How interest rates impact the allocation of alternative investments

Results from the world's best pension systems

Master Thesis

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Abstract

This thesis examines the relationship between changes in interest rates and the allocation of pension funds to alternative assets through empirical research. Data for this study was obtained from the annual reports of 50 pension funds between 2010 and 2020. The countries included in this research are Australia, Denmark, Iceland, and the Netherlands which received the best overall score according to the Melbourne Mercer Global Pension Index in 2021. Using fixed effect estimation, we found that pension funds allocated a greater proportion of their assets under management to alternative assets with lower interest rates. Accordingly, this relationship is influenced by past interest rates and not current ones, indicating that alternative investments are handled as passive investment strategies with low trading frequency and long-term investment horizons. Moreover, we found that funds with a high percentage of active members and those willing to diversify their assets, invest more in alternatives. Finally, we demonstrate that defined benefit funds allocate less to alternatives on average than defined contribution funds, indicating that changes in interest rates affect the two schemes differently.

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1. Introduction

Most people are familiar with the phrase about the eggs and basket, a saying that is often used when talking about risk diversification in portfolios. In essence, the phrase reminds us that it is important to distribute our eggs in many baskets rather than one, as it increases the likelihood of bringing them unharmed to their destination. This is particularly relevant for occupational pension schemes since the number, and size of eggs(assets) they handle are large. Breaking a pension egg can, in many cases, be harmful to an individual's lifetime wealth as most people are without income at retirement or have limited access to public pensions and therefore rely to a large extent on these pension payments.

When saving for retirement, several different methods can be applied, with occupational pension schemes being one of them. The idea behind occupational schemes is, at its core very simple. Institutions, other than the government, receive contributions from employees, either by a fraction of an individual's salary or a fixed payment. The institution, that is the pension fund then invests this contribution in the capital market where it grows over time. At retirement, the pensioner receives benefits, where the amount depends on which type of occupational scheme the individual is a member of. Thus, pension funds play an important role in countries with such systems.

Since the 90s, interest rates in the western world have been decreasing, reaching historically low levels in 2020. This low-interest rate environment, alongside demographic changes, can have implications on pension schemes. When people live longer, the period in which they receive pension increases, given that the retirement age and the return on assets stay the same. This can impact factors like pension funds' solvency, where liquidity issues might occur if the funds do not dynamically adjust their paid-out benefits accordingly.

The lower interest rate environment has also impacted the asset allocation of pension funds and how they obtain returns. Historically, asset returns were obtained by investing in assets believed to be relatively safe such as government bonds. With a declining trend in interest rates over the years, the possession of such safe assets has become less desirable due to their lower returns. This means that occupational schemes have seen some change in asset allocation over the years, with a shift from assets considered safe to supposedly riskier investments. In other words, more risk is needed to obtain the same return as before. This changed environment has directed pension funds to assets that are not in the traditional investment category, namely alternative investments.

Alternatives include non-listed financial instruments, which are illiquid and less regulated than conventional asset classes such as bonds or listed equity securities. As these investments lack an active market price, since they cannot be directly observed in the market, making the valuation of such assets often complex. Furthermore, investors must continuously assess the value of their alternative investments based on external and internal factors that may affect the investment throughout their lifetime.

Growing popularity of alternative investments among pension funds has led to speculations and theories regarding the causes, often attributed to the decline in interest rates. However, the research on these theories and claims has been very limited, with sometimes contradictory results. Therefore, this thesis examines how alternative investments have evolved and empirically tests factors that may influence pension fund investments in alternatives. The research will be based on the period 2010 to 2020 in countries that have established large occupational schemes relative to GDP. These countries are Australia, Denmark, Iceland, and the Netherlands.

2. From then till now

The world is a large and diverse place, with various pension systems in many countries. How these systems differ in quality and setup is something that the Mercer global pension index tries to answer. By ranking pension systems worldwide according to their sustainability, adequacy, and integrity. In 2021, the three countries with the highest possible ratings were Iceland, Denmark, and The Netherlands. Each of them achieved the title of "first-class" which corresponds to having a robust retirement income system with good benefits and a high level of integrity. As of 2020, all three European countries had retirement assets exceeding 200% of GDP. Next in line is Australia, with a b+ rating and pension assets relative to GDP of 131% (OECD, 2021a).

Depending on whether the occupational scheme is a defined benefit (DB) or defined contribution (DC), the investment policy of the individual fund may differ. Consequently, this impacts asset allocation since it is a direct consequence of the investment policy. The difference is due to the definition of who carries the investment risk. In Defined benefit schemes, DB, almost all the risk is borne by the sponsor. Conversely, in defined contribution plans, DC, the sponsor is not subject to any risks such as investment, inflation, interest rate, or longevity risk. Instead, the scheme members share the risk (Sutcliffe, 2016).

Long-term nominal interest rates have decreased substantially over the past two decades in developed markets. This development is illustrated in figure 1.

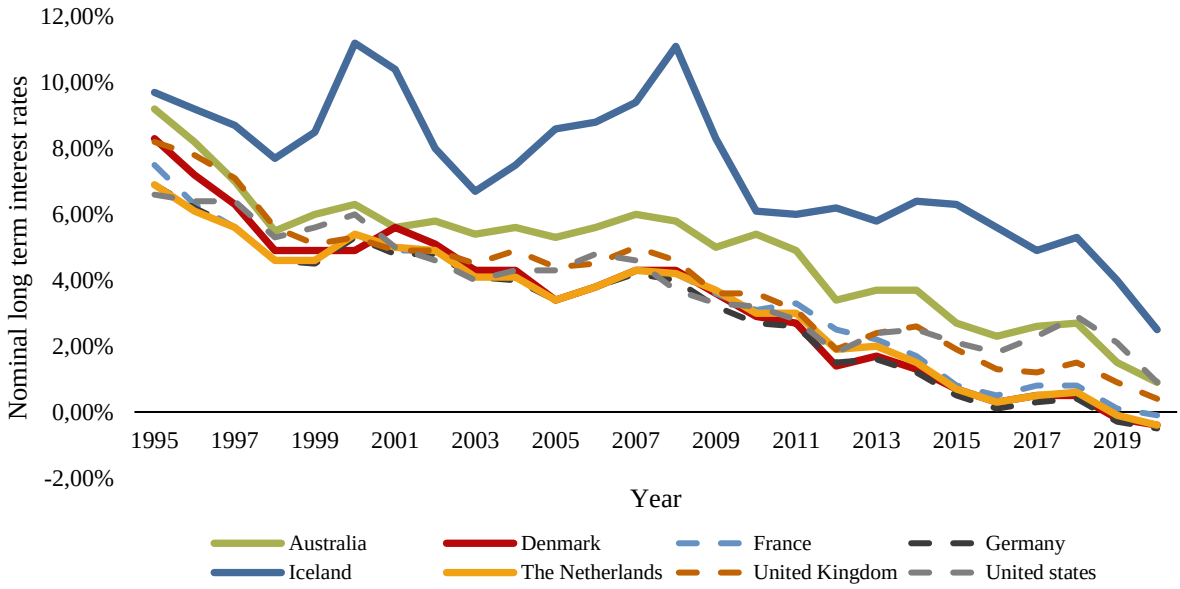


Figure 1: Development of long-term interest rates for several countries from 1995-2020. Source: OECD Data

A closer look at figure 1 shows that the long-term interest rates varied from around 6,6% (USA) to 9,2% (Iceland) in 1995. In comparison to 2020, interest rates ranged from -0,4% (The Netherlands) to 2,5% (Iceland). Over the whole period, nominal long term interest rates were always higher in Iceland compared to other countries. This is very likely due to Iceland's small open economy with its own currency. One may ask how the lower interest rate affect pension funds investment and asset allocations; at first thought, they probably must look to something else than government bonds to obtain a reasonable return.

This changed environment that pension funds face with regards to asset allocation was researched by Callan Associates, a firm that advises large investor. They concluded that in 1991 in the US, a portfolio that was made up of 98% of cash and 2% of bonds would make a nominal return of 7% a year and a standard deviation of 1,1% as seen in figure 2. To obtain the same return in 2021, an investor needed to spread capital across different risky assets, with bonds only covering 3% of the total portfolio. The same 7% nominal return in 2021 would give a standard deviation of 17,3%, meaning that investors face sixteen times more risk compared to 30 years ago. They also note that inflation in the ninety's was higher, making the comparison of real returns different. The complexity level of the investment portfolio increased over time like in the nominal return case, but the additional risk was lower. To obtain a 5% real return, compared to 30 years ago, the results were less drastic, where volatility or risk was about 2½ times higher (Callan, 2021).

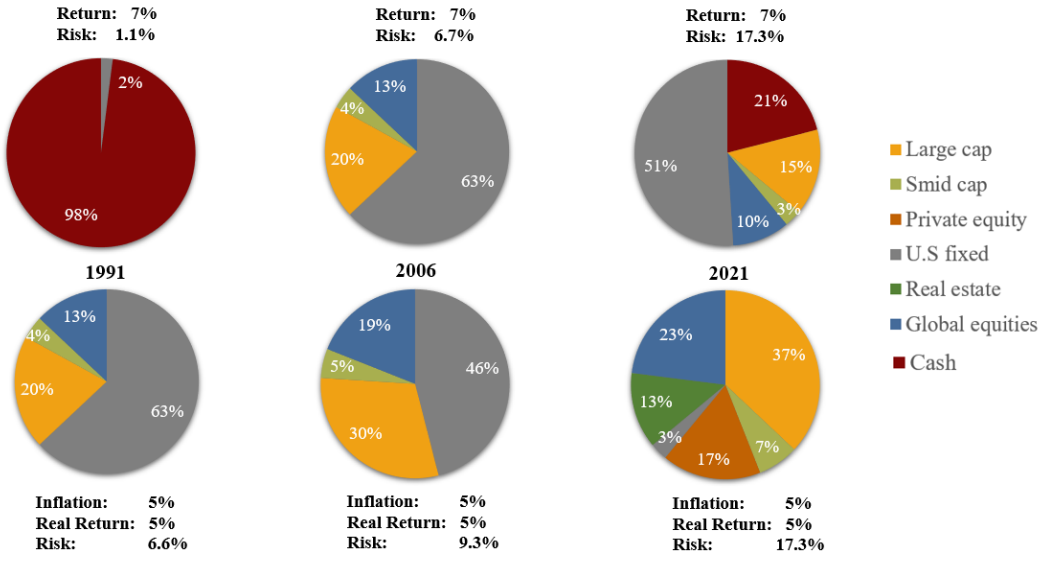


Figure 2: Asset allocation and risk needed to obtain the same return for1991, 2006 and 2021. Source Callan Associates

2.1 Aggregate asset allocation in the top tier systems

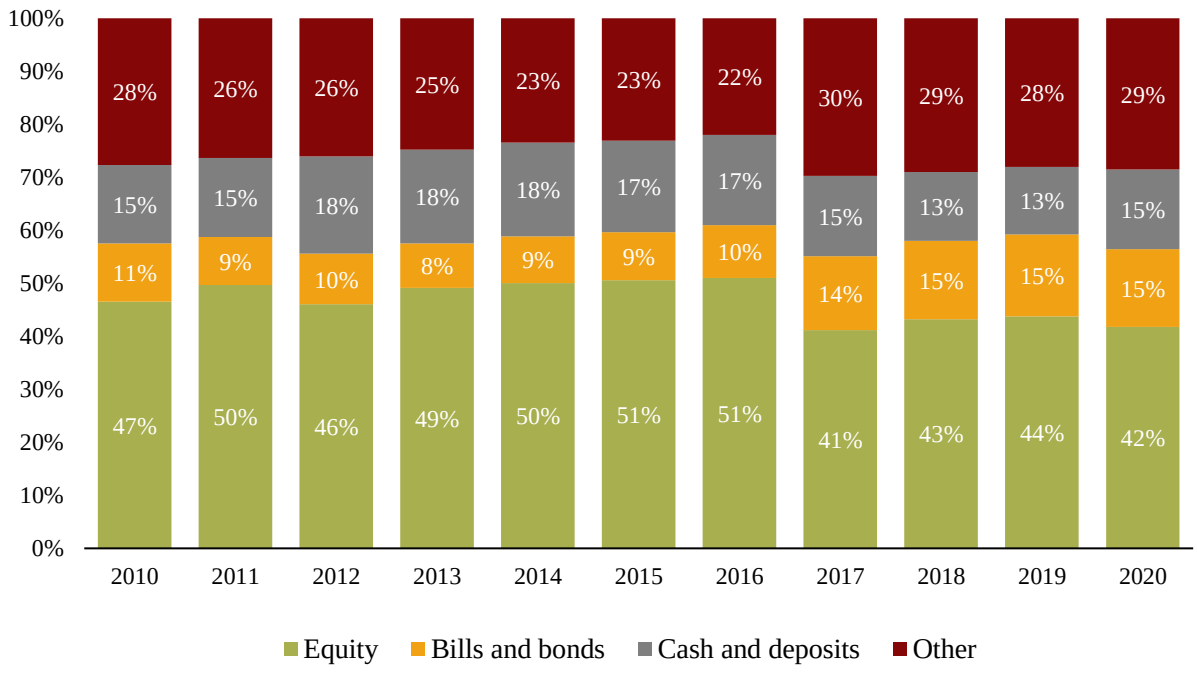
When comparing how the actual asset allocation of pension funds is in each of the four countries, a somewhat different picture than the one pointed out in Callan emerges. It must be noted that in Callan, a 7% nominal or a 5% real return was assumed and that asset allocation and the return of the portfolio go hand in hand. Higher allocation to assets that are considered risky should involve higher expected returns, but also higher volatility in the return.

OECD publishes a report each year, Pension markets in focus, which among other things contains data regarding total asset allocation of pension systems in percentages. In the most recent report OECD (2021b) it is illustrated that looking at the average asset allocation of 53 OECD countries in the long-term, generally, a shift away from bills and bonds towards equities was observed. The report contains available data on asset allocations, which are collected from national pension authorities and show direct investments in equities, bills and bonds, cash and deposits. Additionally, it shows indirect investments through collective investment schemes, CIS. That is, when the transparency of such investments is not available. The last category is labeled as other assets which are mostly, but not entirely made up of unallocated insurance contracts, derivatives, loans (private debt), and alternative investments.

2.1.1 Australia

Pension funds or superannuation funds as they are sometimes referred to in Australia, may be operated by employers, financial services companies, individuals, or industry associations. With a contribution rate of 9,5% in 2021, and a 0,5% annual increase planned thereafter, until reaching 12%. Withdrawing benefits from superannuation is possible from the age of 57-65, but for those born in 1962, the minimum age is 58, 59 for those born in 1963 and 60 for individuals born after 1964. With a possibility to delay benefits after the age of 65 (OECD, 2019a).

Australia's occupational scheme is a nearly fully funded DC, where 95,3% of all members accounts are DC and 3,7% are DB (APRA, 2022). Contributions to superannuation funds were made compulsory in 1992 to ensure that every Australian would save enough for retirement and reduce costs on the public pension system. The state pension, labelled age pension, is means tested, meaning payments increase or decrease in relation to other income, which for example can be pension benefits (NationwideSuper, n.d).



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Return	5,60%	5,31%	0,63%	10,28%	8,87%	7,75%	3,31%	8,13%	6,33%	5,90%	-0,14%

Figure 3: Development of asset allocation and portfolio return for Australian pension funds 2010-2020. Source: OECD Pension funds in figure 2021

Figure 3 shows the change in asset allocation from 2010-2020. From a first look the changes over time do not seem drastic, with bills and bonds changing from 11% in 2010 to 14,7% in 2020, or a 3,7% increase. Equities cover the largest share of the allocation over the whole period where it drops from 46,5% in 2010 to 41,8% in 2020.

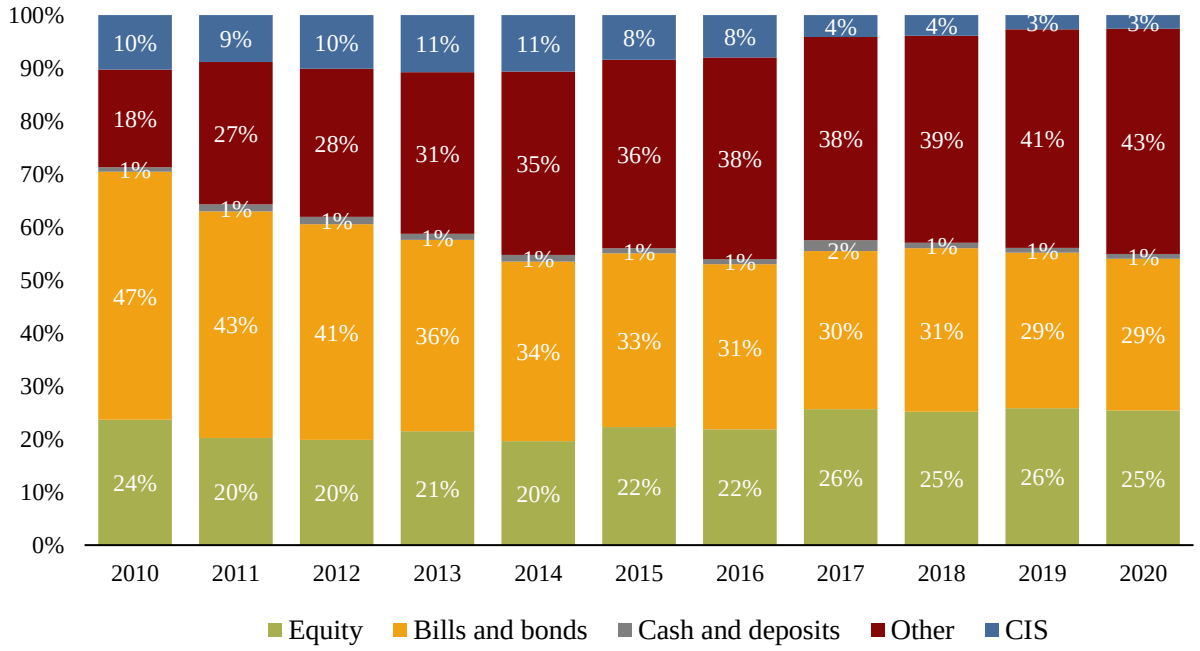
Cash and deposits, cover a surprisingly high share of the portfolio. The data does not disclose which of the two is larger. Cash investments are quite common in Australia super funds, which are mostly made up of money market securities such as bank bills and short-term bonds (AustralianSuper, n.d). One could argue that such investments belong in the bills and bonds category, which could explain the low level of bills and bonds.

