum required return, thus making the fund less sensitive to a change in the BIR.

However, after considering the sufficient funding levels for the majority of the funds, it could be argued that elevated risk and anticipated higher returns could be achieved at a lower cost to the sponsor instead of resorting to upward adjustments in premium payments. Hence, we contend that the disparity cannot be solely attributed to the premium payment flexibility afforded to public funds, necessitating further examination to conclude.

The second explanation could be "the misalignment of incentives" hypothesis. As mentioned in section 3.1.2, public funds have a guaranteed regulation of pension contracts beyond the BIR to ensure that pension members maintain their purchasing power. This implies that the public funds must maintain a higher allocation to risky assets, even though the BIR has fallen in the sample period. We hypothesize that this could be a driver of the difference between public and private funds and their relationship to the BIR. However, it is essential to emphasize that these explanations do not provide a complete understanding of the differences, and further investigations are needed to conclude.

The yield in year$_{t-1}$ is highly significant in columns (1) and (2) and aligns with the findings in the previous section. However, the significance disappears when we include an interaction term for the public funds on the BIR in columns (3) and (4). This suggests that the yield in year$_{t-1}$ does not explain the allocation to risky assets. We hypothesize that the correlation between the yield in year$_{t-1}$ and the BIR can explain the disappearance of the significance. Until 2016, the BIR was derived from the yield curve and could not exceed 60% of the long-term government bond yield (Endr. i forsk. om premier mv., 2003, § 2). This implies that our significant yield coefficient in the previous section was probably capturing the effect of the BIR.

In the rapport from Bjøru et al. (2016), they discuss that overcapitalized funds may take more risk in the asset allocation to achieve better returns. We want to check whether this holds for Norwegian pension funds. Therefore, we have added four variables that capture the effect of being well-funded – the buffer capital, the funding ratio, equity contribution, and the interest result. The buffer capital is defined as the sum of additional reserves, the value adjustment fund, and the pension fund's equity. Higher buffer capital means that the pension funds are better funded, all things equal. We hypothesize that a positive relationship exists between the size of the buffer capital and the allocation to risky assets. Table 5.4 showcases our findings. Columns (1)-(4) suggest a positive and significant relationship between the buffer capital and the allocation to risky assets. In column (4), a one-unit increase in the buffer capital is associated with a 5.9 percentage points increase in the risky allocation. In conclusion, better capitalized funds allocate more to risky assets. We have also added an interaction variable to capture the difference between public and private funds. The regression indicates no difference in the allocation to risky assets based on the buffer capital between public and private funds.

The funding ratio is the ratio between the AUM in the collective portfolio and the premium reserve. The collective portfolio represents the assets related to the coverage of future pension liabilities. The premium reserve is the present value of the contractual obligations in the pension fund, and the ratio is an expression of the funding status[3]. Columns (2)-(4) indicate no significant relationship between the funding ratio and the risky allocation. However, when adding public as an interaction term, we see a significant positive relationship between increased funding status in public funds and risky allocation. Column (1) suggests that a 10% increase in the funding ratio in public funds is associated with an increase in risky allocation of 1.67 percentage points [10 x (0.02+0.165)]. The result is significant at a 10% level. A higher funding ratio is associated with a higher allocation towards risky assets, indicating that they utilize their risk capacity.

Furthermore, we want to test the relationship between equity contributions and risk-taking. The annual report of Trondheim Kommunale Pensjonskasse states that they have received equity contributions from their sponsor to increase their risk capacity (Trondheim Kommunale Pensjonskasse, 2018, p. 9). The variable equity contribution captures the amount of equity contributed by the sponsor in a given year. However, columns (2)-(4) shows no significant relationship between equity contribution and risk-taking. Both public and private funds do not alter their risky allocation based on equity contributions, given that the interaction term $Equity \times Public$ is insignificant in column (4).

The interest result captures the difference between realized return and the BIR in year_{t-1}.

[3] This is an alternative way of expressing their funding status and must not be confused with the SCR ratio.

In years with positive interest results, the additional return will be distributed to buffers that can be drawn on to compensate for negative interest results. We hypothesize that the variable affects the risk capacity, implicating a positive relationship with risky allocation. However, columns (2)-(4) suggest no relationship between the interest result and risk-taking.

Finally, we examine the variable active. Active takes the value one if the funds have an in-house investment team and zero if not. An in-house investment team implicates a greater degree of active asset management, and we are interested in investigating the relationship between active management and risk-taking. Evidence from column (2) indicates that an in-house investment team is associated with an increase in risky allocation. However, the significance disappears when including more control variables, and we cannot conclude if the variable affects the allocation to risky assets.

5.3.3 SCR Ratio and Allocation to Risky Assets

In this subsection, we are interested in examining a potential relationship between the SCR ratio and the risky allocation. We have lagged the SCR ratio to capture the effect of last year's SCR ratio on this year's allocation. The rationale for employing the lagged SCR ratio is the expectation that funds exhibit a higher propensity to respond to the SCR ratio observed in the previous year when making allocation decisions for the current year.

Table 5.5 represents our findings. We have included the lagged SCR ratio in all four specifications. In column (4), a 10% increase in the lagged SCR ratio is associated with a decrease in the risky allocation of approximately 0.35 percentage points, significant at a 1% level. Column (4) also includes an interaction term to capture the effect of public funds. However, the coefficient is insignificant, indicating that public and private funds respond similarly to an increase in the SCR ratio. In the modified stress test, an increase in the risky allocation will increase the solvency capital requirement and decrease the SCR ratio, ceteris paribus. The inverse relationship between increased risk and the decrease in the SCR ratio is a trade-off the funds need to make. A higher allocation to risky assets can contribute to higher buffer capital on sight but can reduce the SCR ratio in the short term. Interestingly, the active dummy is now significant in columns (2)-(4), indicating a positive relationship between actively managed funds and risky allocation.