Returns were positive for all years, excluding 2020, giving a 11-year average of 5,64%. Total assets at the end of 2020 were 1.794.300 million USD, giving a growth of 76,4% from 2010 (OECD, 2021a).

2.1.2 Denmark

From 2010 until 2020, Denmark has seen a significant increase in pension contributions to DC schemes. The Danish financial supervision authority investigated the allocation of contributions to DC or DB pension plans in fourteen pension funds. They found that from 2003-2020 the fraction of contributions to DC schemes increased from around 8% to about 68% (Finanstilsynet, 2020).

In Denmark, about 85 percent of employed workers are covered by occupational pension plans in 2020, which are fully funded DC plans agreed through collective agreements. Under the collective agreement, contributions rates are set for all workers and are of similar size, with a range from 12% to 18%. In addition to the occupational scheme, there exists a public pension scheme, Folkepension, which is means-tested like in Australia. Lastly a fully funded, statutory DC scheme exists, operated by the Danish Labour Market Supplementary Pension, known as ATP. Which covers almost all wage earners, excluding those self-employed and almost all beneficiaries of social security benefits (OECD, 2019b).



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Return	6,42%	6,59%	6,37%	0,64%	11,33%	1,80%	5,90%	3,90%	-1,29%	10,05%	8,69%

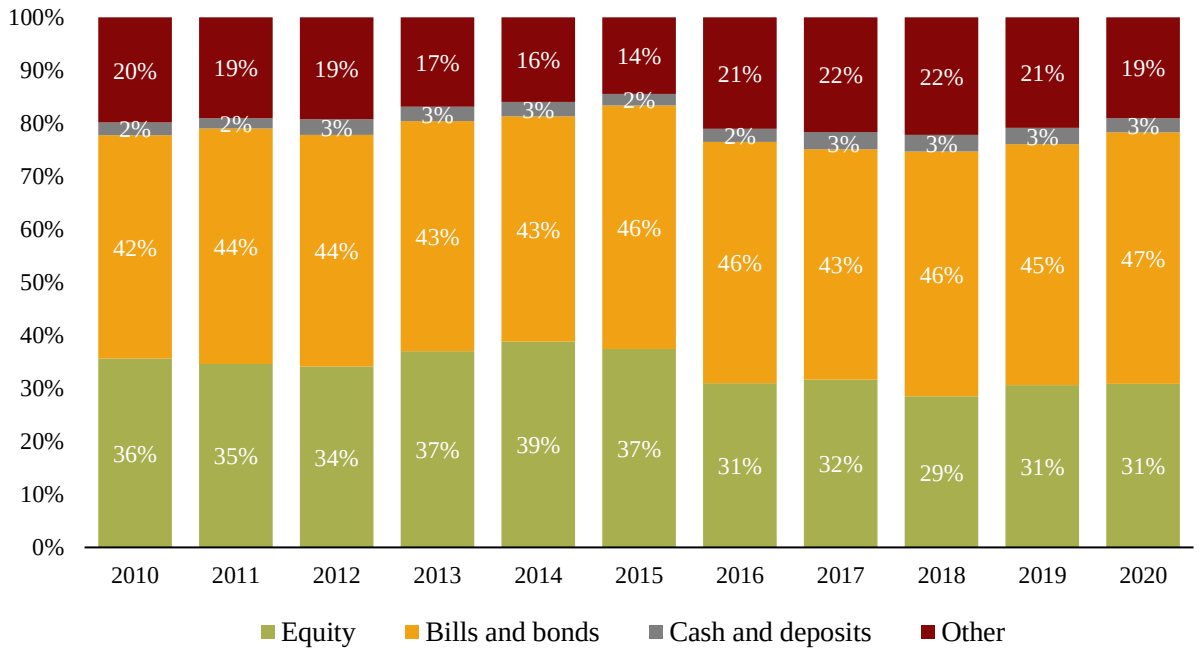
Figure 4: Development of asset allocation and portfolio return for Danish pension funds 2010-2020. Source OECD Pension funds in figure 2021

Over the last decade a clear trend in the asset allocation can be observed in figure 4. With Danish pension funds moving away from bills and bonds towards equities, and other assets. Since available information on collective investment schemes lacks, an own category is needed. However, as the years went on, information on such schemes got better, making the allocation in the correct categories possible, making the overall level of CIS drop. At the start of the decade bills and bonds covered almost half of the total assets but went down to 28,6% at the end of it. The biggest shift was towards other assets, which includes alternatives, from 18,4% in 2010 to a sizeable 42,5% in 2020. This totals a 24,1% increase over 11 years or 2,19% annually. Listed equities covered 23,6% of total assets in 2010, which decreased to 21,9% in 2016 but then saw an upward trend until ending at 25,4% in 2020.

The overall real return was positive for almost all years, excluding 2018, resulting in a 11-year average of 5,49%. Total assets at the end of 2020 were 882.109 million USD, accumulating a growth of 59,5% from 2010. Of the 882.109 million USD 34,86% was invested abroad and 65,14% domestically in 2020 (OECD, 2021a).

2.1.3 The Netherlands

Approximately 94% of Dutch employees in 2021 were covered by a DB scheme with the remaining covered by a DC scheme. Almost all DB plans use lifetime average earnings for benefit calculation purposes, whereas less than 1% use the final salary, or a combination of both. Final salary schemes carry a maximum accrual rate of 1,657% of wages for each year of service, which equates to around 70 percent after 42 years. For average earnings schemes, 1,875% per year is the highest accrual rate. In addition to the funded occupation schemes, a flat rate state pension exits, AOW, which is related to minimum wages and is not means-tested. Total assets at the end of 2020 were 2.088.702 million USD, accumulating a growth of 105,6% from 2010. Of the 2088 billion USD, 90,76% was invested abroad and 9,24% domestically. A total of 51,74% of the 90,76% foreign investments occurred in non-Euros, meaning that they were invested either outside the Euro area or in Euro countries with national currencies, such as Denmark and Sweden (OECD, 2019d).



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Return	8,85%	4,27%	9,50%	1,62%	15,07%	0,88%	8,62%	4,16%	-3,12%	12,84%	6,49%

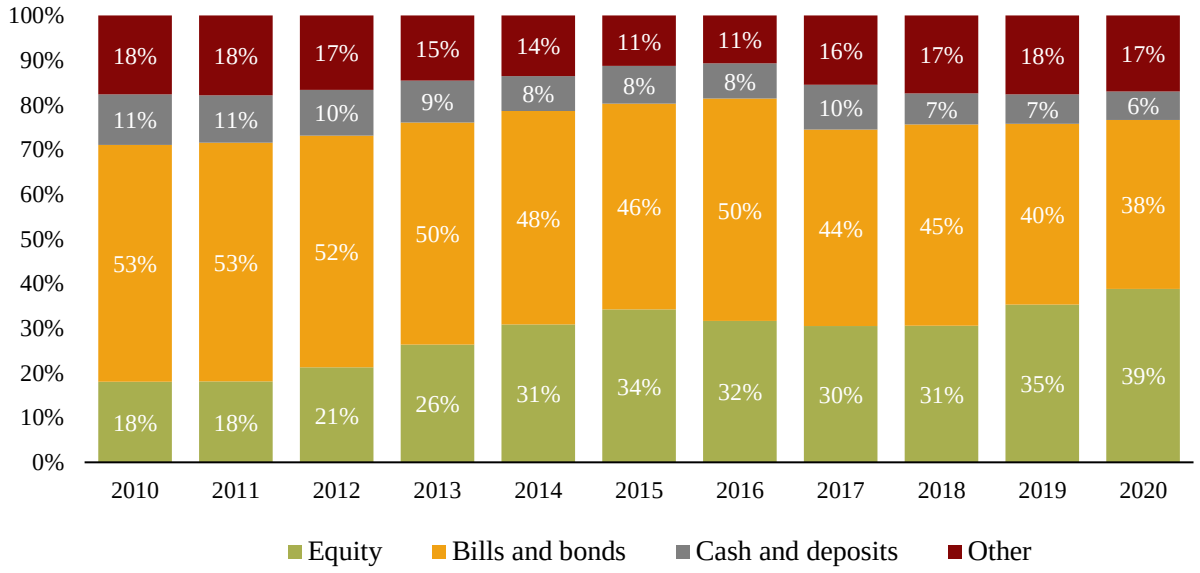
Figure 5: Development of asset allocation and portfolio return for Dutch pension funds 2010-2020. Source: OECD Pension funds in figure 2021

The largest asset class for the whole period is bills and bonds, covering 42,1% of total assets at the beginning and almost half of all assets at the end of it. In the period of 2010-2015, bills and bonds increased by 3,9%, but only by 1,5% in the subsequent five years. Listed equities, the second largest asset class for the whole period showed an increase from the start with 35,6% to 37,4% in 2015 and dropped to 30.8% in 2020. Other assets, which include alternatives, saw a decrease of 5.3% from 2010-2015 but then an increase again by 4,5% until 2020, making the overall change over the whole period of 0,8%. As seen from the numbers, Dutch pension funds shifted away from other assets and towards stocks and bonds in the period 2010-2015, but after that the shift was back the other way with a decrease in listed stocks and a slight increase in bonds. Over the 11-year period, the real return was positive in each of the years except for 2018, which resulted in an average 11-year return of 6,29%.

2.1.4 Iceland

Like Denmark, Iceland has seen a shift toward defined contribution plans in occupational schemes, where DC plans made up 60,9% of total assets in 2010 and 77,7% in 2020. In addition to that, DB plans covered 23,8% in 2010 and 6,6% in 2020. Personal pension plans covered the remainder. At the end of 2020, total Icelandic pension fund assets amounted to 47.842 million USD, representing an increase of 162,9% from 2010. Among the 47 billion USD, 34,86% were invested overseas and 65,14 % domestically (OECD, 2021a).

In Iceland, it is mandatory for all workers to be members of an occupational pension fund and to contribute a certain percentage of their salary to the fund. At least 12% of a worker's earnings must be contributed to occupational pension schemes, with 4% being paid by the employer and 8% by the employee. The employer's contribution may be higher, as in the public sector, but it depends on the collective bargaining agreement. Icelandic law requires pension schemes to aim for a replacement rate of 56% after 40 years of contributions. This results in an accrual rate of 1.4% for each year of service. Generally, pension benefits commence at the age of 67, with the possibility of being brought forward to 65 or delayed until 70. In Iceland, the state pension, ellilífeyrir, is means-tested, as it is in Denmark and Australia (OECD, 2019c).



Year	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Return	1,22%	2,13%	6,87%	4,78%	7,14%	7,46%	-0,29%	5,34%	1,81%	11,59%	8,70%

Figure 6: Development of asset allocation and portfolio return for Icelandic pension funds 2010-2020. Source: Pension funds in figure 2021

In figure 6 it is shown that the largest asset class in 2010 was bills and bonds, covering around 53% of total assets, but in 2020 listed equity had grown to be the largest investment type with a fraction of 38,8%. From 2010-2015 bills and bonds lowered by 6,9%, and other assets went down by 6.3%. The largest increase was in listed equities or by a hefty 16.1%. Over the 11-year period listed equities increased by 20.7% in total, bonds decreased by 15,2% with other assets remaining almost stable with a 0,6% decrease. Implying that most of the reduction in bonds was replaced in listed equities. The overall real return was positive for all years, excluding 2016, resulting in a 10-year average of 5,21%.

2.2 Comparison

In the grand scheme of things, 11 years does not seem like a long time. However, looking at the asset allocation of pension funds among the different countries, it shows that things can change quite drastically in such a period. The historical development is summarized in table 1.

Table 1: Change in asset allocation from 2010-2020

Asset Class	Australia	Denmark	The Netherlands	Iceland
Equity	-4,75%	1,75%	-4,80%	20,76%
Bills and Bonds	3,64%	-18,19%	5,53%	-15,14%
Cash and deposits	0,24%	0,06%	0,26%	-4,99%
Other	0,84%	24,10%	-0,80%	-0,63%
CIS	0,00%	-7,72%	0,00%	0,00%
11-year real return	5,64%	5,49%	6,29%	5,21%

The table shows that in Australia, the changes were smallest, bills and bonds increased, mostly at the expense of equities which declined by 4,75%. Other assets, which mostly include private debt, real estate, unallocated insurance contracts, private investment funds and other alternatives remained stable and increased by 0.84%.

In Denmark, there was a large shift away from bonds, mostly towards other assets, and a small increase in equities of 1,75%. The Netherlands, like Australia increased its allocation in bills and bonds, reduced its equity positions by 4,8% and other by 0,8%. Iceland had the largest change in one asset class overall, a 20,76% increase in equities with the rest of the categories seeing reductions. Bills and bonds went down by 15,14% and other assets went down by 0,63%.

The 11-year real return of the systems were all above 5%, with The Netherlands coming highest at 6,29%, which is surprising, given the relationship between risk and return. With a higher allocation in bills and bonds, the expected return should be lower, but in turn, lower risk follows. Australia and Denmark followed with returns of 5,64% and 5,49%, respectively. The Icelandic pension funds came in last with an average return of 5,21%.

The asset allocation snapshots from 2010-2020 only present the results, but not how they happened. In addition, due to the construction of the data, it is difficult to derive conclusions about alternatives specifically. This is because the other category also contains other assets, such as unallocated insurance contracts and derivatives.

3. Alternative assets

Pension funds are institutions that manage the retirement savings of individuals and invest them to provide retirement benefits in the future. Because their liabilities are long-term by nature, they must also consider their investments in the same manner. As noted in chapter 2, interest rates have declined over the last two decades, changing the investment environment for funds. In general, lower interest rates mean that, to obtain the same return as before, investors must choose assets that are riskier. Additionally, people are living longer, meaning that they receive their pensions for an increased period. To counter both issues, one type of investment has been mentioned, and that is investments in alternatives. With the objective of increasing diversification to their portfolio, lowering volatility, and serving as a long-term investment strategy. As the name suggests, it does not refer to traditional investments such as bonds, equity, and cash, but rather assets that do not fall into the conventional asset classes. Alternative assets cover a wide range of investment opportunities and can include hedge funds, private equity, venture capital, infrastructure, and real estate, as well as unusual assets such as rare vintage wines, fine art, and antiques.

3.1 Characteristics

As there is no clear definition of alternative assets, they are often classified based on what they are not. This is due to their complexity and varying characteristics which differ among the individual assets. These assets, however, typically have some characteristics that distinguish them from traditional investment categories. Firstly, they are not publicly traded and are often illiquid. Secondly, they require a high threshold with regards to minimum investment and often a long-term investment horizon. Since alternatives are designed for institutional investors and wealthy individuals, they are less heavily regulated than more traditional investment options. In addition, since alternatives are privately held, publishing financial information is not as strict and can be difficult to locate in some cases. These characteristics may prove useful for pension funds as they are institutional investors with constant capital inflows. By investing in alternative asset classes, they are meeting their need for long-term investment. It also enables them to obtain the illiquidity premium, that is the premium investors demand in exchange for sacrificing investments in more liquid assets, while still obtaining better portfolio diversification. The diversification argument is based on the fact that alternative investments tend to have low correlations with traditional market assets. This is because traditional market assets are usually procyclical and move in line with economic trends. To sum things up, when alternative assets are added to the pension fund's

portfolio, they can generate higher returns while at the same time reducing overall portfolio risk (Preqin, n.d.).

The investment of alternative assets can therefore be advantageous, but pension funds must address and consider the risk factors associated with them when deciding whether to undertake such investments. Since alternatives are often illiquid and lack transparency, it is essential to conduct a robust risk management approach that considers the particular risk associated with that asset type. One approach is to use traditional asset measurements or historical results. However, the danger is that the specific characteristics of an asset might be overlooked, resulting in inadequate outcomes, for instance due to lack of transparency and difficulties obtaining information which are needed to make a well-informed investment decision.

To address this problem the international organizations of pension supervisors, IOPS issued a paper where they present guidelines to good practices in terms of risk management of alternative investments. There it is stated that the local supervisory authority where the fund operates in, should act to ensure that if the pension fund decides to invest in private assets, independent risks and the characteristics of the return must be analyzed by performing due diligence. That means pension funds should have a clear understanding of the underlying asset and not invest in the asset unless, fully understanding the associated risks (IOPS, 2010).