Table 5.5: SCR ratio and allocation to risky assets

	(1)	(2)	(3)	(4)
	Dependent variable: Percentage allocated to risky assets			
SCR ratio$_{t-1}$	-0.036***	-0.038***	-0.035***	-0.035***
	(0.007)	(0.007)	(0.008)	(0.007)
%Retired	0.018	0.023	-0.026	-0.020
	(0.043)	(0.040)	(0.049)	(0.048)
Yield$_{t-1}$	-1.620*	-3.123***	-0.698	-0.391
	(0.807)	(0.845)	(1.052)	(1.119)
Fund size	-0.014	-0.018	0.008	0.010
	(0.039)	(0.033)	(0.059)	(0.059)
Active	0.047	0.058**	0.132**	0.117*
	(0.034)	(0.023)	(0.057)	(0.054)
Basic interest rate	5.601*	5.804**	8.369***	8.168***
	(2.764)	(2.609)	(2.373)	(2.430)
Buffer capital	0.090***	0.067**	0.061**	0.070**
	(0.020)	(0.024)	(0.024)	(0.025)
Funding ratio		0.095	0.063	0.025
		(0.059)	(0.048)	(0.051)
Interest result$_{t-1}$		0.099	0.076	0.071
		(0.113)	(0.105)	(0.104)
Years since closed		-0.005*	0.003	0.003
		(0.003)	(0.003)	(0.003)
Equity contribution		-0.000	-0.000	-0.001
		(0.001)	(0.001)	(0.001)
Interest rate guarantee premium		-0.000	-0.000	-0.000
		(0.000)	(0.000)	(0.000)
Public			1.698	1.751
			(1.188)	(1.175)
%Retired × Public			0.114	0.101
			(0.106)	(0.107)
Yield$_{t-1}$ × Public			-1.210	-1.423
			(0.870)	(0.852)
Fund size × Public			-0.036	-0.021
			(0.064)	(0.063)
Basic interest rate × Public			-22.167***	-20.572***
			(5.570)	(5.140)
Buffer capital × Public			-0.015	-0.044
			(0.027)	(0.031)
Funding ratio × Public				0.133*
				(0.073)
Equity contribution × Public				0.001
				(0.001)
SCR ratio$_{t-1}$ × Public			-0.022	-0.021
			(0.016)	(0.016)
Constant	-1.235	-0.755	-1.313	-1.489
	(0.714)	(0.554)	(1.087)	(1.097)
Observations	847	847	847	847
Adjusted R-squared	0.858	0.863	0.881	0.881
Year FE	Yes	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the percentage allocated to risky assets for all pension funds in our sample. Risky assets are defined as allocations to equities, alternative assets, and high-yield bonds. As independent variables, we include *SCR ratio*$_{t-1}$, the SCR ratio last year; *%Retired*, the percentage of retired members in the pension funds; *Yield*$_{t-1}$, the 10-year swap rate in the previous year; *Fund size*, the logarithm of the AUM of the pension funds; *Active*, a dummy variable taking the value of one if the fund has its own internal investment team; *Basic interest rate*, the weighted average of the return guarantee; *Buffer capital*, the logarithm of total buffer capital; *Funding ratio*, the ratio between assets in the collective portfolio and the premium reserve; *Interest result*$_{t-1}$, the realized returns in year$_{t-1}$ adjusted for the basic interest rate in year$_{t-1}$; *Years since closed*, a variable measuring the number of years since the pension plan was closed for new members; *Equity contribution*; the logarithm of equity contributions from sponsor in that year; *Interest rate guarantee premium*, the logarithm of the interest rate guarantee premium collected that year; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; *Yield*$_{t-1}$ *× Public*, an interaction term capturing the effect of last year's swap rate on public pension funds; *Fund size × Public*, an interaction term capturing the effect of fund size on public pension funds; *Basic interest rate × Public*, an interaction term capturing the basic interest rate for public pension funds; *Buffer capital × Public*, an interaction term capturing the effect of buffer capital on public pension funds; *Funding ratio × Public*, an interaction term capturing the effect of the funding ratio on public pension funds; *Equity contribution × Public*, an interaction term capturing the effect of equity contributions on public pension funds; *SCR ratio*$_{t-1}$ *× Public*, an interaction term capturing the SCR ratio for public funds in year$_{t-1}$. We include year dummies and fund-fixed effects in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

In summary, our empirical analysis highlights that the risky allocation in Norwegian pension funds has increased during our sample period. We find that a higher fund maturity cannot explain the increase in risky allocation. Further, our results suggest that the BIR is an important determinant of the allocation to risky assets. The main finding is that private and public funds react differently to the BIR. An increase in the BIR is associated with an increase in risky allocation for private funds and a decrease in public funds. Furthermore, our analysis indicates that the funds' buffer capital is an important variable in explaining the risky allocation. Higher buffer capital is associated with a higher risky allocation, ceteris paribus. Finally, the inverse relationship between the SCR ratio and the risky allocation suggests that funds with a higher SCR ratio allocate less to risky assets, ceteris paribus.

5.3.4 Net Benchmark-Adjusted Return

In this section, we investigate the performance of the Norwegian pension funds. Our main motivation is to test our "reach for yield" hypothesis and examine if the reach for yield has affected the performance of the funds. Is there a positive relationship between taking more risks and outperforming the benchmark? Or do the funds invest in risky allocation to boost their returns, sacrificing good asset selection? And can we see that public and private funds take equal bets when they reach for yield, or do they perform differently?

The performance measure is the net benchmark-adjusted return (NBAR), calculated by subtracting the investment costs and the benchmark returns from the value adjusted returns. The advantage of using the NBAR instead of reported returns is that the benchmark considers the geographical allocation and exposure to different asset classes (Andonov et al., 2017, p. 24). If the pension funds invest passively and buy the index, any increase in risky allocation will yield a NBAR equal to zero. This makes the NBAR a good measurement of the security selection skills of the different pension funds.

The empirical analysis of the NBAR is divided into three parts. The first part is inspired by the study of Andonov et al. (2017) and examines the relationship between fund maturity, risk-taking, and performance. In the second part, we include Norwegian-specific variables in the specification. Finally, we include the SCR ratio, and we examine the relationship between the SCR ratio of a fund and its performance.

5.3.5 Pension Fund Performance

The study of Andonov et al. (2017) found that U.S. public firms underperformed the benchmark when they reached for yield. The increased allocation to risky assets were not because of the availability of attractive investments, but due to the LDR hypothesis - ultimately making the U.S. public funds underperform compared to the other funds in the sample. Even though Norwegian pension funds do not have the same regulatory incentives as the U.S. public funds, we still find it interesting to investigate the relationship between fund maturity, risk-taking, and the NBAR. Table 5.6 presents our results.

Table 5.6: Pension fund performance

	(1)	(2)	(3)	(4)
Dependent variable: Net benchmark-adjusted returns				
Active	-0.000	-0.002	-0.001	-0.003
	(0.002)	(0.002)	(0.002)	(0.002)
Public	0.024**	-0.018	0.029**	-0.023
	(0.011)	(0.016)	(0.010)	(0.021)
%Risky	0.006	-0.010	0.006	-0.014
	(0.013)	(0.013)	(0.013)	(0.013)
%Retired	-0.003	-0.005	-0.002	-0.005
	(0.005)	(0.005)	(0.005)	(0.005)
Fund size	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)
Δ Risky_{t-1}		0.018		0.018
		(0.018)		(0.018)
Δ Risky_{t-2}		-0.002		0.000
		(0.012)		(0.010)
%Risky $\times$ Public		0.107*		0.149**
		(0.055)		(0.056)
%Retired $\times$ Public		0.009		0.011
		(0.007)		(0.011)
NBAR_{t-1}			0.032	-0.138
			(0.135)	(0.222)
NBAR_{t-1} $\times$ Public			-0.243	-0.288
			(0.201)	(0.194)
Constant	0.040**	0.032**	0.045***	0.034**
	(0.017)	(0.011)	(0.011)	(0.015)
Observations	922	697	847	697
Adjusted R-squared	0.469	0.662	0.580	0.693
Year FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the net benchmark-adjusted pension fund performance. As independent variables, we include *Active*, a dummy variable taking the value of one if the fund has its own internal investment team; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Risky*, the percentage allocated to risky assets; *%Retired*, the percentage of retired members in the pension funds; *Fund size*, the logarithm of the AUM of the pension funds; $\Delta Risky_{t-1}$, the change in the proportion of AUM allocated to risky assets in year_{t-1}; $\Delta Risky_{t-2}$, the change in the percentage allocated to risky assets in $year_{t-2}$; *%Risky × Public*, an interaction term the allocation to risky assets in $year_t$ for public pension funds; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; $NBAR_{t-1}$, the net benchmark-adjusted performance in $year_{t-1}$; $NBAR_{t-1}$ *× Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-1}$ for public funds. We include year dummies in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

Firstly, we start by investigating whether a performance difference exists between public and private funds. We have added a dummy for public funds in our regression, which takes the value one if the fund is public and zero otherwise. Columns (1) and (3) suggest that public funds have a significantly higher NBAR. Column (3) suggests that a public fund outperforms private funds with roughly 0.03 percentage points annually, significant at a 10% level. However, the significance disappears when adding interaction variables in columns (2) and (4). Consequently, it is hard to conclude whether public funds outperform private funds. In contrast, the study by Andonov et al. (2017) found that U.S. public funds underperformed compared to the other funds in the sample. They relate the underperformance to "the regulatory incentives hypothesis" and lower investment skills among public managers. However, we cannot conclude with the same results in Norway.

Further, we examine the relationship between fund maturity and performance. Fund maturity is expressed as the percentage of retired members in the fund. We hypothesize that there might be a negative relationship between fund maturity and the NBAR. As the funds mature, the risk of them being unable to meet their obligations decreases. Could this reduction in uncertainty lead to funds not striving to take good bets, resulting in underperformance? Or could this lead to funds becoming less motivated to pursue lucrative opportunities, which may also result in underperformance? However, Table 5.6 indicates no significant relationship between fund maturity and underperforming the benchmark. Columns (2) and (4) include an interaction variable between public funds and fund maturity. Our results suggest no significant difference between fund maturity in public and private funds and underperforming the benchmark. Andonov et al. (2017), found that U.S. public funds with higher maturity underperformed the benchmark. However, we cannot conclude with the same results for public funds in Norway.

We are now interested in examining if the increased risky allocation has affected the performance of the funds. Andonov et al. (2017) found evidence in the U.S. that public funds underperformed the benchmark when they reached for yield. We want to examine if the same relationship can be observed in Norway. Our regressions shows no relationship between the level of risk-taking and the NBAR in columns (1), (2), and (3) in Norwegian funds. However, when adding an interaction variable in column (4), we see that public funds outperform the benchmark when they increase their allocation to risky assets.

Column (4) suggests that a one percentage point increase in the allocation towards risky assets is associated with a 0.135 [0.149 + (-0.014)] percentage points increase in the NBAR annually. Consequently, public funds seem to outperform the benchmark when they reach for yield.

We hypothesize that there may be two reasons for the outperformance. The first reason could be that public funds have better security selection skills than private funds. The second reason could be the real estate exposure of the public funds. By examining the asset allocation trend, we see that public funds have increased their investment in real estate more than private funds. Public funds typically invest more in direct real estate investment than private funds. The outperformance could come from the risk premium they have collected for taking more systematic risk compared to publicly listed, more diversified real estate exposure. The real estate portfolio of public funds typically consists of buildings leased to their sponsor on long contracts. Real estate with public counterparts on long-term leases has been attractive in a period with real interest rates in negative territory.

Finally, we examine the relationship between having an in-house investment team and performance. We hypothesize that funds with active management follow the market more closely and will therefore take better bets. However, we cannot find any evidence supporting this rationale, and we conclude that funds with an in-house investment team do not outperform the benchmark.

5.3.6 Norwegian Specific Variables and Pension Fund Performance

In this section, we add Norwegian-specific variables to further build on the specification of Andonov et al. (2017). We have added three new variables to the regression: equity contribution, the BIR, and the funding ratio. The objective is to examine whether Norwegian-specific variables can explain a potential outperformance. In addition, we also investigate the story of potential persistency in returns by adding NBAR_{t-2} and NBAR_{t-3}. We begin with a simple specification in column (1) before adding more variables and interactions in columns (2)-(4). Our results are presented in Table 5.7.