3.1.1 Private equity

One type of investment which investors have shown a great interest in when considering non-listed products is private equity. In short, private equity can be described as when institutional and other large investors buy a share in private companies, usually through funds with limited partnerships, with the hope of improving the operation and therefore its value. The goal is to sell it in the future at a higher price and gain the profit. Many institutions do this in practice with the intention of going public. That is investors expose themselves to private companies and exit these positions later when the firm is listed on an organized market or merged with another firm. This industry has attracted billions of dollars worldwide over the years as it offers diversification possibilities and many (but not nearly all) investors have enjoyed abundant return. The illiquidity premium is very relative when it comes to private equity. In most cases, investors are tying up

their capital for a long time, which sometimes also requires additional capital since the investment can return a negative cash flow for the first years.

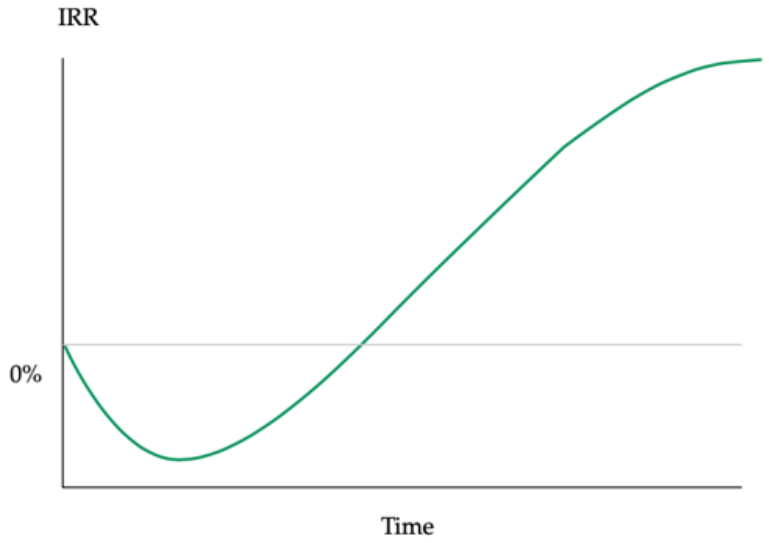


Figure 7: J-curve illustrating how the return of private equity develops over time. Source: CAIA Association 2018

In fact, the rate of return for private equity is often portraited by the so-called J-curve. As seen in figure 7, investors can expect a negative internal rate of return (IRR) for the first few years due to institutional and management fees. It can also originate from write-offs of investments that have not lived up to standards, declined in value, or gone out of business. But over time, some of the underlying companies that are included in the private equity fund collection begin to grow in value and the gain is realized through an IPO or a merger. The inability to enter and exit the investment at a predetermined market price, at a time the investor likes can be a severe risk where situations can arise where liquidation of their investment is needed. Moreover, as the underlying asset does not have an observable market price, the cost of obtaining financial information, buying the asset, and monitoring performance involves higher costs compared to market assets. Due to this illiquidity premium, investors expect returns to be higher in private equity compared to listed assets. Historically, private equity investments have generated investment returns that exceed the returns on traditional assets by almost 3% (Chambers et al., 2018).

3.1.2 Infrastructure

For societies to function, infrastructure is essential. Thus, it is among the asset classes pension funds are becoming increasingly interested in. According to Alonso, Arellano, and Tuesta (2016) investing in infrastructure offers a long-term investment horizon, potential growth, and a convenient method to generate long run capital activities while at the same time providing vital service to citizens. Infrastructure can be a variety of projects related to economic structure such as transportation and renewable energy to social infrastructure like schools and hospitals. In many cases, infrastructures operate in monopolistic markets. For example, Iceland only has one international airport, which consequently has no direct competition.

Based on a report published by the CFA Institute's research foundation CFA (2019), infrastructures tend to operate in highly regulated environments that have entry barriers and high fixed costs. These assets typically require maintenance over a long period of time and can generate a stable cash flow for decades, being relatively insensitive to the return of other asset classes. The reason is that regardless of where the economy is heading, commutes or energy distribution is still likely to play an important role for households. The report points out that historically, unlisted infrastructures have performed close to traditional equities while the volatility is only half of equities, with almost no correlation between the two.

3.1.3 Real estate

In the world of real estate, there are several types of properties, such as apartment buildings, hotels, retail stores, and other types of commercial real estate. These properties tend to provide a stream of cash flow to its owners through rents. Furthermore, this asset class usually grows in value over time so there is also a potential capital gain when the properties are sold (Marston, 2011).

Investing in real estate can have many appealing features which relates to pension funds as it allows them to diversify their portfolio. This is due to real estate’s low correlation with other asset classes, while at the same time offering attractive premiums, and a total return that can hedge against inflation. The argument is that rent income increases in line with inflation. This characteristic seems feasible, especially in times of low interest rates. Even though rent from real estate may not always keep up with inflation, it is reasonable to assume that it will respond to inflation over time.

Therefore, long run investment in real estate can secure protection against one of the biggest threats facing pension funds when investing in traditional assets like bonds, namely persistent and high inflation rates (Stanyer, 2014).

3.1.4 Commodities

Commodities are distinguished from natural resources such as minerals by the fact that they have been extracted or produced. Energy products, agricultural products, metals, and building materials are some examples of commodities, which are goods that are generally available in large quantities. Examples include grains, oils, and steel. As an investment class, commodities are products with somewhat passive exposure (i.e., buy and hold) to commodity prices. The exposure can be obtained through futures contracts, physical commodities, natural resource companies, and exchange-traded funds (CAIA Association and Chambers, 2020).

Exposure to commodities through futures can be obtained either directly or through commodity managers. Unlike an option, a futures contract is an agreement to exchange an underlying asset on a specified settlement or delivery date. Long positions in the contract represent an agreement to buy, and short positions represent an agreement to sell. Most futures contracts do not end with delivery but rather with both parties closing their positions prior to the delivery date. Most participants do not engage in futures contracts for the purpose of taking or making delivery; rather, they do so to take on or off the price risk associated with the underlying asset. Participants in the market who wish to maintain exposure to a commodity roll over their positions periodically from contracts close to delivery to contracts with later delivery dates. For example, selling the expiring March contract and buying the June futures contract (Chambers et al., 2018).

3.1.5 Hedge funds

Hedge funds are a popular type of alternative investment, at least in the US. They can be described as privately held investment companies that offer a pooled investment strategy, managed by professional investment firms with only a few restraints. The idea of adding hedge funds to the portfolio is to obtain returns that differ from those achieved in the more common stock and bond markets. This is achieved by investing in less popular and regulated instruments

Although hedge funds strategies typically differ among individual funds there are certain aspects that they have in common. Their commission is usually constructed in such a manner that it is highly favorable to the manager when the fund is doing a decent job.

Hedge fund managers usually charge both management and performance fees. The management fee most often lies within the range of 1-2% of the asset value and is charged regardless of how the underlying assets are changing in value. The incentive fee usually amounts for 10-20% of profits earned over the year. Commonly, hedge funds have worked by the 2-20 rule meaning 2% management fee and 20% performance fee. Another distinction for hedge funds is their flexibility when it comes to portfolio construction, as hedge funds are usually focusing on investments that are not publicly available. That gives them more flexibility than other traditional funds, since private placements are less regulated and offer more disclosure with respect to how the portfolio is constructed. This private placement structure means that the investors, for instance pension funds, are called limited partners and the hedge fund managers are called general managers. Decisions regarding investments are made by the general manager (Chambers et al., 2018).

In the annual report from 2015 of the second largest pension fund in The Netherlands, PFZW an announcement with the following message followed; Most of the remaining investments in the hedge fund investment category was sold in 2015 with the asset class no longer being a part of the strategic asset mix. This decision was taken in 2014, due to hedge funds complexity and its contribution to the fund was uncertain. In addition the contribution to our sustainability policy was expected to be low with high costs (PFZW, 2015).

This raises the possible question of whether hedge funds in the future become less desirable for pension funds due to their disclosure setting, making the tracking of sustainability harder, which is becoming ever more important with time.

3.1.6 Private debt

In a low interest rate world, it can be appealing for investors to turn their attention to private debt to generate higher returns and to diversify their investment portfolio. According to (Preqin n.d) private debt is a relatively new trend in the world of alternatives as it emerged as a key asset class from the financial crisis of 2008, when traditional lenders such as banks moved away from risky loans. That created space for alternative source of lending, which private lenders filled.

Today this type of asset has grown to be the third largest private capital asset class for pension funds behind private equity and real estate, respectively.

Private debt is when institutions other than banks provide loans that are not traded publicly to companies or individuals. This lending can be done both to listed and unlisted companies as well as to projects that fall under the criteria of real assets such as real estate and infrastructure. One feature of private debt is that it is often regarded as a low-risk investment choice compared to other alternative investments. That is because firms are purchasing the debt of the companies that they are lending to, instead of acquiring equity. In case of financial distress or bankruptcy, debt is paid out ahead of equity making private debt less risky than private equity and therefore private debt has a lower expected return compared to private equity.

For pension funds, investing in private debt can be beneficial as it functions as an alternative to fixed income investments, has a relatively low correlation to other types of assets and generates predictable income. In the Danish pension fund, PensionDanmark, the investment strategy states that the main focal point is to build a well-diversified portfolio. Achieved by investing in robust credit investments with long term maturities and gains of the illiquidity premium (PensionDanmark, 2020).

In Iceland, pension funds have mainly been focusing on mortgage to their fund members and have over the past years increased their share on the market drastically at the cost of commercial banks. For instance, the share of direct lending to fund members as a fraction of total bond value increased from 13% in 2015 to 24% in 2020 for LIVE, the second largest fund in Iceland (LIVE, 2020).

3.2 Valuation

An asset's value may be difficult to determine in the absence of an organized market and choosing the most suitable method of valuation requires judgment. Different valuation techniques are likely to produce different results. This is a consequence of the fact that different inputs are used and adjustments to the balance sheet may differ according to the method of choice.

In IFRS (2013), fair value of an investment is defined as the price at which an orderly transaction to sell an asset or transfer a liability would occur between market participants at the measurement date under current market conditions (i.e., an exit price). The timing and/or amount of future cash flow and other factors are often uncertain in such financial reporting measurements.

The framework also states a variety of techniques, which are not explicitly required for determining the most appropriate valuation technique. However, depending on the facts and circumstances, it recommends a usage of more than one technique to see how the results compare.

The following factors should be considered by an investor when selecting the most appropriate valuation techniques:

- Market conditions
- Investment type and horizon
- Life cycle of investment
- The industry in which the investment operates

One way to determine investment value is to use a discounted cash flow method, or DCF. The DCF model is classified as either a direct or indirect model. In the direct model, the investment's value is calculated by discounting the free cash flows, which uses only cash transactions, while the indirect model values the investment by using net income and adding non-cash expenses to determine its value (Plenborg & Kinserdal, 2020).

The present value of all future cash flows determines the value of an investment when using a DCF model. Mathematically, this can be written as:

$$Enterprise\ Value_0 = \sum_{t=1}^{\infty} \frac{(FCFF_t)}{(1+WACC)^t} \quad (1)$$

Where $FCFF_t$ is the after-tax free cash flow at time t and WACC is the weighted average cost of capital. Meaning that either higher cash flows or lower WACC increases the investment/firm value and decreases if the effects are opposite.

WACC can be defined as:

$$WACC = \frac{E}{V} * r_e + \frac{D}{V} * r_d(1 - T) \quad (2)$$

Where:

$$E = Market\ value\ of\ equity$$

$$D = Market\ value\ of\ debt$$

$$V = Total\ investment\ value$$

$$r_e = Required\ rate\ of\ return\ on\ equity$$

$$r_d = Required\ rate\ of\ return\ on\ debt$$

In the case of debt financing, (1-T) describes the tax shield associated with it. The required rate of return on equity r_e, can be derived from the CAPM model, where risk is considered through the beta coefficient. A risk-averse investor seeks the highest return possible for given risk; therefore, they do not want to take a risk by investing in a new investment if they can gain a higher return by investing in the market portfolio.

$$Enterprise\ value_0 = \sum_{t=1}^{N} \frac{FCCF_t}{(1+WACC)^t} + \frac{FCCF_{(n+1)}}{WACC-g} * \frac{1}{(1+WACC)^n} \quad (3)$$

The approach can also be specified as a two-stage model to give better intuition, seen in equation (3). The first part is a forecast of revenues and cost, labelled as a budget period, then followed by a terminal period. In the terminal period, cash flows are assumed to be steady at an annual growth rate. Due to the underlying drivers, calculations of the company's total value contain uncertainty. Meaning that a short budget period leads to a larger part of the value coming from the terminal period. Underlining the importance of a correct budget period for each specific investment. Although the discounted cash flow model is a technically relatively simple valuation approach, it requires inputs that are time consuming to generate (Plenborg and Kinserdal 2020).

Another method of valuing alternatives is to use multiples or relative valuation models. Investors value investments based on multiples of peers which have assets that that are comparable, meaning that expected growth rates, cost of capital and profitability are the same.

Earnings multiples, or P/E, compare earnings generated by a company to its current market price; EBITDA is often substituted for net profits in this calculation. This comparison can be problematic however since the compared industry can be under or overvalued. Revenue multiples use price over revenue in valuation. Compared to other multiples, revenue is less affected by accounting. Book Value multiples use price over the book value of a public company's assets. It can vary among industries as a solar panel company should have more assets than an unlisted software company (John Wiley & Sons, 2020).

Precedent transaction analysis is a valuation method in which the price paid for similar instruments in the past is considered an indicator of an investment value. When conducting such analysis, investors must consider factors such whether the environment that the investment operates in is dynamic, and if market conditions have changed over time. Since otherwise it might bias the estimation when transaction prices are used as a measurement of fair value of instruments at measurement dates.

Lastly, there is the adjusted net asset value method, NAV, which derives the fair value of equity instruments from its assets and liabilities (recognized and unrecognized) as seen in equation 4. Depending on which measurement method is used to measure assets and liabilities, the results can vary. That means that, sometimes, assets and liabilities need to be adjusted, usually in intangible assets, property and equipment, receivables, and financial assets since they are not measured at fair value. Another example, is an investor measuring the fair value of unlisted equity, as he must consider whether potential performance fees are recognized appropriately in the fund's net asset value (IFRS, 2013).

$$Net\ asset\ value = Value\ of\ assets - Value\ of\ liabilities \tag{4}$$

3.2.1 Valuation in practice

Taking a closer look at the annual reports of individual pension funds in the countries we have studied so far, shows that they conduct valuation in different ways. One common feature that they all have is that they receive valuations from external fund managers, which they then perceive as the value. Sometimes they are compared with own calculations of the fund, or back tested. The methods these external fund managers use however are unfortunately undisclosed. For most of the funds, individual information was unavailable in terms of which method was used for each asset category. To sum things up, table 2 shows the different methods used when information was available for two selected pension funds in each country.

Table 2: Valuations Methods used for alternative assets for selected pension funds. Source: Annual reports from 2020

	Pension fund - Country							
	Australian Super	QSuper	AP	PFA	ABP	PFZW	LIVE	LSR
Valuation methods	Australia	Australia	Denmark	Denmark	The Netherlands	The Netherlands	Iceland	Iceland
Reported values*	✓	✓	✓	✓	✓	✓	✓	✓
Reported values-back tested**			✓					
DCF	✓	✓	✓	✓	✓	✓	✓	
Multiples	✓			✓				
Precedent transaction values		✓				✓	✓	✓
Net asset values					✓	✓		

*Valuations from external fund managers

**Reported values, compared to own calculations

3.3 Investment cycle of alternatives and secondary funds

The majority of alternative investments have a long-term nature. With a full cycle possibly lasting nearly a decade and involving many different aspects of the financial system. The different investment steps, and the order in which they are executed are illustrated in figure 8. The steps are usually the same among different alternatives, but with a large variation with respect how long each step takes, and the methods used. Firstly, investing in alternatives requires deployment of capital where the timing varies across the different asset classes. The longest period involves private equity, where an acquisition of an entire company or a large share of one, can last for months, even with the failure of a deal. While the shortest time is investments in hedge funds that invest in liquid securities which are traded on exchanges. In that case, investments can take from milliseconds to days. Same goes for exiting such investments, it can be short as microseconds or take up to a year.

Funds handling investments in alternative assets are mostly closed-end funds that do not allow investors withdrawals of capital due to the illiquidity of the investments. Open-ended fund structures, on the other hand, allow investors to request the return of their capital at any time.

Prior to becoming closed, a fund-raising period usually occurs which lasts from 6-18 months, where the fund receives contributions from investors. When the fund is eventually closed, the investment process begins. This is not the case for hedge funds, since they are usually open ended which allows for raising of capital and investing at the same time. Investors looking to get out of their closed fund position can sell their stakes to secondary funds that specialize in such deals (World Economic Forum 2015).