Table 5.7: Norwegian specific variables and pension fund performance

	(1)	(2)	(3)	(4)
Dependent variable: Net benchmark-adjusted returns				
Active	-0.002	-0.002	-0.002	-0.002
	(0.002)	(0.002)	(0.002)	(0.002)
Public	0.020*	-0.038	-0.012	0.005
	(0.010)	(0.023)	(0.058)	(0.045)
%Risky	0.006	-0.014	-0.017	-0.008
	(0.012)	(0.013)	(0.013)	(0.014)
%Retired	-0.002	-0.003	-0.003	-0.002
	(0.005)	(0.004)	(0.005)	(0.004)
Fund size	-0.001	-0.000	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)
Δ Risky$_{t-1}$	0.020	0.019	0.018	0.036
	(0.016)	(0.017)	(0.019)	(0.028)
Basic interest rate	-0.097	-0.088	-0.265	-0.015
	(0.303)	(0.267)	(0.415)	(0.229)
Equity contribution	0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Funding ratio	-0.004	-0.001	-0.004	0.002
	(0.011)	(0.012)	(0.012)	(0.010)
%Retired × Public		0.013*	0.020*	0.003
		(0.007)	(0.009)	(0.010)
%Risky × Public		0.145**	0.132***	0.095***
		(0.062)	(0.029)	(0.022)
Basic interest rate × Public			0.394	-0.830
			(2.388)	(1.778)
Yield$_{t-1}$			0.409	0.381
			(0.359)	(0.335)
Yield$_{t-1}$ × Public			-1.083	0.348
			(0.941)	(0.832)
NBAR$_{t-1}$			-0.276	0.148
			(0.163)	(0.093)
NBAR$_{t-2}$			-0.132	-0.092
			(0.205)	(0.339)
NBAR$_{t-3}$				0.382***
				(0.075)
NBAR$_{t-1}$ × Public				-0.212
				(0.167)
NBAR$_{t-2}$ × Public				0.306*
				(0.164)
NBAR$_{t-3}$ × Public				-0.421*
				(0.187)
Constant	0.038*	0.037	0.050	0.004
	(0.021)	(0.021)	(0.036)	(0.029)
Observations	772	772	772	697
Adjusted R-squared	0.575	0.617	0.662	0.758
Year FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the net benchmark-adjusted pension fund performance. As independent variables, we include *Active*, a dummy variable taking the value of one if the fund has its own internal investment team; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Risky*, the percentage allocated to risky assets; *%Retired*, the percentage of retired members in the pension funds; *Fund size*, the logarithm of the AUM of the pension funds; Δ $Risky_{t-1}$, the change in the proportion of AUM allocated to risky assets in year$_{t-1}$; *Basic interest rate*, the weighted average of the return guarantee; *Equity contribution*; the logarithm of equity contributions from the sponsor in year$_t$; *Funding ratio*, the ratio between assets in the collective portfolio and the premium reserve; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; *%Risky × Public*, an interaction term capturing the allocation to risky assets in $year_t$ for public pension funds; *Basic interest rate × Public*, an interaction term capturing the basic interest rate for public pension funds; $Yield_{t-1}$, the 10-year swap rate in year$_t$; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of last year's swap rate on public pension funds; $NBAR_{t-1}$, the net benchmark-adjusted performance in $year_{t-1}$; $NBAR_{t-2}$, the net benchmark-adjusted performance in $year_{t-2}$; $NBAR_{t-3}$, the net benchmark-adjusted performance in $year_{t-3}$; $NBAR_{t-1}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-1}$ for public funds; $NBAR_{t-2}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-2}$ for public funds;$NBAR_{t-3}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-3}$ for public funds. We include year dummies in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5% and 1% levels are indicated by *, **, and ***, respectively.

Firstly, we examine the relationship between the BIR, equity contribution, and funding ratio. Columns (1)-(4) suggest no relationship between the Norwegian-specific variables and the NBAR. We, therefore, conclude that the Norwegian-specific variables cannot explain any performance deviations from the benchmark.

In line with the findings in the previous section, we still find that public funds outperform the benchmark when allocating more to risky assets. In column (4), a ten percentage point increase in the risky allocation is associated with an outperformance of 0.87 [10 $\times$ ((0.095 -(0.008))] percentage points annually, significant at a 1% level. In addition, we now see a significant effect on the interaction variable *Retired* $\times$ *Public* in columns (2) and (3). The relationship suggests that public funds outperform the benchmark when the fund maturity increases. In column (3), a one percentage point increase in the fund maturity is associated with an outperformance of the benchmark of 0.017 [0.02 + (-0.003)] percentage points annually. Regarding our "misalignment of incentives hypothesis," we expect the relative performance measured against the benchmark to be equal for the two fund types. Because of the asymmetrical return distribution of private funds and the underlying regulatory mechanism of pensions in public funds, both fund types should be incentivized to beat the benchmark through good allocation decisions.

Finally, we find the return persistence in Norwegian pension funds worth investigating. We find no evidence of persistence in returns on a one-year horizon. Columns (3) and (4) indicates that both NBAR_{t-1} and $NBAR_{t-1}$ $\times$ *Public* are insignificant. Our results indicate that public funds outperform the benchmark on a two-year horizon. In column (4), a one percentage point increase in the NBAR in year_{t-2} is associated with an 0.31 percentage point increase in the NBAR in year_t. The coefficient for private funds is insignificant in column (4), and we cannot conclude if private funds have persistence in returns on a two-year horizon.

At last, we find that private funds outperform, while public funds underperform the benchmark on a three-year horizon. In column (4), a one percentage point increase in the NBAR in year_{t-3} is associated with a 0.38 percentage point increase in the NBAR in year_t for private funds. However, public funds underperform the benchmark by 0.04 [0.382 + (-0.421)] percentage points annually in the same time period. It should be emphasized that the number of observations is lower on this time horizon, potentially affecting the robustness of the result. In summary, it is hard to establish a consistent view of the persistence in returns over time. Our findings point in the same direction as the findings of Forbrukerrådet (2018), who found low persistency in returns across time periods for Norwegian mutual funds.

5.3.7 SCR Ratio and Pension Fund Performance

This last subsection examines the relationship between the SCR ratio and the NBAR. We have lagged the SCR ratio by one year to capture how the SCR ratio in $year_{t-1}$ affects the performance in $year_t$. Our results are presented in Table 5.8. We find no significant relationship between the SCR ratio and the NBAR in columns (1), (2), and (3). However, in column (4), the interaction variable $SCR\ ratio_{t-1} \times Public$ becomes significant at a 10% level. A ten percentage point increase in the SCR ratio is associated with a relative outperformance of the benchmark for public funds of 0.09 [$10 \times (0.013 - (0.004))$] percentage points annually. In contrast, a ten percentage point increase in the SCR ratio for private funds is associated with an annual underperformance of the benchmark of 0.04 percentage points.

To summarize, this section has investigated the performance of Norwegian pension funds. Our empirical analysis is ambiguous when it comes to fund maturity and performance. Our results suggest that public funds outperform the benchmark when fund maturity increases. However, we cannot see the same results for private funds. Further, we find evidence that public funds outperform the benchmark in some specifications. An interesting finding is that public funds tend to outperform the benchmark when they allocate more to risky assets, implying that the reach for yield in public funds does not compromise performance. The finding contradicts the findings of Andonov et al. (2017), where an increase in risky assets for public funds was associated with an underperformance of the benchmark. We hypothesize that the outperformance in public firms can be explained by the increased allocation to real estate, where they receive a risk premium for their direct investments. We also see that the Norwegian-specific variables cannot explain any differences in benchmark performance. Finally, we identify a positive return persistency on a three-year basis for private funds, while public funds seem to outperform on a two-year horizon.

Table 5.8: SCR ratio and pension fund performance

	(1)	(2)	(3)	(4)
Dependent variable: Net benchmark-adjusted returns				
SCR ratio_{t-1}	-0.001	-0.004	-0.004	-0.004
	(0.002)	(0.003)	(0.002)	(0.003)
Active	-0.002	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
Public	0.020*	-0.063	-0.040	-0.042
	(0.009)	(0.037)	(0.053)	(0.043)
%Risky	0.003	-0.020	-0.018	-0.015
	(0.011)	(0.013)	(0.012)	(0.015)
%Retired	-0.002	-0.003	-0.003	-0.003
	(0.005)	(0.005)	(0.005)	(0.005)
Fund size	-0.001	-0.000	-0.000	-0.000
	(0.001)	(0.001)	(0.001)	(0.000)
Δ Risky_{t-1}	0.019	0.020	0.021	0.034
	(0.015)	(0.017)	(0.017)	(0.030)
Basic interest rate	-0.072	-0.017	-0.095	0.014
	(0.284)	(0.244)	(0.337)	(0.214)
Equity contribution	0.000	0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Funding ratio	-0.002	0.003	0.003	0.007
	(0.013)	(0.013)	(0.012)	(0.012)
SCR ratio_{t-1} × Public		0.016	0.009	0.013*
		(0.012)	(0.006)	(0.006)
%Risky × Public		0.143**	0.095**	0.112***
		(0.057)	(0.035)	(0.023)
%Retired × Public		0.008	0.011*	-0.001
		(0.010)	(0.005)	(0.012)
Basic interest rate × Public			1.646	-0.295
			(2.519)	(1.696)
Yield_{t-1}			0.663**	0.315
			(0.291)	(0.301)
Yield_{t-1} × Public			-1.510	0.586
			(1.090)	(0.771)
NBAR_{t-1}				0.134
				(0.095)
NBAR_{t-2}				-0.099
				(0.329)
NBAR_{t-3}				0.372***
				(0.076)
NBAR_{t-1} × Public				-0.213
				(0.158)
NBAR_{t-2} × Public				0.302*
				(0.158)
NBAR_{t-3} × Public				-0.420**
				(0.178)
Constant	0.038*	0.038*	0.017	0.008
	(0.021)	(0.019)	(0.028)	(0.026)
Observations	772	772	772	697
Adjusted R-squared	0.575	0.627	0.639	0.763
Year FE	Yes	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variable is the net benchmark-adjusted pension fund performance. As independent variables, we include *SCR* $ratio_{t-1}$, the SCR ratio last year; *Active*, a dummy variable taking the value of one if the fund has its own internal investment team; *Public*, a dummy variable taking the value of one if a pension fund is public; *%Risky*, the percentage allocated to risky assets; *%Retired*, the percentage of retired members in the pension funds; *Fund size*, the logarithm of the AUM of the pension funds; Δ $Risky_{t-1}$, the change in the proportion of AUM allocated to risky assets in year_{t-1}; *Basic interest rate*, the weighted average of the return guarantee; *Equity contribution*; the logarithm of equity contributions from the sponsor in year_t; *Funding ratio*, the ratio between assets in the collective portfolio and the premium reserve; *SCR* $ratio_{t-1}$ × *Public*, an interaction term capturing the SCR ratio for public funds in the previous year; *%Risky × Public*, an interaction term capturing the allocation to risky assets in $year_t$ for public pension funds; *%Retired × Public*, an interaction term capturing the percentage of retired members among public pension funds; *Basic interest rate × Public*, an interaction term capturing the basic interest rate for public pension funds; $Yield_{t-1}$, the 10-year swap rate in year_{t-1}; $Yield_{t-1}$ × *Public*, an interaction term capturing the effect of last year's swap rate on public pension funds; $NBAR_{t-1}$, the net benchmark-adjusted performance in $year_{t-1}$; $NBAR_{t-2}$, the net benchmark-adjusted performance in $year_{t-2}$; $NBAR_{t-3}$, the net benchmark-adjusted performance in $year_{t-3}$; $NBAR_{t-1}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-1}$ for public funds; $NBAR_{t-2}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-2}$ for public funds;$NBAR_{t-3}$ × *Public*, an interaction term capturing the net benchmark-adjusted performance in $year_{t-3}$ for public funds. We include year dummies in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

5.4 SCR Ratio Dynamics: Exploring Drivers of Change

The following section is presented in two parts. In the first part, we investigate the drivers of a change in the SCR ratio. The second part investigates the measures a fund with an inadequate SCR ratio takes to improve its solvency position. We find the relationship between risky allocation, performance, and solvency worth investigating. So far, our analysis has identified drivers of the allocation towards more risky assets and its implications on relative performance. To meet their guaranteed rate of returns, pension funds have increased their allocation towards risky assets in our sample period. To our knowledge, there is no concrete research on how the change in asset allocation has impacted their solvency position. Could the change in the allocation have increased the risk that pension funds cannot meet their obligations in the future? Given the size and systemic importance of pension funds, we believe our analysis provides useful insights and a better understanding of the consequences of a change in the asset allocation. The following regressions in Table 5.9 investigates potential drivers for the change in the SCR ratio for Norwegian pension funds on different time horizons. Columns (1), (2), and (3) illustrate the drivers of the changes on a one, two, and three-year basis, respectively. This allows us to differentiate between short- and medium-term drivers of the changes in the SCR ratio.

An important disclosure is that we only consider 13 years, involving fewer observations for columns (2) and (3). Combined with the short-term focus of the modified stress test 1 model (a 12-month horizon), we believe the results in column (1) to be the most representative of our analysis. We hypothesize that an increase in the variables associated with the buffer capital will positively affect the SCR ratio. In contrast, the variables related to asset allocation are expected to impact the SCR ratio negatively. Lastly, we expect the interest rate difference to affect the SCR ratio negatively. The interest rate difference measures the difference between the current yield and the BIR[4]. Since the yield curve has fallen below the BIR, the fair value of liabilities has exceeded the book value, as mentioned in section 3.2. The increase in the present value of liabilities is further subject to stress in the interest rate risk model and will ultimately increase the solvency capital requirement. We present our findings in Table 5.9.

[4]The interest rate difference must not be confused with the interest result.

Table 5.9: Drivers of change in the SCR ratio in the short and medium-term

	(1)	(2)	(3)
	Δ SCR ratio 1.yr	Δ SCR ratio 2.yr	Δ SCR ratio 3.yr
Δ Realized return	0.266	0.970	0.958
	(0.599)	(0.646)	(0.888)
Δ Value adjusted return	-0.093	-0.356	-0.351
	(0.228)	(0.351)	(0.220)
Δ Interest rate difference	8.515	-3.813	-9.525
	(14.284)	(12.151)	(12.664)
Δ Duration	-0.071**	-0.070**	-0.064*
	(0.032)	(0.028)	(0.029)
Δ Paid in capital	0.224	0.311*	0.417*
	(0.174)	(0.163)	(0.187)
Δ Retained earnings	0.083**	0.096**	0.041
	(0.032)	(0.040)	(0.057)
Δ Additional reserves	0.018	0.007	0.007
	(0.020)	(0.009)	(0.010)
Δ Value adjustment fund	0.007	0.015**	0.007
	(0.008)	(0.007)	(0.007)
Δ Premium fund	0.013	0.010	0.012
	(0.008)	(0.013)	(0.019)
Δ%Equity	-4.870***	-4.706***	-5.256***
	(0.731)	(0.724)	(1.186)
Δ %Investment grade bonds	-0.989**	-1.405*	-2.371*
	(0.406)	(0.671)	(1.168)
Δ %High yield bonds	-2.620**	-3.152**	-3.997**
	(1.011)	(1.201)	(1.466)
Δ %Hedge funds	-5.766***	-4.604***	-4.581**
	(0.809)	(0.922)	(1.446)
Δ %Private equity	-4.214***	-6.712***	-6.682***
	(1.044)	(1.289)	(1.860)
Δ %Real estate	-3.018***	-3.319**	-4.541**
	(0.871)	(1.218)	(1.513)
Constant	0.034	-0.087	-0.182*
	(0.066)	(0.079)	(0.098)
Observations	676	608	537
Adjusted R-squared	0.255	0.348	0.427
Year FE	Yes	Yes	Yes
Fund FE	Yes	Yes	Yes
Double-clustering	Yes	Yes	Yes