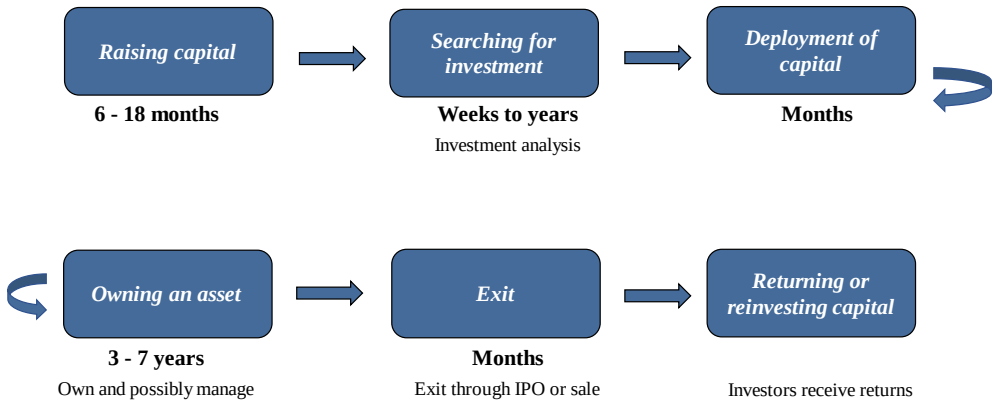


Figure 8: Closed fund investment cycle for private equity. Source World Economic Forum 2015

An active secondary market has developed over the past two decades, allowing investors to sell their investments in private equity funds. Transactions in this "over-the-counter" market consist of the transfer of a limited partnership interest from the selling Limited Partner ("Seller") to the new owner ("Buyer"), who assumes all rights and obligations of the Seller, as well as any remaining open commitments to the funds being transferred. In most cases, the General Partner ("GP") who is responsible for managing the affairs of the private equity fund must consent to this transfer process.

The price of secondary market securities is determined by the reported valuations that private equity funds publish, typically on a quarterly basis, and expressed as a percentage of the reported Net Asset Value (NAV). Buyers and sellers generally agree on a valuation date (sometimes referred to as a "reference date") at the start of a transaction. The valuation date (reference date) corresponds to the NAV valuation date and is used to determine the settlement of cash flows (capital calls and distributions prior to the closing date) between the buyer and seller. Cash flows occurring after the reference date are considered when calculating the final purchase price at closing. The seller is usually reimbursed for capital calls, while distributions are kept by the seller and reduce the purchase price. Any changes to the valuation of the underlying fund interests will generally benefit – or adversely affect – the buyer and will not affect the final payment. Private equity investors have a wide range of liquidity options and solutions available to them today, following a decade of strong volume growth in the private equity secondary market involving venture capital, real estate, and infrastructure (CAIA, 2016).

Global secondaries transaction volume saw a record of 132$billion USD in 2021, see (James, 2022), a 486% increase from 2010 (Lodge, 2021). With the increased demand for alternatives, a secondary market is growing as well, which is advantageous for individual institutional investors. Consequently, funds experiencing liquidity shocks for example, can exit their positions. The secondary market, however, is still small when compared to alternative investments, meaning that if large shocks occur to many pensions' funds' liquidity, the story may be different. In other words, the secondary market might not be able to serve everyone's needs.

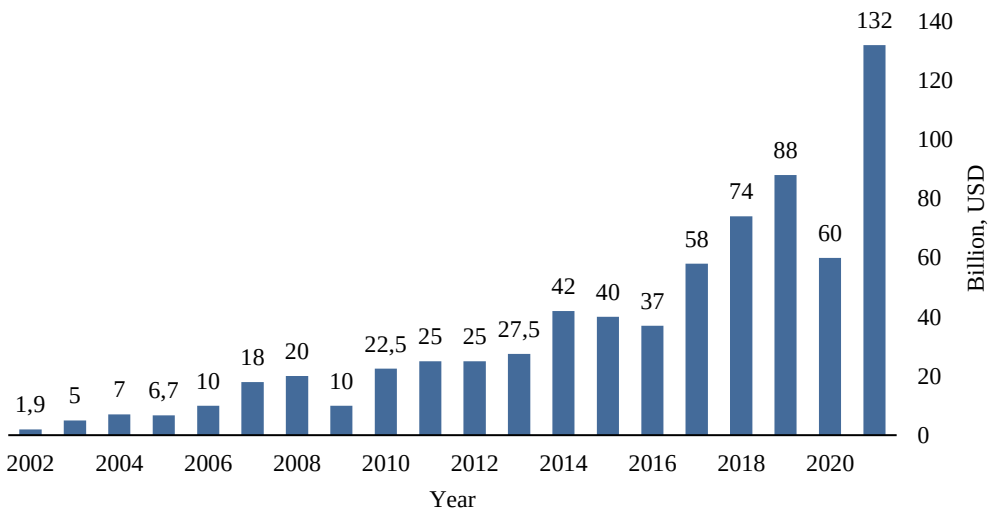


Figure 9: Market volume for secondary transactions 2002-2021. Source: Commonfund and own calculations

3.3 Legislation

Pension funds face many restraints regarding how they operate. Legislation is one of them and affects how they can invest and how they must keep track of their solvency. Laws regarding investments can impose a particular maximum, or a minimum percentage allowed to be invested in a particular asset category. Pension funds investment laws differ by countries and are usually enforced by the local financial supervisory authority or the central bank.

3.3.1 Solvency and liquidity

In the European union, of which Denmark and the Netherlands are members, the Solvency II directive came into effect on 1 January 2016. The main goal of the directive was to harmonize the EU insurance regulation, primarily regarding required capital firms must hold to reduce the risk of insolvency. The regulation also introduced prudential requirements tailored to the specific risks faced by each insurer or in our case, pension funds. The prudential requirement states that, companies must invest their assets in a way that serves their customers' interests in the best way possible and is resilient to fluctuations in financial markets. In general, insurance companies and pension funds can only invest in assets that can be adequately identified, measured, monitored, managed, controlled, and reported. Thus, promoting transparency, comparability, and competitiveness within the sector.

The Solvency II directive has three main pillars:

- **Pillar 1**: Quantitative requirements
- **Pillar 2**: Requirements for the governance, risk management and supervision
- **Pillar 3**: Focus on transparency and disclosure requirements.

The first pillar, quantitative requirements, includes regulations concerning valuation of assets (particularly technical provisions), capital requirements and identification of own funds to cover these requirements.

Own funds are calculated using a standard Solvency II formula or a pre-approved internal model by the local financial supervision authority. Regulations require internal models to meet strict requirements, such as risk profiles, statistical quality, and governance. This makes the acceptance of a model a lengthy and complex process. Assets and liabilities are valued by their market value, or IFRS fair value. Based on the difference between the two, the available equity is determined. A technical provision is the amount an insurer is required to maintain on its balance sheet to settle all existing debt with policyholders. In the case of pension liabilities, where obligations lie further into the future, the valuation of technical provisions are based on a best estimate plus a risk margin using statistical methods. Two of the most relevant capital requirements are the Solvency Capital Requirement (SCR) and the Minimum Capital Requirement (MCR). The SCR specifies the amount of capital required to enable a company to absorb significantly unforeseen losses from investment risks. It is based on a value at risk (VaR) of 99.5%, which means that a company should have sufficient capital to be 99.5% certain it will be able to cover their worst-case scenario within the coming year. The minimum capital requirement is the amount of capital a company must maintain before the risk of insolvency is too high and the authorities intervene. In accordance with the directive, the MCR cannot exceed 45% of the company's SCR or be below 25% of the SCR (Starita and Malafronte, 2014).

The second pillar focuses mainly on governance, including own risk and solvency assessment (ORSA). The ORSA report is an internal process used to assess the adequacy of solvency positions under different stress scenarios and risk management processes. It also relates to the organization and operations in general, reliability of directs, internal control and outsourcing. The report requires insures to analyze all relevant material risks that can impact the ability to meet policyholders' obligations.

The third pillar, which consists of four parts, deals with transparency and financial supervisors. The first part covers solvency, financial position, and their statements. The second part is on supervisory reporting, the third is on reporting in predefined events and the last on is on policy regarding publication of information and reporting to the local regulator (EIOPA 2009a).

In addition to Solvency II, local laws in Denmark and the Netherlands also contribute to the regulatory framework for the pension funds.

Dutch laws regulate pension funds liquidity through funding ratios. The funding ratio shows whether there is enough capital for the fund to pay out all pensions now and in the future. It indicates whether the fund has adequate reserves to pay out benefits to its current and future members. The investment of assets is divided by the value of liabilities (present and future), which is expressed in percentage terms and can be seen in equation 5. The current value of liabilities is calculated using an actuarial interest rate, which is determined by the DNB and is the market interest rate (risk-free). Regulations govern the funding ratio percentage. For example, pension funds are not permitted to apply partial or full index-linking unless their funding ratio exceeds 110%. Index-linking means that a pension fund can raise pensions in line with rising inflation. Pension funds must take steps to improve their financial condition if their funding ratio is too low (below 104%). When it is between 104% and 110% index linking is not available. This means that the pension benefits do not increase with inflation, and when it is greater than 110% partial or full index linking is available. The purpose of the regulation is to ensure that pension funds distribute their assets properly between current and future pensioners. In extreme cases, where the funding ratio falls below 104% for five consecutive years, it may be necessary to either increase contributions or reduce benefits (DNB, n.d).

$$Funding\ ratio = \frac{Value\ of\ assets}{Value\ of\ Liabilities} * 100\% \quad (5)$$

In Denmark, the regulation is more mixed, meaning that rules regarding the funds differ depending on which scheme the fund offers. It can also be that the fund offers both DB and DC schemes meaning that it must follow two regulatory requirements on how assets and future liabilities are valued. They also differ depending on whether the scheme is inflation guaranteed or not. For guaranteed products (DB), the Danish FSA sets the maximum basic interest rate that pension funds must use to discount future liabilities, but for present liabilities that are already

guaranteed(present) they remain the same. In 2020 this rate was 1% but changed to -0,5% in 2021 (Erhvervsministeriet, 2015).

Australia has no formal funding and solvency requirements on defined contribution funds. Defined benefit funds, however, are faced with own governing rules and legislation (Thomson Reuter, 2022). Since our focus is mainly on defined contribution funds in Australia, we will not go into further details.

Iceland's law mandates that every year the board of the individual pension funds must carry out an actuarial examination of their funds. Following the examination, the results are included in the annual report. This examination must be conducted by someone independent of the institution and the inspection must be based on government rules derived from factors such as mortality rates and real interest rates, which in 2020 were 3,5% above inflation. These factors are then used to determine the present value of present and future pension benefits. Furthermore, the regulation specifies how net assets are to be calculated to pay pension liabilities. If the inspection reveals more than a ten percent deficit between the fund's assets and liabilities, adjustments must be made to future benefits. Additionally, this occurs if the deficit exceeds 5% for five consecutive years (Alþingi, 1997).

DB schemes appear to be more regulated when it comes to defining the net assets. This is because changes in liabilities are adjusted when the discount rate changes since they are guaranteed. Therefore, they may have to acquire additional technical provisions, whereas DC schemes do not.

3.3.2 Asset allocation

When it comes to asset allocation limits there is no specific ceiling in Australia. Pension funds, must however consider the prudent person principle when allocating investments, meaning adequate diversification is required, which is regulated by APRA, the Australian Prudential Regulation authority.

Followed by Denmark, the regulations differ depending on the type of the fund. The largest funds have the most leniency where there is no allocation limit, but Solvency II regulation and the prudent person principle apply. Two funds, ATP, and LD act according to their own regulation when it comes to diversifying (OECD, 2020).

A closer look at the regulation of investment allocation of pension funds in Australia, Denmark, Iceland, and The Netherlands are shown in table 3.

Table 3: Regulation for investment allocations. Source OECD Annual survey of investment regulation of pension funds

Country	Equity	Real estate	Bonds	Retail investments funds	Private investment funds	Loans	Bank deposits	Foreign
Australia	No limit	No limit	No limit	No limit	No limit	No limit	No limit	No limit
Denmark	Solvency II - PPP*	Solvency II - PPP*	Solvency II - PPP*	Solvency II - PPP*	Solvency II - PPP*	Solvency II - PPP*	Solvency II - PPP*	No limit
Iceland	Up to 60%	Up to 60%	100% public 80% private	<80% UCITS < 60% non UCITS	Up to 60%	No limit	No limit	OECD and EU Foreign currency exposure < 50% accrued liabilities
The Netherlands	No limit	No limit	No limit	No limit	No limit	No limit	No limit	No limit

Note: PPP* refers to the prudent person principle

Pension funds in the Netherlands are regulated by the Pensioenwet, Dutch law regarding pension funds. They do not include quantitative restrictions on asset allocation, but they require the investment policy of the pension funds to follow the prudent-person rule and some sort of diversification. Additionally, they must establish an investment cycle in which the strategic investment policy, investment plan, and implementation are periodically evaluated and reassessed (DNB, 2019).

The country with the most direct investment constraints is Iceland. Pension funds are not required to follow Solvency II, despite Iceland´s membership in the EEA. However, there is Icelandic law, Lög um skyldutryggingu lífeyrisréttinda og starfsemi lífeyrissjóða, that regulates pension funds. The law specifies that equity can make up 60% of the total portfolio, 60% is allowed in real estate, 80% in private bonds, 60% in private investment funds and up to 80% in retail investment funds that are classified as UCITS, if not then 60%. Public bonds, loans and bank deposits are not subject allocation constraints.

Furthermore, the regulation specifies an aggregate constraint where the total allocation of those specific classes must not exceed 80%(Fjármálaeftirlitið, n.d).

$$C + D + E + F < 80\% \quad (6)$$

$$D + E + F < 60\% \quad (7)$$

$$F < 10\% \quad (8)$$

Where:

C: Bonds that are issued by banks and insurance companies, UCITS.

D: Corporate bonds issued by non UCITS CIS

E: Equity shares in non-UCITS CIS

F: Financial derivatives

Compared to each other, the countries have different approaches to asset allocation regulation. Iceland relies heavily on prescriptive investment limits whereas the other countries rely more on the prudent person principle and other arguments related to investment diversification.

4. Theory of pension investing

4.1 Modern Portfolio Theory

When an investor makes an investment choice, he is faced with two key decisions. First, he needs to know which investment categories to invest in, and second how to best allocate his financial resources. One method to estimate investment decisions and asset allocations is the Modern portfolio theory of Henry Markowitz.

The intuition is that an investor can construct an optimal portfolio, which maximizes expected returns by taking on a quantifiable amount of risk. Typically, investments that yield high returns come with high risk, whereas investments that yield low returns come with low risk. By using investment diversification, Markowitz suggested that investors could achieve the best result by calculating an optimal asset mix based on individual risk assessments. The risk of owning a particular asset is defined as its standard deviation from the mean in return; therefore, the risk of holding a portfolio of diverse individual stocks will be lower than the risk of holding any one of the individual stocks, provided that the risks of the individual stocks are not highly correlated. Markowitz showed that investment is not just about picking stocks, but also choosing the right mix of stocks among which to distribute one's nest egg (Markowitz, 1952).

Pension funds, as pointed out in Elton et al. (2014) optimize their portfolio returns differently than individual investors. Consequently, the portfolio may be prevented from reaching Markowitz´s (1952) most efficient frontier. Solvency arguments may be one cause of this since the intent of pension portfolios is to meet future liabilities. Therefore, when considering asset mixes, outflows of future pension liabilities must also be considered. Therefore, it is critical to consider the tradability of the investments in the portfolio, or the ease with which they may be converted into cash. The most liquid assets are cash and market assets, while alternative assets such as real estate are among the least liquid. Pension funds must be able to withstand unanticipated changes in liquidity, underlining the importance of such considerations when constructing their portfolios. That is, the funds may be forced to hold a minimum amount of liquid assets in their portfolio to avoid problems with solvency. Lastly, tax and legal regulations might impact the asset allocation, with possibly stricter regulations or different tax rules on the different asset classes.

One major benefit of investing in alternatives is the often mentioned, low correlations with traditional market assets.

After a year of an ongoing pandemic, Australian Super (2020) noted in their annual report that their unlisted asset class proved to be less volatile than market assets, even though their value was update frequently. Underlining the low correlation argument and the benefits that it brings (AustralianSuper, 2020).

4.2 Capital asset pricing model – CAPM

The Capital Asset Pricing Model, better known as CAPM, was first introduced in the early 1960's by Sharpe (1964) and Lintner (1965) and is still today considered one of the most influential frameworks when it comes to financial theory. The model builds on the same assumptions as the MPT theory, by Markowitz, that is individuals only consider the return and the variance of the investment at hand. The model assumes that all investors in the CAPM world are of the same belief about the return, variance and the covariance of the financial instruments. Additionally, they can borrow at a given risk-free rate. Since all investors agree on the distribution of return, they will construct the same mean variance portfolio, mixed with the risk-free rate. In other words, all investors will invest in the tangency portfolio, but how much they will hold in it compared to the risk-free asset depends on their utility and risk aversion. In equilibrium the total demand for assets must equal the supply. Thus, the portfolio weights of the market are equal to those of the tangency portfolio resulting in the market portfolio being mean variance efficient.

Although the model makes simplistic assumptions about reality it can shed some light on the basic principles of financial theory. One extension of the CAPM was introduced by Jensen (1968) where the idea is to make a risk adjusted measure for a portfolio by making use of a time series regression on the portfolio. The intercept is called Jensen´s alpha and measures whether the assets are mispriced relative to what the CAPM predicts. According to CAPM, the alphas for all the assets in the portfolio should be equal to 0 and if there is a positive alpha, that means the return of that particular asset is above what the CAPM predicts when taking the risk into account. Put differently, that particular asset is beating the market and generating better return for a given risk relative to what CAPM predicts (Fama and French, 2004).