In this table, we have estimated a panel model. The dependent variables are the percentage point change in the SCR ratio measured on a one, two, and three-year time horizon, in columns (1), (2), and (3), respectively. As independent variables, we have included the same variables for every time horizon, matching their respective dependent variable. As an example, Δ*Realized return* will be measured on a one-year time horizon in column (1), a two-year time horizon in column (2), and a three-year horizon in column (3). We have included Δ*Realized return*, the change in the realized return over the time period measured in percentage points; Δ*Value adjusted return*, the change in the value adjusted return over the time period measured in percentage points; Δ*Interest rate difference*, the difference between the extrapolated yield curve and the basic interest rate measured in percentage points; Δ*Duration*, the change in the duration of assets over the period; Δ*Paid in capital*, the change in the logarithm of accumulated equity contributions over the period; Δ*Retained earnings*, the change in the logarithm of retained earnings over the period; Δ*Additional reserves*, the change in the logarithm of the additional reserves over the period; Δ*Value adjustment fund*, the change in the logarithm of the value adjustment fund over the period; Δ*Premium fund*, the change in the logarithm of the premium fund over the period; Δ*%Equity*, the change in the allocation in equities over the period measured in percentage points; Δ*%Investment grade bonds*, the change in the allocation in investment grade bonds over the period measured in percentage points; Δ*%High yield bonds*, the change in the allocation in high-yield bonds over the period measured in percentage points; Δ*%Hedge funds*, the change in the allocation in hedge funds over the period measured in percentage points; Δ*%Private equity*, the change in the allocation in private equity over the period measured in percentage points; Δ*%Real estate*, the change in the allocation in real estate over the period measured in percentage points. We include year dummies and fund-fixed effects in all regressions. The robust standard errors are double clustered by fund and year, and reported in parentheses. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

5.4.1 Dynamics on a One-Year Basis

Our results in column (1) suggest that the asset allocation decisions are an essential driver for the change in the SCR ratio on a one-year horizon. A one percentage point increase in the allocation to equities is associated with a 4.9 percentage point negative change in the SCR ratio, significant at a 1% level. We also observe that the change in allocation to hedge funds, private equity, real estate, HY bonds, and IG bonds is significant. In line with our expectations, a positive change in the asset allocation is associated with an adverse change in the SCR ratio. It is worth mentioning that the asset classes experiencing the highest stress factor in the modified stress test are also the variables that exhibit the most significant impact on the SCR ratio. As previously described in the summary statistics, we have seen that Norwegian pension funds have increased their allocation to risky assets during our sample period. Our results suggest that the increased allocation to risky assets has decreased the SCR ratio of the funds, ceteris paribus. This is also in line with the findings of Braun et al. (2017), as described in the literature review.

Further, we observe that an increase in the duration of the fixed-income portfolio is associated with a negative change in the SCR ratio. The relationship aligns with our expectations, as a higher duration will increase the solvency capital requirement, ceteris paribus.

Moreover, retained earnings are an important variable in explaining the SCR ratio on a one-year basis. Since the retained earnings are a part of the buffer capital, we expect an increase to be associated with a positive change in the SCR ratio. Our results suggest that a one-unit increase in the retained earnings is associated with an 8.3 percentage points positive change in the SCR ratio, significant on a 5% level. Finally, we expected a change in the interest rate difference to be significant. However, our regression suggests no significant relationship between the interest rate difference and the change in the SCR ratio.

5.4.2 Dynamics on a Two-Year Basis

The drivers of change in the SCR ratio on a two-year horizon are relatively consistent with those observed in column (1). We still find the change in asset allocation to be an essential variable when explaining the change in the SCR ratio on a two-year horizon. An increase in the allocation to risky assets is still associated with a decrease in the SCR ratio, significant for all variables. The duration of the fixed-income portfolio is still significant, and indicates that an increase in the duration of the fixed-income portfolio is associated with an adverse change in the SCR ratio.

The buffer capital seems to be more significant on a two-year horizon. We observe that both the value adjustment fund and the paid-in capital are now significant, and an increase is associated with a positive change in the SCR ratio. A one-unit increase in the value adjustment fund is associated with a 1.5 percentage point positive change in the SCR ratio. Throughout our sample period, multiple funds have built significant value adjustment funds because of increased allocations towards risky assets and the strong performance in these asset classes. Ultimately, this has resulted in the value adjustment fund being an important determinant in explaining changes in the SCR ratio. Furthermore, a one-unit increase in the paid-in capital is associated with a 31.1 percentage point increase in the SCR ratio, significant on a 5% level. Our results highlight that a strong development in the equity position gives a considerably better change in the SCR ratio on a two-year horizon.

5.4.3 Dynamics on a Three-Year Basis

We also observe that the drivers of the SCR ratio on a three-year horizon are relatively consistent with the drivers on a two-year horizon. Asset allocation is still an important determinant of the SCR ratio on a three-year horizon. However, we now observe that the value adjustment fund and the retained earnings become insignificant.

To conclude, the drivers of the change in the SCR ratio are relatively consistent over time. Our specifications suggest that pension fund allocation is the most consistent driver of the change in the SCR ratio. An increase in allocation towards risky assets is associated with a negative change in the SCR ratio, ceteris paribus. We also observe that the buffer capital is more inconsistent when explaining the change in the SCR ratio over time. For example, the value adjustment fund is significant when explaining the change in the SCR ratio over a two-year horizon. However, on a one and three-year horizon, the significance disappears.