The CAPM alpha's have been a subject of discussion with the growing popularity of alternatives. As pension funds and other yield-hungry investors show these private assets more interest, there is an increasing risk that the alphas will eventually dissapear, due to limited supply as the demand for such assets increases, and the prices of them going up (Michelle Teng, 2021).

4.3 Defined Benefit vs Defined Contribution

As mentioned before, when it comes to asset allocation of individual pension funds, the difference can be quite substantial depending on which occupational scheme the fund is running on. DC schemes normally assign members to different pension investment pots where they can choose their preferred pot and therefore, their asset allocation. While some schemes offer around 3-10 choices, others offer hundreds which can have behavioral implications on investment choices made by the members (Sutcliffe, 2016). This was indeed confirmed by Iyengar and Kamenica (2010) where they found that as the size of the menu got larger, member moved towards investing in cash, bonds and avoided equities.

Individual´s finances can change over the course of their lives, and lifetime asset allocation can be altered by changes in relative prices. According to consumption theory, such changes should lead to rebalancing of an individuals' portfolio but that is not the case as shown in Keim and Mitchell (2015). To account for this, life cycle or lifestyle pots have been introduced where asset allocation automatically, and gradually changes from risky investments to low risk as the individual approaches' retirement.

DB schemes investment decisions are made by the sponsor or their delegated agent, for the entire fund on a pooled basis, making the asset allocation decision different compared to a DC fund. The funding ratio, which is the ratio between available assets and liabilities, is also more heavily regulated in DB schemes, potentially causing implications on asset allocation (Sutcliffe, 2016).

Since future benefits are not guaranteed in DC schemes unlike the case for DB plans, lower interest rates have different effects on the two schemes. The present value of future benefits is calculated using discount rates, which are derived from market rates in The Netherlands. That means if the market rate goes down, the present value of liabilities rises, while only being partially offset by changes in asset values. This is referred to as a duration gap. One way to reduce a negative duration gap is to increase the duration of assets. That can be achieved by investing in either long term bonds or swaps, which can restrict investment decisions of funds seeking returns (Kortleve and Ponds, 2010).

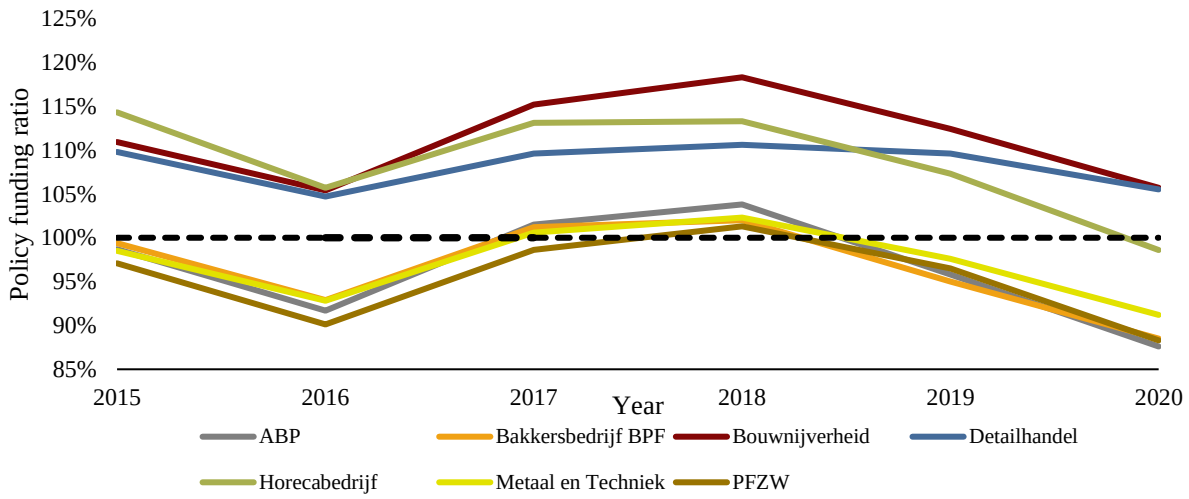


Figure 10: Policy funding ratio of selected Dutch pension funds 2015-2020. Source: DeNederlandsche Bank

This scenario is similar to the development of the Netherlands over the last 10 years, where the proportion of fixed income investments has increased from 42,1% to 47,5% in the years 2010-2020 in the aggregate asset allocation described in chapter 2.

Figure 10 shows the change in the funding ratio from 2015-2020 for selected Dutch pension funds which all are included in our analysis later.

The Dutch system came under a lot of pressure due to the increased negative duration gap in 2019. With claims coming out that future benefits had to be reduced (CNN, 2019). The overall pressure on the Dutch pension system due to lower interest rates and increased longevity has sparked discussions of reforms. In 2019, an agreement was reached between the government, unions, and employers over pension reforms, where the intention is to move away from DB towards DC.

4.3.1 The Dutch pension reforms

As argued by ABP , the largest pension fund in The Netherlands, times have changed since the old Dutch pension system was enacted, where fewer people now work for the same employer throughout their lives and more people work as freelancers, as well as longer lifespans. In the old pension system, changing pension funds could result in complicated calculations of pension benefits. This means, for example, that employees who left their pension fund half-way through their career to start their own business would potentially build up insufficient pension in

comparison to their contributions. Therefore, the redesigned DC scheme should be better aligned with the changes in demographics and the labor market (ABP, n.d).

Switching to a DC scheme allows pension providers accommodate for the different investment preferences of their members. Younger cohorts, for example, are still several years away from retirement and can continue to contribute for a long time. As a result, pension funds can assume greater risks on their behalf. Compared to younger groups, older cohorts have fewer chances to recover from volatile and potentially lower returns making funds less willing to take on risk on their behalf, as they require a higher degree of security (DNB, n.d).

This increased flexibility in investing that comes from both, less sensitivity on the liability side when changes occur in interest, and the opportunity to split investments into different pools depending on the member's age. This can have substantial effects on how the pension funds choose to allocate their investments. As of 2020, 84,10% of all liabilities on the asset side of occupational schemes in Europe were held by DB funds and 15,9% by DC funds. Out of the 84,10%, 75,41% came from Dutch DB funds (Mac, 2018).

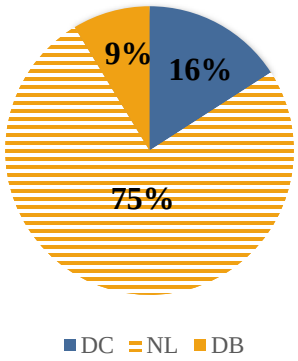


Figure 11: Percentage of bonds in Europe held by DB and DC schemes respectively in 2020. Source: European Insurance and Occupational Pension Authority 2020.
Note: Other EU countries include Austria, Belgium, Spain, Finland, France, Italy, Portugal, Sweden, Slovenia, Germany, Croatia, Luxembourg, Norway, Denmark, Liechtenstein, Latvia, and Malta. Data does not include sovereign pension funds.

With over 1.7 trillion euros in assets under management, the Dutch system is by far the largest in the Euro area. Therefore, a shift towards a DC scheme is expected to have a positive effect on the equity financing sector, in addition to boosting the already growing investment fund sector. This also applies for other asset categories, such as alternative investments. As a result, long-term bonds and swaps will be structurally reduced.

In a recent report by the ECB, empirical evidence is provided which underlines the reduced demand following a change from DB to DC schemes. One of them is that market demand for certain maturities has an impact on how the yield curve shapes see Cox, Ingersoll, and Ross (1985). Which is very relevant, given the Dutch funds preferences towards long term government bonds. Additionally, the negative duration gap of a DB pension funds typically widens when interest rates decline, due to the negative convexity on the balance sheet. Negative convexity is primarily caused by a size effect since interest-bearing assets tends to be a small proportion of total liabilities. The (longer) duration of the liabilities is more sensitive to a decline in interest rates than the (shorter) duration of the assets. In response to a widening duration gap, DB pension funds can increase their exposure to long-term bonds and swaps when interest rates decline, as discussed earlier. Hedging using derivatives can amplify the impact of rate shocks, possibly at the cost of returns. With the transition of the Dutch system the share of DC schemes in the euro is area is expected to rise over time from about 17% to 77% (ECB, 2021).

5. Literature review

Researchers, like investors, have shown increased interested in private investment and how they affect portfolios over the years. Karavas (2000) demonstrated that pension funds can benefit from allocating a fraction of their portfolio to private, illiquid assets. As a result of his analysis, alternative investment must be included in the portfolio and supplement traditional assets, such as equity and bonds to obtain the highest possible return given the risk.

In their empirical study, Fischer and Lind-Braucher (2010) concluded that investors should consider alternatives when constructing their portfolio. Their result indicated that asset allocation with a mixture of alternatives and traditional investments generated a significantly better performance than a portfolio excluding alternatives, in the period of 1999-2009. The paper argues that an investor with a mixed portfolio would have gained a return exceeding 50% over the 10-year period while investing solely in stocks would have led to a loss of 20%. Therefore, the study showed that private investments have high diversification potential and are relevant in times of crisis. This is due to the low correlation in returns of alternatives, compared to more traditional assets, allowing investors to build a portfolio that is more resilient in loss of value.

Similarly, Schweizer (2008) argues that there are two fundamental reasons why the proportion of alternative assets has been rising over the years. During turbulent times with big drops in equity and bond values, alternative assets provided diversification since their return drivers typically show a low correlation with the drivers of equity and bonds. The second reason is that diversification does not adversely affect the expected return and risk performance. Thus, alternatives play a significant role when it comes to portfolio optimization, regardless of risk aversion.

Kräussl, Lehnert, and Rinne (2017) studied the effect of declining interest rates on asset allocation and concluded that low interest rates would encourage pension funds to allocate more of their assets to alternatives. This conclusion was, however, not supported by empirical evidence. Defau and De Moor (2020) followed up on this result by conducting empirical research on pension funds' investment behavior in alternatives. Prior to that there were no empirical studies to fully support the reasoning behind more alternative investing during low interest rate periods. Their results were opposite to what Kräussl et al found, namely that pension funds invested less in equities and increased their allocation to alternatives when interest rates were higher.

In addition to that, their analysis suggests that pension funds with a higher focus on diversification tend to have a higher proportion of alternatives in their portfolio.

The goal of this thesis is to further expand research in alternative assets allocation of pension funds in low interest rate enjoinment, while emphasizing on the pension systems that are considered the best in the world. Our analysis will follow the same approach as Defau and De Moor (2020). Contrary to prior research, our analysis is not done with a private dataset, meaning that full disclosure of data in certain countries and funds can be made. The undisclosed dataset used in prior research consists of pension funds from the United States (54%), Canada (27,7%), Australia (1,3%), Eurozone (9%) and other (8%). Most of the dataset is dominated by the United States, ranked by Melbourne Mercer global pension index as C+ and Canada ranked as B. Whereas the countries chosen in this thesis are rated A or B+. Another new angle that separates this study from Defau & De Moor is that in their analysis 4447 funds were defined benefit funds, in a total amount of 5444 funds, or 81%. In our study large part of the sample, apart from the Netherlands, one fund in Australia, and a few funds in Denmark are defined as DC.

6. Empirical framework

6.1 Data

To perform the empirical study in this paper, data is required about how individual pension funds decide to allocate their assets and how those assets are developing over time. Since the aggregate data from OECD does not provide enough datapoints and is not precise enough, it cannot be used to draw conclusions from empirical methods. Therefore, to obtain adequate data, information was collected by going through and analyzing annual reports for the pension funds in Australia, Denmark, Iceland, and the Netherlands. In the financial statements, information regarding distribution of assets was gathered with a particular emphasis on alternative investments. That makes the information highly reliable since it comes directly from the funds themselves, but one drawback is that the four countries do not have the same regulations regarding how the balance sheet is presented. Meaning that sometimes calculations were required to make the data comparable. To maintain consistency, we avoided pension funds that had substantial changes to their balance sheet in the case of mergers. The collected datapoints are gathered on an annual basis and the time horizon for this research covers 11 years, or from 2010-2020. The reason for the relatively short period is the lack of available data, as not all pension funds publish their breakdown of assets with respect to alternatives prior to that time. In addition, it was often problematic to obtain annual reports prior to 2010, as that was the last available annual report for a large share of the funds. Overall, this gave us an unbalanced dataset of 50 pension funds which resulted in 485 observations over the 11 years. Individual pension funds in each country were chosen after size, where we started with the largest and worked our way down. This was done both to capture a larger share of the assets of the system and larger funds often had better information on how the assets were allocated. Below is a detailed description of how the data for each country was collected.

The Australian data used in this analysis builds on information from 13 different superannuation funds obtained from their annual report. In total we have a dataset which consists of 143 observations spread over the research period. The size of these 13 pension funds covered more than a half of the Australian system in June 2020. One thing worth mentioning is that in Australia the financial year differs from what we are used to in Europe. The annual report describes an activity which takes place from 1st July to 30th June the following year. Therefore, the investment performance is based on 30th June each year instead of 31st December, which is the date used by

the other countries. While it is important to keep this difference in mind, we conclude that since we are analyzing the situation over time and this gap is always the same, it is possible to compare the trend in asset allocation between the countries based on averages. In addition, all other explanatory variables for Australia will be adjusted for the right dates. By examining financial statements of individual funds, we were able to acquire knowledge as to how asset classes have been evolving over the last decade. The funds specify how the portfolio is divided into domestic and foreign securities such as shares and fixed interest instruments but also include information on categories such as property, infrastructure, and other assets in their report. That makes it possible to calculate how much falls into each of the four categories we use for this thesis and determine with accuracy the proportion of alternative assets relative to assets under management. The four categories are: 1) listed equity, 2) bonds, 3) alternatives and 4) other investments which mostly consists of deposits and are not considerable part of the total investment.

In Denmark, pension funds publish specifications of their assets as a part of the financial statement. Generally, they specify how much of their portfolio is invested in different asset types such as bonds, listed and unlisted equity, real estate and so on. Thus, we were able to isolate the fraction that pension funds choose to invest in alternative assets and access how it changes over time.

In our analysis we collected data for 13 of the largest funds in Denmark. These are pension funds that receive contributions from workers and are accountable for approximately 70 % of the assets in the Danish pension system. Prior to new law in 2015, the pension funds were not required to give full disclosure of their total asset allocated into the two different schemes, markedsrente or DC and DB, gennemsnitsrente (Erhvervsministeriet, 2015). Consequently, data before 2015 only shows either DC or DB allocations for some funds, usually depending on which is larger. With growing popularity of DC schemes in Denmark, like mentioned in chapter 2, excluding them before 2015 would therefore give a skewed image of the real asset allocation of the funds. If data before 2015 would be included, we would only be able to include one scheme into the calculations as otherwise large jumps would occur between 2014 and 2015 due to missing data. Therefore, the decision was made to only include data from 2015-2020 in Denmark which overall, gave us 78 datapoints.

Pension funds in Iceland are required to calculate and publish multiples that specify how the percentage of their total assets in listed and unlisted financial instruments have evolved over the

last 5 years. Therefore, it is easy to access data for how much the funds place in both listed and unlisted equity as well as bonds. Furthermore, they disclose how much goes into other investment such as cash and deposits. One drawback is that Icelandic pension funds do not give any details about how their portfolio of unlisted assets is distributed across various types. For this study, information was collected for 11 funds operating in Iceland who were responsible for managing assets exceeding 75% of the Icelandic system in the year 2020.

The portfolio for each fund was divided into the same four sub-categories as before which makes it possible to observe how much of the total portfolio is distributed to alternative assets. The calculations were done for all 11 years, giving in total 485 observations.

Like with the other countries, data for The Netherlands was acquired by going through annual reports issued by pension funds. Pension funds in the Netherlands give a more detailed information of how they allocate their assets, especially when it comes to non-traditional assets. Thus, information about precisely how much is invested in real estate, private equity, hedge funds and infrastructure are a common sight in Dutch financial statements. To make the data comparable across countries the portfolio for each fund was divided into the usual categories namely, listed equity, fixed income, alternatives, and other investments.

For the Dutch data, information about 13 of the biggest pension funds was used which covers roughly 70% of the total pension system assets and includes 143 datapoints.

6.1.1 Interest rates

The aim of this thesis is like previously stated, to explore to what extent pension funds alter their investment strategy when interest rates change over time. Interest rates are one of the key components that must be considered when portfolios are constructed. Changing interest rate affect the cost of borrowing money. When interest rates rise it becomes more expensive to borrow and lower rates make it cheaper to access capital. For the traditional investment choices this relationship is clear. Interest rates and bonds have a well-known negative relationship, meaning lower rates push the price of bonds up. For equity there is an inverse relationship as well, while the effect might not be direct. Lower rates generally lead to a shift in low-risk securities to instruments with a higher risk (U.S Securities & Exchange Commission, 2013). Declining interest rates decrease investors incentive to store their capital in deposits and government bonds, while increasing their will to invest in high yield bonds and other assets to obtain returns.

In addition, lower interest rates, lead to increased lending capacity of banks and other financial institutions and with lower interest rates, firms financing cost should decline which has a positive effect on their operation and price valuation.

When it comes to alternatives, the relationship is however not that simple. As seen in figure 1 from chapter 2 long term nominal interest rates have decreased over the last two decades. This trend has made investments in relatively safe government bonds unappealing and returns on deposits have been close to none or even negative. To analyze the relationship between alternatives and interest rates further we gathered data for each country over the 11-year period from OECD on annual nominal long term interest rates, which refer to the yield on government bonds maturing in ten years. The rates are mainly determined by the price charged by the lender, risk related to the borrower and a fall in capital value. With long-term interest rates generally being averages of daily rates, measured as a percentage. The implied prices depend on the price which the government bonds are traded on financial markets, not the interest rates at which the loans were issued.

In all cases, they refer to bonds whose capital repayment is guaranteed by governments (OECD, 2022).

6.1.2 Pension fund size

To what extend fund size has on asset allocation has been well covered in the literature. Boon, Briere, and Rigot (2014) found that a standard deviation increase in asset size under management, would lead to a considerable increase in risky assets, especially alternative assets. The argument they provided was that larger and more sophisticated funds have resources to hire professionals who can monitor and track investment performance in complicated assets for instance, infrastructure and private equity. López-Villavicencio and Rigot (2013) presented similar results in their research, finding that larger funds allocate more to private equity, while equity was unaffected by pension fund size.

Since none of the pension funds settle in the same currency, we converted the size reported in the financial statement into millions of euros. The collected data is reported on an annual basis and thus the average exchange rate of each currency for the corresponding year in our analysis was used.

Table 4 shows the average size of the pension funds in millions of euros. The average fund size has grown considerably in every country over the decade, most in Iceland where on average

pension funds have more than tripled the value of assets under management. It is clear however that when performing the econometric analysis, it is not ideal to use levels of size as an explanatory variable. The reason is twofold. Firstly, due to heteroscedasticity, as we move ahead in time the variance of the size is not constant but is getting larger. The second reason is the likelihood of large outliers both on the upside as well as the downside. In absolute value, the Dutch funds are by far the largest ones and for instance did ABP report a value of nearly 575 billion euros in 2020 which is nearly twice the size of the second biggest fund PFZT and more than 3 times greater than the average Dutch pension fund in 2020. At the same time some of the Icelandic funds scrape the bottom and hardly exceed 500 million euros, which sounds like a large amount but is nowhere near the average fund size. Since we are only interest to see if larger funds allocate more to alternatives but not by how much we take the natural logarithm and transform the data. This is to alter the scale, while maintaining the correct size order, therefore monocity is maintained while heteroscedasticity is reduced.

Table 4: The average size of pension funds for each country. Source: Annual reports and own calculations

Year	Australia	Denmark	Iceland	The Netherlands
2010	19.236		703	40.104
2011	23.230		779	43.685
2012	27.647		910	51.437
2013	30.883		1.012	52.626
2014	33.521		1.192	64.730
2015	38.104	24.867	1.456	63.721
2016	39.524	27.309	1.750	70.641
2017	45.138	29.034	2.176	76.865
2018	48.367	29.699	2.244	75.624
2019	53.959	34.935	2.462	89.355
2020	57.945	37.747	2.534	97.293

Note: Amounts are in millions of euros.

6.1.3 Diversification

According to an international survey conducted by PwC (2015) vast majority of pension fund across the globe mentioned diversification benefits as the main reason for investing in alternatives. Over 80% of the participants said that mixing the portfolio with alternatives provides them with a

reduction in volatility due to low correlations to market assets and its possibility to lower short-term fluctuations, without impacting long term expected returns.

To capture the effects diversification has on alternatives we constructed a dummy variable which takes the value 1 if pension funds invest less than 60% of their assets under management in one particular asset class and 0 otherwise. In other words, if pension funds place more than 60% of their capital in one investment category they are defined as investors who do not exhibit characteristics of diversifying risk across different asset classes. This is based off the idea of the classic risk diversifying 60/40 portfolio. Figure 12 illustrates the trend of diversifying pension funds in our sample. As one might expect, most of the funds capitalize on the benefits of diversification, where around 85% allocate less than 60% into one category. There can however be reasonable explanations why pension funds might want to be conservative when it comes to their investment strategy as their structure is not identical. For example, ATP, Denmark´s biggest pension fund splits its portfolio into two parts, a hedging portfolio which accounts for 80% of the total assets and an investment portfolio which covers the remaining 20%. The purpose of the hedging portfolio is according to ATP´s investment approach, to obtain a high degree of security for its members so the fund can honor its guaranteed pension benefits in the future (ATP, 2020). This is done by tying up a considerable proportion of the fund's asset in "safe investments" while the investment portfolio is intended to include more risky assets. All this is reflected in ATP choosing to allocate more than 70% of their portfolio on average in fixed income during the sample years.

Most of the drops and increases over the years can be attributed to changes in fixed income and equity, which are not tied to any country.

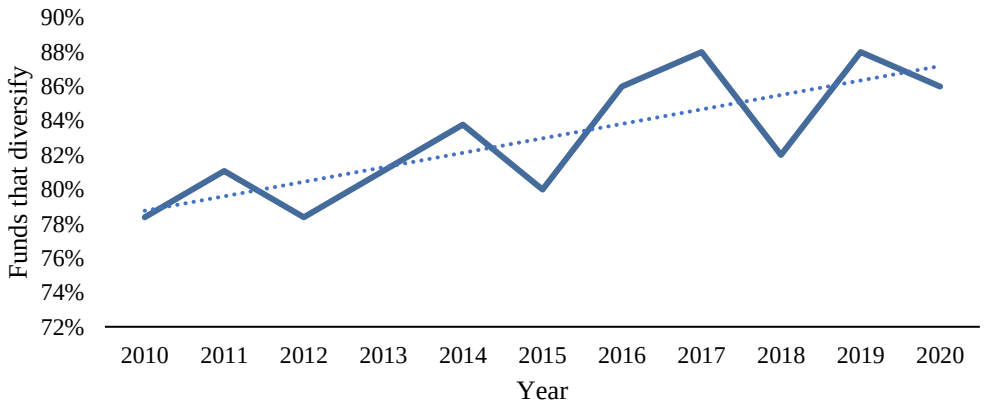


Figure 12: Percentage of pension funds that diversify by investing less than 60% in one asset class. Source: Annual reports and own calculations

6.1.4 Defined benefit funds

When trying to estimate the impact changing interest rates have on asset allocation it is important to account for how the pension liabilities of the funds are structured, that is whether the funds operate as a defined benefit or defined contribution. The former type guarantees fund members some pre-determined income in the future while the return in the second scheme is not guaranteed and depends on contributions and market returns over time. As discussed in chapter 4.3 these two pension schemes have different sensitivities when changes occur in the interest rate.

When it comes to DB the pension liabilities are more regulated and often computed by discounting the cash flow using long-term interest rates or other interest rates which correspond to the current economic environment. Therefore, decreasing long term interest rate will increase the future liabilities of the pension fund, while at the same time, lead to an increase in the value of the bond portfolio. To what extend this affects the DB funds will depend on what changes more. In the case of DC which offer no guarantee of future benefits, and are affected by market returns, the reduction in interest rate will be reflected in higher bond prices. By how much will depend on the duration of the assets. Thus, DC will show an increasing return, at least in the short run when interest rates decline (Antolin, Schich, and Yermo, 2011).

To isolate the different reactions to lower interest rates depending on the type of the funds, we constructed a dummy variable which takes the value 1 if the fund is DB and 0 otherwise. In Denmark, many funds have actively been shifting their assets away from DB towards DC. Since some of the funds operate under a mixed system, meaning a fraction of the fund members still enjoy guaranteed benefits, while others choose to link their future benefits to market rates, we define those funds where more than 60% of assets that are tied to guaranteed benefits as DB in our analysis. The reason for 60% and not a simple majority is to prevent fluctuations between years. In total, this resulted in 204 DB funds and 281 DC funds.

6.1.5 Fund member´s age and maturity

When trying to explain by how much retirement funds allocate their assets into alternatives, another crucial factor to take into consideration is the pension fund member's active participation rate. Active participation has been defined in different ways and Turner and Muller (2013) define active participation in DC schemes as whether one has contributed to the fund for a given year

while the Icelandic pension fund Live (2021) defines it as those who have been contributing regularly to the fund on a monthly basis over the year.

It is well known that nations around the globe are getting older, see UN (2020). Thus it is crucial for pension funds to take the maturity of its members into considerations when allocating their assets under management. Defau and Moor (2018) show that funds with a higher participation rate, that is fund with a higher fraction of younger members, invest more of their assets in risky assets, whereas mature funds have a more conservative investment approach and invest a higher proportion in safe assets such as bonds. Our hypothesis is in line with previous literature, and we expect a positive relationship between the participation rate and percentage of assets allocated to alternative assets. Pension funds with younger members, and therefore a higher proportion of contributing members have more leeway to take on risk and invest in long term projects to gain the illiquidity premium.

In our analysis we obtained information about the active participation in Iceland and Denmark by going through individual annual reports. The data for the Netherlands and Australia was collected through the respective pension supervisory authority for each country, De Nederlandsche Bank and The Australian Prudential Regulation Authority. For a given fund we calculated the ratio of those who are actively contributing to the fund and divided by the number of total pension fund members. Among the four countries the highest participation rate on average is in Australia. This is consistent with what we observe in the descriptive statistics during the sample years, where the Australian pension funds were the most eager to allocate assets to non-traditional investments.

6.2 Econometric methodology

To estimate the relationship between long term interest rates and other factors on the asset allocation of pension funds in alternatives, a couple of things must be considered. Firstly, the four different countries make up different environments in which the pension funds operate. Secondly, over time, different pension funds might be exposed to different economic changes of separate sizes which affect their allocation towards alternative assets. With that in mind, heteroskedasticity is to be expected in the allocation of alternatives which can make the usage of linear model's problematic, since the results become unreliable if the residuals of the regression are not distributed with an equal variance.

To confirm our suspicion of the unreliability of a linear model, a simple OLS regression was conducted, and the residuals collected. From there we conducted an Breusch-Pagan test which gave an p-value less than 0,05. That means we were able to reject the null hypothesis of homoscedasticity and conclude that the residuals were, indeed, heteroskedastic. In addition to that, an auto correlation function, ACF, was plotted of the residuals which showed that they contained serial correlation as well. The linear estimation and graphs related to this result can be found in the appendix. Moving forward, other methods than OLS had to be considered, starting with Fixed effects.

6.2.1 Fixed effects estimation

According to Wooldridge (2010), due to simplicity in calculation, interpretation and understanding, fixed effects models is the most widely used panel data regression method. Fixed effects estimation clears out time invariant factors for individual data points, i's, which in our analysis are pension funds. By doing so, the estimation reduces the omitted variable bias that might be caused by things like the environment, or legislation as the funds operate in the different countries. The fixed effect estimator with two explanatory variables can be written as:

$$y_{it} = \beta_1 x_{it} + \beta_2 x_{it} + \alpha_i + \delta_t + u_{it} \quad (9)$$

Where α_i is a time invariant factor, often labelled as individual effects and δ_t is a time variant factor, labelled as time effects. By using the time effect coefficient, controls can be enforced on macro-economic trends which affect the data points. Lastly, the idiosyncratic error is labelled as u_{it}.

When controlling for time effects two methods can be used, either dummy variables can be set for each period (years, months etc.) or through a de-meaning calculating process. The latter method is a regression in deviations from the entities (pension funds) mean so it does not include the individual effects, α_i. It starts by calculating averages across time for all i's in the following equation which are then subtracted from the original equation 9.

$$\bar{y}_i = \beta_1 \bar{x}_i + \beta_2 \bar{x}_i + \alpha_i + \bar{\partial} + \bar{u}_i \quad (10)$$

The individual effects, α_i, are time invariant and therefore remain constant over time after averaging. Values denoted with bar, are average values. When equation 9 is subtracted from 10 we obtain:

$$y_{it} - \bar{y}_i = (x_{it} - \bar{x}_i) + \beta_2(x_{it} - \bar{x}_i) + \delta_t - \delta + u_{it} - \bar{u}_i \qquad (11)$$

$$\dot{y} = \beta_1 \dot{x}_{it} + \beta_2 \dot{x}_{it} + \dot{\delta}_t + \dot{u_{it}}$$

The time demeaned estimation is now complete which makes it is now possible to calculate the within estimators by using regular ordinary least squares methods.

In total, five assumptions are required for an unbiased and consistent estimate when using fixed effects. Firstly, an unobserved effect must be present, whether that is individual effects, time effects or both. This can be tested for, after conducting the first stage of a fixed effect estimation which includes no individual nor time effects. A Lagrange multiplier test (Breusch-Pagan) is then conducted. The results of the tests had p-values below 0.05, meaning that both time and individual effects were present. The second assumption is a random sample from the cross section, which is hard to fulfill.

Thirdly, no perfect multicollinearity in the explanatory variables, along with them having some variability. In our case, a variable which has perfect multicollinearity becomes omitted, in the statistical program R where the analysis is conducted. The fourth assumption assumes homoscedastic explanatory variables and unobserved effects. Since tests showed heteroskedasticity to be present robust standard were used. The method of choice was used with intuition from Petersen (2009), where clustering of standard errors around pension funds was used to correct for heteroskedasticity.

The fifth and last assumption assumes no autocorrelation in the idiosyncratic error term over time, based on the unobserved effect and explanatory variables. If these assumptions are fulfilled the FE estimators is unbiased, consistent and the best linear estimator of the explanatory variables. It is very likely in our example that the unobserved effect is correlated among years since effects like legislation impacts asset allocation for more than one year. To eliminate or at least largely reduce this magnitude of autocorrelation we include time dummies. By doing so, correlation is transferred to the given year, which otherwise would end up in the error term.

We decided to use the plm or fixest package in R, which adjusts the fixed effect regression for an unbalanced dataset by reducing the degrees of freedom from 11 to 7. This affects how the de-meaning process is conducted on the data from Denmark as data from 2010-2014 is unavailable, for reasons mentioned before. That means for the Danish data, the average is calculated for less years, compared to the other countries.

6.2.2 Random effects and the Hausmann test

The fixed effects estimator is not the most efficient if we believe the unobserved effects from before are not correlated with our explanatory variables, if so, a random effects estimator should be used instead. This model is similar to the fixed effects model, but it adds an intercept that allows the mean of the unobserved effects to equal 0. In general terms the Random effects can be written as:

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \cdots + \beta_k x_{itk} + \alpha_i + u_{it} \quad (12)$$

Since the unobserved effects is not removed, it can possibly be included in a composite residual term, e_i, which then clearly has serial correlation. To remove the autocorrelation, transformation is needed. First the correlation is filtered out by a parameter:

$$\varphi = 1 - \left(\frac{\sigma_u^2}{\sigma_u^2 + T\sigma_a^2}\right)^{\frac{1}{2}} \quad (13)$$

Once the original equation is transformed, it becomes a half time-demeaned equation:

$$y_{it} - \varphi\bar{y}_i = \beta_o(1-\varphi) + \beta_1(x_{it1} - \varphi\bar{x}_{i1}) + \cdots + \beta_k(x_{itk} - \varphi\bar{x}_i) + (e_{it} - \varphi e_i) \quad (14)$$

The values of φ varies from 0 to 1. When it equals 1, which it never does, it becomes a fixed effect estimation. Usually, the estimate will be close to one. When it is zero, the regression equals a pooled OLS. By using the half time-demeaned estimation constant factors are included which hold no bias.

One thing to note when deciding whether to use Fixed effects or Random effects is that the RE estimation assumes that α_i is random which is not the case for our study, as within each country, different pension funds have structural nonrandom differences. In FE estimation, the unobserved effect is removed and therefore does not correlate with explanatory variables (Wooldridge, 2012).

A Hausman test can be used to draw conclusions on whether FE or RE are consistent. The null hypothesis states that the Random effect model is consistent, where the alternative hypothesis is that FE is more consistent. The results of the Hausman test confirmed our beliefs, with a p-value below 0.05, meaning that we reject the null hypothesis and conclude that the FE is more consistent.

6.2.3 Fixed Effects vs First difference

Lastly, we considered the possibly that first difference estimation method would be better fit than Fixed effects. Wooldridge (2012) states that it can be difficult to choose between FE and first difference, FD, if they give different results.

When T = 2, all test statistics and estimates from both regressions are identical. When T > 3, the FE and FD estimators don't give the same results. Since they are both unbiased under the same criteria, that is for large n or i's and small T, the choice between FE and FD should depend on the efficiency of the estimators. The efficiency is determined by the serial correlation in the error term $u_{it.}$ Since our regressions is based on more than two periods, the methods result in two different estimates. However, since they are very similar, we decided to move on with the fixed effects estimation. Regression results of FD can be found in the appendix.

6.3 Summary statistics

Before proceeding with the analysis, it can be helpful to get a sense of how the data looks like. Table 5 exhibits a statistical overview of the main variables used in the regression.