5.5 Analyzing Measures Funds Take to Improve their Solvency Position

In this section, we have examined the measures a fund with an inadequate SCR ratio takes to improve its solvency position. The SCR ratio in Norwegian pension funds must always exceed 100% to ensure that the insurance provisions are sufficient to cover the future obligations (Bjøru et al., 2016, p. 62). Commonly, the board of directors in the pension funds has developed a traffic light system, where they start implementing measures when the SCR ratio falls below 130-140% (Arendal Kommunale Pensjonskasse, 2022; Skien Kommunale Pensjonskasse, 2022). To investigate the fund's measures, we conduct a difference-in-difference analysis. The treatment group is the funds with a SCR ratio of 135% or lower, while the control group is the funds with an SCR ratio higher than 135%. The difference-in-difference analysis is based on the average value of year_{t-1} and year_{t-2} compared to the average value of year_{t+1} and year_{t+2}, where the treatment is received in year_t.

There are two potential ways a fund can improve its SCR ratio. The first method is to increase the eligible capital, which consists of equity, the value adjustment fund, and additional reserves. The second method is to reduce the investments in risky assets and hence reduce the aggregated solvency capital requirement. However, reducing the risky allocation may come at a cost for the pension funds. A lower allocation to risky assets could potentially lead to lower expected returns in the future, ultimately affecting the eligible capital. Therefore, pension funds must continuously make trade-offs between meeting the SCR ratio requirements in the short term and fulfilling their pension obligations in the long term. This trade-off has been the main criticism of the Solvency II regulation.

We emphasize that the results should be interpreted cautiously, as the Solvency II framework was first implemented for pension funds in 2019. As a consequence, we analyze measures the funds have taken, even though they were not regulatory obliged to act. However, before 2019 the pension funds still had to report their solvency position through other solvency metrics, such as the buffer capital ratio (The Financial Supervisory Authority, 2019). Since the buffer capital ratio is built on the same principles as the SCR ratio, we believe the funds needed to take similar measures to improve their solvency position.

We have divided the analysis into four parts. The first part will examine the measures taken by the sponsor of a stressed fund. Can we observe that the sponsor of the stressed fund has contributed with more equity compared to the control group? The second part of the analysis investigates if the funds have changed their asset allocation to improve their SCR ratio. The third part will examine the differences in buffer capital development between the two groups. Finally, we investigate the development in the SCR ratio between the treatment and control groups. Our results are presented in table 5.10.

Table 5.10: Measures funds take to improve their solvency position

	Mean Treatment Difference (Avg. of Year_{t+1} & Year_{t+2} vs. Avg. of Year_{t-1} & Year_{t-2})	Mean Control Difference (Avg. of Year_{t+1} & Year_{t+2} vs. Avg. of Year_{t-1} & Year_{t-2}	Mean of Diff-in-Diffs (Controls vs. Treatments)	t-statistic for Difference-in-Differences
Action from sponsor				
Equity contribution	0.7592	1.0432	0.2840	1.424
Allocation				
% Cash and cash equivalents	-0.0039	0.0042	-0.0003	-0.065
% Investment grade bonds	-0.0354	-0.0015	-0.0339***	5.219
% High-yield bonds	0.0107	0.0021	0.0089**	-2.064
% Equities	0.0229	0.0180	-0.0049	-0.802
% Hedge funds	0.0004	0.0019	0.0016	0.979
% Private equity	0.0013	0.0017	0.0004	0.359
% Real estate	0.0120	0.0076	0.0044*	-1.937
Return				
Value adjusted returns	-0.0001	0.0050	0.0051	1.219
Realized Returns	-0.0014	-0.0020	-0.0006	-0.272
Buffer capital				
Value Adjustment Fund	2.3047	1.2293	-1.0753***	-3.883
Additional reserves	0.9398	0.5818	-0.3580***	-2.208
Paid-in capital	0.2153	0.1969	-0.0185	-0.411
Retained earnings	0.3438	0.4141	0.0703	0.298
Premium fund	0.5508	0.7806	0.2298	1.166
SCR ratio				
Eligible capital	0.5975	0.4627	-0.1348***	-3.536
SCR	0.4249	0.3579	-0.0670**	-1.963
SCR ratio	0.1632	0.1153	-0.0478	-1.483
Treated observations	154	154		
Control observations	468	468		
Total observations	622	622		

This table presents how pension funds react to an inadequate solvency position, measured against a control group. An inadequate solvency position is defined as an SCR ratio below 135% in any given period. We have included *Action from sponsor*; where the *Equity contribution* represents the relative change between the two periods measured in %; *Allocation*, where all variables shows the change in allocation weights between the two periods measured in percentage points; *Return*, where both variables represents the change between the two periods measured in percentage points; *Buffer capital*, where all variables measures the relative change between the two periods measured in %; *SCR ratio*, where all variables represents the relative change between the two periods measured in %. For each variable, we measure the average in the two following years (year_{t+1} and year_{t+2}) compared to the average in the years before the treatment in year_t (year_{t-1} and year_{t-2}). This is done for the treatment and control groups, representing the treatment and control differences, respectively. The difference between the control and treatment group is presented in the column for Diff-in-Diffs. Variables related to volatile balance sheet items are winsorized at the one percent level. The t-statistics have been calculated using bootstrapped standard errors. Statistical significance is only shown for the mean of the Diff-in-Diffs. The statistical significance at the 10%, 5%, and 1% levels are indicated by *, **, and ***, respectively.

Equity Contribution

Following the mechanisms of the stress test, we expect the equity contributions to be the most effective action to improve the SCR ratio. In line with our expectations, both groups have increased their equity contributions. However, we find no evidence that a stressed fund receives more equity contributions from its sponsor than the control group. Surprisingly, our results suggest the opposite. In our sample period, the control group had a larger change in equity contributions compared to the treatment group. To conclude, we cannot observe that the stressed funds receive greater equity contributions than the control group to improve their solvency position.

Allocation

The asset allocation is where we see the most significant differences between the two groups. Our results indicate a significant difference when examining the allocation to IG bonds, HY bonds, and real estate. We observe that both the control and treatment groups reduce the allocation to IG bonds in our analysis, in line with the findings of the summary statistic in section 5.2. However, our results suggest that the treatment group significantly decreases the allocation to IG bonds by 3.4 percentage points more than the control group, significant at a 1% level. We also observe that the treatment group increases the allocation to HY bonds and real estate, with 0.9 and 0.4 percentage points more than the control group, significant at a 5% and 10% level.

We believe two motivations can explain the change in allocation. The first motivation is that a reduction in IG bonds (low-risk assets) and an increase in HY bonds and real estate (risky assets) improves the expected return of the funds. Higher expected returns can lead to a higher buffer capital and a better SCR ratio on sight. The second motivation is that the modified stress test imposes a relatively modest strain on HY bonds and real estate compared to other asset classes, such as equities. We hypothesize that the funds attempt to increase the expected return to build buffers over time while ensuring that the SCR ratio still remains within the 100% threshold. However, we cannot find evidence that the increased allocation to HY bonds and real estate has led to significantly better returns. It could be argued that the improvements in returns take time, and our analysis does not capture long-term improvements.

Buffer Capital

Our analysis suggests that the value adjustment fund and the additional reserves of the treatment group have significantly improved more than the control group. Measured in relative changes, the treatment group has approximately 108 percentage points greater change in their value adjustment fund than the control group. For the additional reserves, the difference is 36 percentage points in favor of the treatment group. Our results are significant at a 1% level. We hypothesize that the significant difference between the two groups stems from base effects. Since funds with a low solvency ratio are likely to have lower value adjustment funds and additional reserves, any increase will yield a high percentage change in favor of the treatment group. In addition to the base effects, we believe the regulatory hurdle of the additional reserves could explain the differences in the relative change between the treatment and control groups. The regulatory hurdle limits the additional reserves to a maximum of 12% of the premium reserve. Since well-funded funds are likely to be closer to this limit than funds with an inadequate SCR ratio, our results suggest that this might cause them to distribute their interest result differently.

SCR Ratio

In our final analysis, we have deconstructed the SCR ratio into eligible capital and the solvency capital requirement. Compared to the control group, the treated funds increased their eligible capital and solvency capital requirement by roughly 13.5 and 6.7 percentage points, respectively. These findings are significant on a 1 and 5% level. However, we cannot observe that the overall improvement in the SCR ratio for the treatment group is significantly better than the control group.

In conclusion, our results indicate that a fund with an inadequate SCR ratio tries to improve its solvency position by reaching for yield. We observe that the treatment group invests more in HY bonds and real estate while they invest less in IG bonds. Changes in asset allocation can be explained by the expectation of higher returns and, consequently, higher buffer capital. Although the change in the allocation has not led to a significant outperformance for the treatment group, we observe that they have built significantly higher buffers. We further argue that this may be due to base effects. Finally, our results suggest that the development of the SCR ratio in the treatment group has not been significantly higher than in the control group.

6 Conclusion

In the following section, we summarize our findings and the empirical discussions. Further, we include proposals for future research on the topic. In this thesis, we have investigated potential drivers of risky allocation for Norwegian pension funds and how the shift in their asset allocation has impacted their relative performance and solvency position. The field has received little scholarly attention, and we contribute to the literature in all three parts of our empirical analysis. The empirical analysis is based on 75 Norwegian pension funds with a sample period from December 31st, 2009, to December 31st, 2021.

Our first analysis focuses on the determinants of risky allocation in Norwegian pension funds. We start by showcasing a descriptive summary of how the risky allocation in Norwegian pension funds has increased during our sample period. We then present our regressions with the most critical determinants of the risky allocation. Our main finding is that the BIR is an essential determinant in explaining the allocation to risky assets. Private and public funds react differently to the BIR, and our findings suggest that private funds increase their allocation to risky assets when the BIR increase and public funds decrease their allocation. We explain the discrepancy between public and private funds with differences in legislation and the "misalignment of incentives" hypothesis. Our regression results also suggest a significant relationship between risk-taking and the SCR ratio of a fund, indicating that funds with a stronger solvency position take less risk.

Our second analysis further indicates that the preference for riskier allocation is associated with an outperformance of the benchmark for public funds. However, we cannot see the same results for private funds. There is general evidence of public funds outperforming private funds. The outperformance could come from the risk premium public funds have collected for taking more systematic risks in their real-estate exposures. Lastly, we have looked at the persistence of returns in the Norwegian pension funds. Our results suggest a persistence in returns on a three-year basis for both public and private funds. We also see that the persistence among private and public funds seems to vary over time.

Our final analysis is divided into two parts. The first part has studied the drivers of a change in the SCR ratio in Norwegian pension funds. Our results suggest that the asset allocation decisions of the funds are the most consistent driver of a change in the SCR ratio over time. An increase in allocation to more risky assets has decreased the SCR ratio of the pension funds, ceteris paribus. The results also suggest that the building of buffers positively impacts the SCR ratio. The findings are most likely related to the stress test mechanism of the balance sheet of pension funds and the strong market performance throughout our sample period. The second part studied the measures a fund takes in response to an inadequate SCR ratio. Our analysis highlights that funds with an inadequate solvency position respond by increasing their allocation towards more risky assets, such as real estate. This points toward reach for yield, where funds try to increase their SCR ratio by building buffer capital through higher expected returns.

In order to conduct our analyses, we spent a significant time extracting the dataset. For the calculations of the SCR ratio, our simplifications and focus on publicly available information could have influenced our results and conclusions. As the reporting quality increased throughout the sample period, we believe more comprehensive and efficient data extraction can be performed in the future. This is particularly relevant for the SCR ratio, where future studies can use the reported SCR ratio, ultimately improving the robustness of the analysis. For future research, it will be interesting to see the implications of the recent spike in yields on the allocation to risky assets, the relative performance, and the solvency position of the funds. What if the yield continues to spike, and we get prolonged periods of poor overall market performance? How will the pension funds react to this economic climate, and will they be able to deliver sufficient returns? As of June 2022, the increase in interest rates has lowered the present value of their liabilities more than the reduction of their buffers, pointing in the direction of stronger solvency positions (The Financial Supervisory Authority, 2023).

In conclusion, Norwegian pension funds have increased their exposure to risky assets in a period with low interest rates, which could have increased their solvency risk. However, our evidence shows that over the same period, their solvency position has improved. This must be seen in the context of the almost continuous bull market across most financial assets in our sample period. At the same time, this highlights a potential for even higher risk-taking to provide better pensions for future pensioners, but raises an essential question to the boardrooms: Are we better off safe than sorry?

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Appendix

A1 Abbreviations

Table A1.1: List of abbreviations

Abbreviation	Meaning
BIR	Basic Interest Rate
BSCR	Basic Solvency Capital Requirement
EIOPA	The European Insurance and Occupational Pensions Authority
GASB	Governmental Accounting Standards Board
HY bonds	High Yield Bonds
IG bonds	Investment Grade Bonds
IMF	International Monetary Fund
IORP	The Institutions for Occupational Retirement Provision
LDR	Liability Discount Rate
LLP	Last Liquid Point
NAV	Net Asset Value
NBAR	Net Benchmark-Adjusted Returns
NOK	The Norwegian Krone
OECD	The Organization for Economic Cooperation and Development
OLS	Ordinary Least Squares
PE	Private Equity
SCR	Solvency Capital Requirement
SCR ratio	Solvency Capital Requirement Ratio
ST4X	Norwegian Government Bond Index with 3-year duration
UFR	Ultimate Forward Rate