Table 5: Summary statistics

Variable	Mean	25th percentile	75th percentile	Min	Max	Std. Dev.	Number of funds
Alternatives %	19,9%	12,9%	27,0%	2,2%	42,4%	8,7%	485
Log size Alternatives	7,4	6,2	8,7	1,8	12,0	181%	485
Fixed Income	43,4%	30,0%	55,5%	10,9%	81,7%	15,8%	485
Equity	34,4%	26,2%	42,1%	3,5%	63,9%	11,5%	485
Other	2,3%	0,0%	2,8%	0,0%	12,6%	4,1%	485
Yield	2,6%	0,6%	4,9%	-0,4%	6,4%	2,2%	485
Log fund Size	8,3	7,1	9,5	4,8	13,3	180%	485
Inflation	1,9%	1,2%	2,5%	0,3%	5,4%	1,2%	485
Active	43,0%	23,7%	62,1%	17,7%	71,9%	18,8%	435
Domestic volatility	13,0%	5,7%	18,9%	-9,0%	43,4%	10,5%	485

As for the dependent variable, the funds included in this database allocate on average around one-fifth of their portfolio to alternative assets. They are however not homogenous, and the scale for the 485 observations goes from the Dutch pension fund Stipp, which usually allocated less than 4% of their portfolio to alternatives and a minimum of 2,2% in 2013 to the Danish PKA-

Sygeplejerske fund which invested around 40% during the years we look at. Since the funds are of such different sizes, we chose to include the natural logarithm of the actual amount invested into alternatives to make the numbers more comparable like mentioned in subchapter 6.2.2. Despite that there is still a large standard deviation of 180%, which is very little compared to the untransformed data (1.850.293%).

Looking at the other asset classes, fixed income is on average the biggest one with 43% of the funds' assets invested in bonds followed by equity with an average value of around 35%. These two asset classes vary however greatly depending on whether the funds are DB or DC and their average member age.

The interest rates have seen a steady decline in all four countries and the mean value over the sample period is roughly 2,5%. Interestingly, 25% of the sample fall below value of 0,6% and 75% of the observations are below 5%.

7. Do lower interest rates increase investments in Alternatives?

We assess the underlying dynamics of the changes in alternative investments by testing effects at the individual fund level, having reviewed and classified previous literature on the increased popularity of alternative investments. A particular focus is given to the variables, which are discussed in chapter 6.2.

7.1 Descriptive statistics

Table 6 shows the variation in average asset allocation among all the funds in the sample over time. First thing that we notice is that over the sample period, the fraction of alternatives as a proportion of total assets under management decreased from 21% to 20%, at the same time interest rates decreased. The structure of pension funds varies among countries and thus, it is important to consider whether the same trend is observed in all countries in the sample. Noting that in chapter 2, we already observed variation among countries, where for example fixed income securities increased in The Netherlands. While Denmark and Iceland experienced a decrease. In Table 7 on the next page, the development for each country over the sample period is shown.

Table 6: Descriptive statistics

Year	Alternatives	Equity	Fixed income	Other	Number of funds
2010	20,36%	34,43%	42,76%	2,46%	37
2011	21,06%	32,83%	43,23%	2,88%	37
2012	21,37%	32,91%	43,48%	2,23%	37
2013	20,00%	35,78%	42,28%	1,94%	37
2014	19,20%	36,17%	42,39%	2,25%	37
2015	18,16%	34,54%	44,62%	2,68%	50
2016	18,69%	33,54%	45,25%	2,51%	50
2017	19,50%	34,53%	44,05%	1,92%	50
2018	20,28%	33,41%	44,21%	2,21%	50
2019	20,69%	34,98%	42,18%	2,16%	50
2020	19,98%	35,60%	42,00%	2,43%	50

Table 7: Descriptive statistics for each country

Year	Alternatives	Equity	Fixed Income	Other	Funds
Australia					
2010	23,54%	47,45%	24,27%	4,74%	13
2011	23,60%	48,11%	23,98%	4,31%	13
2012	25,74%	45,70%	24,57%	4,00%	13
2013	25,07%	48,40%	22,68%	3,85%	13
2014	23,32%	48,78%	24,13%	3,77%	13
2015	24,47%	48,73%	23,43%	3,37%	13
2016	25,23%	45,81%	25,15%	3,82%	13
2017	25,09%	47,35%	25,00%	2,56%	13
2018	25,90%	47,81%	23,70%	2,58%	13
2019	26,78%	46,55%	24,52%	2,14%	13
2020	26,09%	44,46%	26,79%	2,66%	13
11-year average	24,99%	47,20%	24,38%	3,44%	
Denmark					
2015	15,13%	26,00%	54,02%	4,85%	13
2016	16,03%	24,70%	54,52%	4,74%	13
2017	17,63%	26,23%	51,73%	4,40%	13
2018	19,18%	24,73%	51,97%	4,12%	13
2019	19,10%	26,68%	50,08%	4,13%	13
2020	18,71%	26,71%	49,62%	4,96%	13
6-year average	17,63%	25,84%	51,99%	4,53%	
Iceland					
2010	20,37%	23,74%	54,11%	1,78%	11
2011	23,21%	20,76%	54,21%	1,82%	11
2012	22,61%	23,27%	53,04%	1,08%	11
2013	19,83%	26,75%	52,70%	0,72%	11
2014	21,27%	27,98%	50,08%	0,67%	11
2015	18,72%	32,28%	47,31%	1,69%	11
2016	19,89%	31,17%	48,46%	0,48%	11
2017	21,56%	31,92%	46,31%	0,20%	11
2018	22,47%	32,12%	44,95%	0,45%	11
2019	23,51%	36,15%	40,02%	0,32%	11
2020	21,68%	41,40%	36,79%	0,13%	11
11-year average	21,38%	29,78%	48,00%	0,85%	
The Netherlands					
2010	17,17%	30,44%	51,63%	0,75%	13
2011	16,70%	27,77%	53,19%	2,34%	13
2012	15,96%	28,28%	54,30%	1,45%	13
2013	15,08%	30,79%	53,07%	1,06%	13
2014	13,33%	30,48%	54,13%	2,05%	13
2015	14,39%	30,81%	54,12%	0,67%	13
2016	13,82%	32,12%	53,37%	0,69%	13
2017	14,02%	32,23%	53,50%	0,25%	13
2018	13,89%	28,79%	56,33%	0,98%	13
2019	13,79%	30,70%	53,77%	1,75%	13
2020	13,69%	30,72%	53,98%	1,62%	13
11-year average	14,71%	30,29%	53,76%	1,24%	
Total	19,87%	34,43%	43,38%	2,32%	485

Even though the proportion of alternative assets in the sample has decreased, table 7 shows that most of the countries have increased their exposure to this particular asset type over the last decade. Australian and Icelandic pension funds allocated roughly 1,5% more to non-traditional assets in 2020 compared to 2010. In Denmark, the increase was around 2,5% for the period 2015-2020. The only country investing less on average in alternatives was the Netherlands with a hefty drop of 5%.

When looking at the trends in other asset classes there is evidence that alongside the drop in interest rates Icelandic and Danish pension funds have been shifting away from fixed income investments into riskier asset such as equity and alternatives. At the same time the Dutch pension funds have gone the other way around and invested about 5% more in fixed income in the year 2020 compared to the begin of the sample period. That supports the hypothesis that funds operating under different schemes respond differently to the lower interest rate environment. With the possible culprit being the negative duration gap. As mentioned before, one way to reduce the negative duration gap is to purchase bonds with long maturity. This is exactly what we see in the descriptive data as the Netherlands, where all funds operate under a DB plan, have steadily increased their hold in bonds mostly at the cost of alternatives.

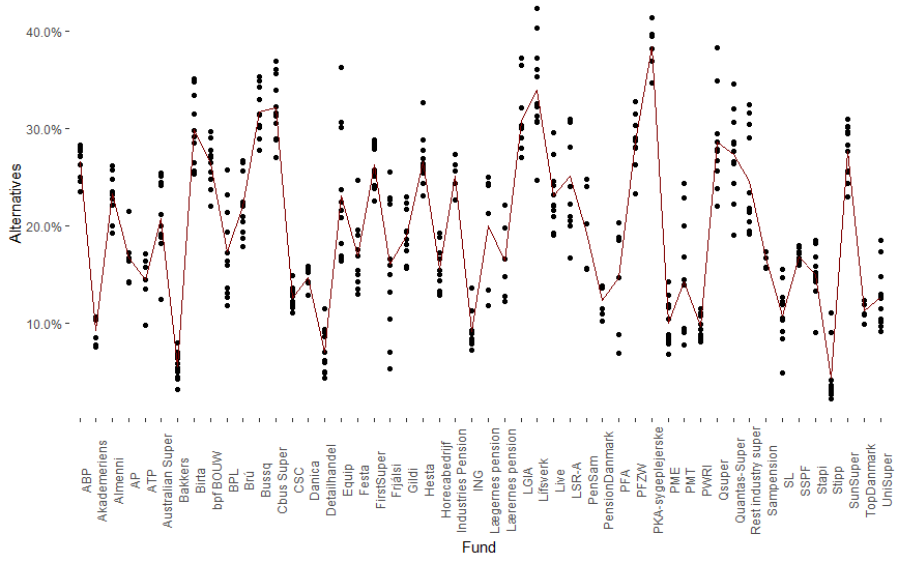


Figure 13: Alternative assets as a fraction of total assets across funds. Source: Annual reports and own calculations

A plot of different funds and their share of alternatives can be seen in figure 13. The different funds are on the x-axis and the fraction of alternatives is on the y-axis. For each fund, a few data points can be seen which represent the percentage for the given year.

The red line shows the average for each fund over the 11-year period. From the figure, specifying the difference across years is not possible so a second visualization is needed.

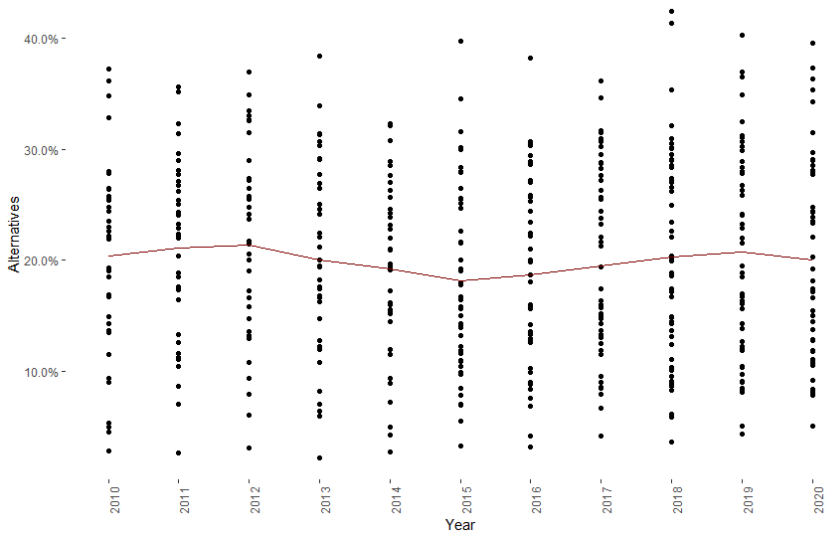


Figure 14: Alternative assets as a fraction of total assets over time. Source: Annual reports and own calculations

Figure 14 shows the variation in alternatives over time, where each dot on the x-axis represents different funds. As before the red line is the sample mean for percentage of alternatives for each year. We observe that the mean increases from 2010-2012, then decreases from 2012 to 2015 and increases again from 2015-2019 until decreasing in 2020.

7.2 Regressions

Following the descriptive analysis, we present our empirical results. Starting with our baseline model, we examine the effects of interest rates on asset allocation, investment diversification behavior, the size of the funds, type, and active members. Furthermore, we extend the same model to include alternatives in levels, or log-levels. This is to verify prior results when the portfolio is investigated in percentages. Since other factors on the balance sheet can directly impact the percentage held in alternatives. For example, large increases in the market value of equity can make it seem that alternatives are decreasing as a percentage in the portfolio, where they possibly remain the same or just growing at a slower pace than the equity.

As a final step, we compare the baseline model with an alternative model based on lagged interest rates. Possibly underlining the importance of investment policies.

Since they are determined before the start of each year, where specific weights are assigned to each asset category based upon a certain percentage range.

7.2.1 Baseline model: Alternatives in %

First off, we use a Fixed Effect Model as described in section 6.2.1 while gradually increasing the number of variables. In all regressions, we control for individual and time fixed effects to account for time-variant and time-invariant characteristics that may influence allocations to alternatives in a pension fund at a specific time. In accordance with the theoretical model presented in part 6.2.1, we estimate the following regression:

$$Alternatives_{it} = \beta_1 Yield_{it} + \beta_2 Complex_{it} + \beta_3 Size_{it} + \beta_4 DB_{it} + \beta_5 Volatility_{it} + \beta_6 Active_{it} + \alpha_i + \partial_t + u_{it} \quad (14)$$

Here, i represents the individual pension funds that operate in different countries, while t is an indicator of time. The dependent variable $Alternatives_{it}$ is the proportion of the portfolio held in alternative assets. Long term nominal interest rates in each country are $Yield_{it}$ in each country where the pension fund operates. $Complex_{it}$ is a dummy variable that represents pension funds that invest less than 60% of their portfolios in one asset class. The $Size_{it}$ is the natural logarithm of the pension fund's total assets in millions of euros in each country. Volatility on domestic equity markets in each country is $Volatility_{it}$. DB_{it} is a dummy variable used to represent funds with more than 60% of assets in a defined benefit plan. The number of active members divided by the number of inactive members across the different funds is represented by $Active_{it}$. The fund fixed effects are α_i and δ_t are time effects, followed by the idiosyncratic error u_{it}.

In table 8, we present the results of our baseline model using all 50 funds over an 11-year period. We highlight the specifications of each regression in the bottom part of the table. Model 1 in table 8 shows the results for a regression of yields on the percentage of alternatives. As predicted, the coefficient is negative, suggesting that lower interest rates lead to the funds holding a higher percentage of alternatives. However, it is not significant.

To increase the explanatory power of the model, extra variables are added to model 2. We will begin by incorporating the complex variable, which has a positive sign and is highly significant. As we expected, funds that exhibit a higher degree of risk diversification should hold more alternatives in their portfolios. This has often been mentioned as one of the primary reasons to invest in the asset class. The size coefficient is positive, and significant which does not come as a

surprise, given the high significance of the coefficient in Defau and De Moor (2020). The lower significance level in our model, compared to prior research may be since we are unable to distinguish between the different alternative asset classes. Alternatives are as numerous as they are diverse, and that also applies to costs relating to the investments. With the argument being that larger funds can incur more costs related to the investments such as management fee and cost related to obtaining information. Therefore, they can invest more.

Model 3 of table 8 also adds the defined benefit variable. In line with our expectations, defined benefit funds hold less alternatives in their portfolio on average. Secondly, domestic volatility in local equity markets is incorporated, a negative, but insignificant effect. The volatility of equity markets has two effects, firstly when volatility increases, pension funds might become more risk averse and look to other assets (possibly alternatives). Secondly, depending on how the volatility is constructed, meaning that if it only comes from differences in positive returns, such changes affect the percentage allocation of alternatives funds negatively. That is, given that other asset classes in the balance sheet of individual funds grows less.

Lastly model 5, includes the active members variable, which is positive and significant, meaning that funds with a higher fraction of active members invest more in alternatives. Unfortunately, the DB variable drops out to multicollinearity so models 4 and 5 are kept separate.

Table 8: Baseline model using percentage of alternatives as a dependent variable

Alternatives %	Model 1	Model 2	Model 3	Model 4	Model 5
$Yield_t$	-0,3583 (0,5828)	-0,3064 (0,5605)	-0,3489 (0,5626)	-0,3362 (0,5608)	-0,4068 (0,4345)
Complex		0,0262** (0,0099)	0,0239** (0,0098)	0,0237** (0,0097)	0,0246*** (0,0098)
Size(log)		0,0234** (0,0107)	0,0237** (0,0105)	0,0241** (0,0106)	0,0182* (0,110)
DB			-0,0724*** (0,0097)	-0,0737*** (0,0092)	
Domestic volatility			-0,0205 (0,0181)		
Active					0,2936* (0,1425)
Fixed effects					
Fund	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,75377	0,76718	0,77125	0,7704	0,7722
Observations	485	485	485	485	443

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

In table 9 we analyze what happens when substituting the percentage of alternatives for its size. Due to the large size differences among funds, we opted to use the natural logarithm to reduce heteroskedasticity. Previously, in the baseline model we noticed that as interest rates are lower, the allocation as a percentage of total portfolio increases with a non-significant effect. This raises the question of how the actual size changes with interest rates. Therefore, we want to verify that the percentage increase is not explained by a reduction of other categories, meaning that when interest rate decline, alternatives are both increasing as a percentage of portfolio allocation and in actual amounts. If the other asset categories are growing faster than alternatives, alternatives can increase over time, while decreasing as a percentage of the total asset allocation of funds. One thing to note here is that we are unable to tell the story of how alternatives are increasing as the value increase/decrease comes both from investments and returns.

Table 9: Baseline model 2 using log size of alternatives as a dependent variable

Log size of alternatives	Model 1	Model 2	Model 3	Model 4	Model 5
$Yield_t$	6,218	-0,5927	-1,061	-0,9367	-0,1756
	(3,812)	(3,075)	(3,097)	(3,048)	(3,359)
Complex		0,1738**	0,1523**	0,1514**	0,1610**
		(0,0719)	(0,0705)	(0,0696)	(0,0684)
Size(log)		1,092***	1,109***	1,110***	1,166***
		(0,1919)	(0,1912)	(0,1922)	(0,1950)
DB			-0,6397***	-0,6427***	
			(0,0611)	(0,0592)	
Domestic volatility			-0,0418		
			(0,1030)		
Active					1,672**
					(0,7483)
Fixed effects					
Fund	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	by: Fund	by: Fund	by: Fund	by: Fund	by: Fund
R^2	0,79584	0,80827	0,80886	0,80886	0,80978
Observations	485	485	485	485	443

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

We start by simply regressing alternatives on yield. In contrast to the benchmark model in table 8 above, the coefficient is now positive, but not significant. The model fails to estimate the relationship due to few variables, so we move on.

As before, we add explanatory variables to the regression in model 2,3,4 and 5. The coefficient for yield is now negative and insignificant. The coefficient for complex investors, Size, DB, Active and domestic volatility have not changed in significance and sign compared to the baseline model. Log size increased in significance, which is not very surprising given that the size of the fund determines the alternative size.

7.2.2 Model with last year's interest rate

As discussed in the previous section, interest rates do not appear to have an important impact on the allocation of resources to alternatives at first glance. However, since the results are quite unexpected, we believe something else is responsible for these results. As we discussed in relation to alternative assets in chapter 3, this is a large asset class with many different options, each of which is unique. Despite this, almost all of them have one thing in common. They are either illiquid or extremely illiquid. As a result, it can be argued that trading of these assets should be infrequent due to their illiquidity, as investors must hold them to gain the illiquidity premium. Thus, a passive investment strategy should be more compatible. Since, in general, illiquid assets, which are traded before full maturity or possibly earlier, might have prices well below the expected maturity value and can even accrue losses. As we mentioned before, like in the case of private equity, the returns are often described by the J-curve. Meaning that for the first years of the investment, returns after costs can be negative due to institutional and management fees. Also, transactions costs can be high, making early sales, for example with real estate, potentially incur losses.

One might question how this can be accounted for in the model. In our opinion, the answer may lie in the strategic asset allocation of the funds, which is predetermined at the beginning of each year. When estimating future allocations, the funds must consider future investment returns, while also pay attention to liquidity and the age of the members of the fund. As more and more people approach retirement age, the risk should be reduced due to how soon benefits will begin to flow from the fund. This is easier for DC funds, since they can split their members different investment pots, whereas DB pools members. With that being said, it is probable that when the fund makes such estimates, they recognize past interest rates, as well as projected interest rates in the future. It therefore makes intuitive sense to examine the yield of the prior year, since when fund managers/board members construct their proposed allocation for next year, it will play a significant role.

Results of the alternative model are provided in table 10, with the same variables as before, excluding yield, which has been lagged one year.

Table 10: Alternative model using alternative assets as percentage a dependent variable

Alternative assets %	Model 1	Model 2	Model 3	Model 4	Model 5
$Yield_{t-1}$	-0,4434 (0,5857)	-0,8816* (0,4712)	-0,8867* (0,4796)	-0,9544** (0,4597)	-0,9920** (0,4579)
Complex		0,0244** (0,0095)	0,0221** (0,0094)	0,0215** (0,0094)	0,0228** (0,0059)
Size(log)		0,0240** (0,0102)	0,0247** (0,0101)	0,0249** (0,0101)	0,0194* (0,0107)
DB			-0,0726*** (0,089)	-0,0747*** (0,0089)	
Domestic volatility			-0,0156 (0,0184)		
Active					0,2828** (0,1427)
Fixed effects					
Fund	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,75389	0,77190	0,77560	0,77511	0,77557
Observations	485	485	485	485	443

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

When compared with the baseline model, most of the variables have the same significance and sign. Yet, the variable of interest, yield, becomes significant when last year's interest rates are considered. Confirming our suspicion of the relationship between passive investment strategies and the strategic asset allocation. Meaning that, prior interest rates affect the strategic asset allocation, which then impacts the actual allocation. As investing in alternative investments is generally a lengthy and complicated process, most often with high trading costs, it can be stated that investment opportunities in alternative investments are located, if the asset allocation strategy suggests it, and then executed. Since active trading is uncommon, the unlagged yield variable is unable to catch the effects of lower interest rates, as decision regarding alternatives is primarily based on long-term planning. That means for periods in which the interest rate is going up, which it does in some cases, the funds do not react by selling. Surely this can be very different among funds but looking at the standard errors of two models, a pattern emerges. Where the standard errors of yield are higher than of $yield_{t-1}$.

This indicates that reactions to yearly changes in interest rates show a greater degree of variability, and that funds who have already invested in an alternative asset might not sell it if interest rates rise, as theory predicts.

Like before, we explore how the model responds when changing the dependent variable from alternatives as a percentage to its log size. In table 11 the results from that regression are shown. The coefficient for the lagged value of yield is significant and negative, indicating that alternatives increase in size on average as last year's interest rates decline. This further strengthens our hypothesis that alternatives are passive investments. As for other variables, not much has changed in principle.

Table 11: Alternative model using log size of alternatives as a dependent variable

Log size of alternatives	Model 1	Model 2	Model 3	Model 4	Model 5
$Yield_{t-1}$	8,396* (4,478)	-6,489** (2,857)	-6,792** (2,852)	-6,830** (2,824)	-7,491** (2,821)
Complex		0,1760** (0,0738)	0,1534** (0,0722)	0,1530*** (0,0714)	0,1635* (0,0707)
Size(log)		0,2790*** (0,0863)	0,2820*** (0,0822)	0,2848*** (0,0867)	0,2736*** (0,0868)
DB			-0,6545*** (0,0617)	-0,6564*** (0,0591)	
Domestic volatility			-0,0229 (0,1023)		
Active					1,683** (0,7226)
Fixed effects					
Fund	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,79655	0,79982	0,80032	0,80020	0,80023
Observations	485	485	485	485	443

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

7.2.3 Do Dutch funds affect the results?

The descriptive statistics in chapter 7.1 showed that over time, funds in The Netherlands allocated less to alternatives over the 11-years, while the other three countries increased their allocation. It is quite interesting to investigate whether the possible decrease in the Netherlands may cancel out the increase in other countries when interest rates decrease. If such scenario is the case, one would expect different results from the regression when dropping the Netherlands from

the sample. The following regressions in table 12 show the baseline and alternative model with the full sample and then without the Netherlands, first with long term interest rates and then lagged long term interest rates.

Table 12: Baseline model regression excluding the Netherlands

Alternative assets %	(1) All countries	(2) All countries	(3) Restricted sample	(4) Restricted sample
$Yield_t$	-0,3362 (0,5608)	-0,4068 (0,4345)	-0,4374 (0,666)	-0,6235 (0,6992)
Complex	0,0237*** (0,0097)	0,0246** (0,0098)	0,0226* (0,0125)	0,0270* (0,0145)
Size(log)	0,0241*** (0,0107)	0,0182* (0,0110)	0,0291** (0,0132)	0,0258** (0,0136)
DB	-0,0737*** (0,0092)		-0,0708*** (0,0107)	
Active		0,2936** (0,1425)		0,1996** (0,0807)
Fixed effects				
Fund	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
S.E. Clustered	by: Fund	by: Fund	by: Fund	by: Fund
R^2	0,77048	0,77223	0,70388	0,67571
Observations	485	443	342	300
Alternative assets %	(1) All countries	(2) All countries	(3) Restricted sample	(4) Restricted sample
$Yield_{t-1}$	-0,9544** (0,4597)	-0,9920** (0,457)	-1,119** (0,4296)	-1,211*** (0,4366)
Complex	0,0215** (0,0094)	0,0228** (0,0059)	0,0223* (0,0124)	0,0270* (0,0143)
Size(log)	0,0249** (0,0102)	0,0194* (0,0107)	0,0292** (0,0124)	0,0268** (0,0128)
DB	-0,0747*** (0,0089)		-0,0714*** (0,0104)	
Active		0,2828** (0,1427)		0,1933** (0,0795)
Fixed effects				
Fund	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,77519	0,77557	0,70756	0,67996
Observations	485	443	342	300

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

First thing that we observe is that the Yield coefficient becomes more negative when excluding data from The Netherlands, but the standard errors rise as well. Meaning that, the effect of lower interest rates on allocation towards alternatives increases, but also how the funds react (higher variation). The coefficient for yield is still insignificant.

The increased negativity is to be expected since DC funds have higher flexibility in investments when interest rates are lower and most of the DB datapoints in the sample were removed (143 out of 204).

The Complex coefficient loses some significance and drops in overall value. We believe the reason to be that many of the Dutch funds increased their holdings in fixed income above 60% while interest rates went down. For example, ING (Dutch pension fund) went from 55% in 2011 to 63% in 2013 and 76% in 2020. This makes the model define them as a non-complex investor

The second part of the table includes the lagged yield and as before, the coefficient for last year's yield becomes more negative. However, now the standard errors decrease, instead of increasing like before. The significance level mostly stays the same among the variables. The DB variable remains significant, pointing towards that DB funds outside The Netherlands are also allocating less to Alternatives on average compared to DC funds. We believe this confirms our belief that DC pension funds have a greater flexibility to adapt to changes in interest rates and allocate more to alternatives when interest rates are lower compared to DB schemes.

7.2.4 Some insight on the policy allocation

To give some insight on the policy allocation, we take a closer look at the investment policy of two funds. One from Iceland (LIVE) and another from the Netherlands (BPL).

When formulating its investment policy, LIVE looks at how to improve the interplay between return and the risk of its portfolio by using a strategic asset allocation. That is performed by considering pension obligations, legal restrictions, and investment opportunities. Similarly, the fund analyzes what returns and risks can be expected from the major asset classes, as well as assumptions about the relationship between asset class returns. As a result, the fund's assets are sufficiently diversified to prevent undesirable concentration and accumulation of risk in its portfolio. The fund states that asset management can be passive or active. Where passive management seeks to achieve market returns, while active management seeks to deliver returns higher than the benchmark (market). Passive management is applied when investments are regarded as long term and the frequency of transactions is limited within a portfolio, which in return, result in lower transaction costs. Whereas active management provides an opportunity to achieve returns in excess of the market's average return, considering costs and risks. The frequency of trading in active management varies depending on the nature of the asset class in which the

investment is made. Private debt, a type of alternative, is an example where passive management is used, while active management is rather applied to asset classes such as listed equities. Whether the management is passive or active, there is always a certain criteria that must be met in terms of expected returns, standard deviation, covariances, and the development of the fund's pension liabilities, which must be weighed and assessed (LIVE, 2021).

The investment policy of BPL describes how the policy allocation is computed after an asset liability management (ALM) study is completed. Using a variety of different scenarios, the ALM calculates how the fund's financial position is likely to evolve over time. As a long-term investor, BPL mentions that it invests for the long term, rather than attempting to beat the market in the short term. Their point is that success should not be compared to the performance of financial markets in the short term. Additionally, they point out that their investments in alternatives are ideal for a passive investment strategy, since they are illiquid, resulting in higher expected returns (BplPensioen, 2017).

Unfortunately, neither Danish nor Australian funds offer any insights into their active or passive investment strategies when it comes to alternatives. But to get some idea on the intuition the following quote can be found on Australian Super website regarding investments, which strongly suggests that alternatives are managed passively.

> *The longer-term investment outlook for unlisted assets is aligned with the long-term nature of superannuation funds. Unlisted infrastructure, property and private equity investments are generally held for the long-term. This helps asset owners and government bodies to make decisions to improve the long-term value of unlisted assets. In contrast, listed boards can sometimes be pressured into making shorter term decisions – to meet shareholder expectations – which can affect long-term value. (AustralianSuper, 2021, page. 2)*

7.3 Robustness checks

7.3.1 Possible endogeneity

To assess the robustness of the findings, a series of tests are conducted. There are roughly three categories of potential problems that could influence the validity of our results. First, there may be issues related to endogeneity at any given point in time. If at any time t, where the independent variables are correlated with the idiosyncratic error term, the model will suffer from omitted variable bias. Second is intertemporal endogeneity, which can also skew the results if any of the

independent variables at a particular time point, say t_{+3}, are correlated with the idiosyncratic error term. In that case the assumption of strict exogeneity of the independent variables will be false, making the fixed effects estimate incoherent. Lastly there are potential problems related to sampling. If the results are highly dependent on the inclusion of a subset of the sample, for example one country with a large variation within a given variable, the results will be of little value.

One way to reduce the effects of endogeneity is to use fixed effects, but it is nevertheless useful to check whether our results are robust and our assumptions of exogeneity holds. One method to do that is to add additional variables to the model and test whether these variables change our findings. If the results end up being the same as before, we can assume that endogeneity is not a problem.

Factors affecting long term nominal interest rates is easily something that can be the focus of another thesis. Generally, real long-term interest rates tend to move together in different countries due to the existence of global financial markets. However, nominal long-term rates reflect inflationary expectations in individual economies, which in turn reflect the credibility of national monetary policy. Exchange rate expectations are closely related to inflationary expectations; however, exchange rate movements can also occur for reasons unrelated to inflation differentials. Therefore, it is not straightforward to determine how changes in short-term interest rate affect long-term interest rates. An increase in short-term rates can lead to, or coincide with, an increase in long-term rates, but the long-term rates can also decline if the markets are convinced that future inflation has been prevented (European Parliament, 2001).

Since higher inflation expectations lead to higher nominal interest rates, one would expect that as the expectations of future and current inflation gets higher, the yield gets higher, and allocation to alternatives decreases. By ignoring this variable, we run the risk of it being included in the error term and biasing our estimates of market interest rates. Because this data is based on inflation forecasts there is still a possibility of some measurement errors, so to see if we get similar results, we test normal inflation as well. Data was therefore collected from OECD for inflation and forecasted inflation for the 11-year period.

Secondly, we considered changes in the risk premium of the 10-year yields. Based on Ferri, Liu, and Majnoni (2000), we estimate crudely the risk premium from S&P sovereign debt credit and include it as an explanatory variable in the regressions. As a higher credit rating lowers the likelihood of defaulting on debt, it should lead to lower risk premia and lower interest rates.

Lastly, we consider the active variable as countries with older populations will likely have a lower number of active participations. Even though the percentage of active members differs between funds, we decided to include the dependency ratio of each country, which gives insight to the ratio of working-age to non-working age people. Because the age distribution may vary among the countries in which the funds operate, it can affect the percentage of active members.

Table 13 13 Robustness check for current yield

Alternative assets %	Original Model	Robustness check (1)	Robustness check (2)	Robustness check (3)	Original model (2)	Robustness check (4)
	-0,3362	-0,4829	-0,5519	-0,5509	-0,4068	-0,5664
$Yield_t$	(0,5608)	(0,5288)	(0,5153)	(0,5165)	(0,4345)	(0,5986)
	0,0237***	0,0215***	0,0214**	0,0212**	0,0262**	0,02386**
Complex	(0,0097)	(0,0093)	(0,0092)	(0,0090)	(0,0062)	(0,00102)
	0,0241***	0,0235***	0,0236***	0,0234***	0,0182**	0,0151*
Size(log)	(0,0107)	(0,0105)	(0,0106)	(0,0105)	(0,0110)	(0,0110)
	-0,0737***	-0,0739***	-0,0741***	-0,0744***		
DB	(0,00568)	(0,0089)	(0,0088)	(0,0097)		
Inflation forecast		-0,6533** (0,2991)				
			-0,7386**	-0,7272**		
Inflation			(0,3503)	(0,3295)		
				0,0005		
Credit rating				(0,0009)		
						-1,289
Dependency						(1,160)
					0,2936**	0,2462**
Active					(0,0859)	(0,1121)
Fixed effects						
Fund	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,77048	0,77371	0,77396	0,77396	0,77394	0,77556
Observations	485	485	485	485	435	435

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

The results for the baseline model are shown in table 13, followed by models where variables are added to see if we have any omitted variable bias in the yield. We observe that the coefficient for yield is increasing, and almost doubles when actual inflation is included. In addition to that, the standard errors decrease, but the yield is still very far from being significant. Pointing to the fact that there does not seem to be a problem of omitted bias related to the yield. Same goes for the active variable, where the coefficient gets smaller, standard errors increase, but there is no change in significance.

Table 14 14 Robustness check for lagged yield

Alternative assets %	Original Model	Robustness check (1)	Robustness check (2)	Robustness check (3)	Original model	Robustness check (4)
$Yield_{t-1}$	-0,9544**	-0,9096*	-0,9938**	-0,9916**	-0,9920**	-1,054*
	(0,4597)	(0,4599)	(0,3723)	(0,3320)	(0,457)	(0,5642)
Complex	0,0215**	0,0220**	0,0214**	0,0230**	0,0228**	0,0245**
	(0,0094)	(0,0093)	(0,0090)	(0,0087)	(0,0059)	(0,0104)
Size(log)	0,0249**	0,0214**	0,0230**	0,0230**	0,0194*	0,0168*
	(0,0102)	(0,0055)	(0,0056)	(0,0056)	(0,0107)	(0,0106)
DB	-0,0747***	-0,0736***	-0,0755***	-0,0755***		
	(0,0089)	(0,0089)	(0,0089)	(0,0089)		
Inflation forecast$_{t-1}$		-0,1595				
		(0,7438)				
$Inflation_{t-1}$			-0,7808**	-0,7462**		
			(0,370)	(0,3570)		
Credit rating$_{t-1}$				0,0003		
				(0,0009)		
Dependency						-1,547
						(1,188)
Active					0,2828**	0,2378*
					(0,1427)	(0,134)
Fixed effects						
Fund	Yes	Yes	Yes	Yes	Yes	Yes
Year	Yes	Yes	Yes	Yes	Yes	Yes
S.E. Clustered	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund	By: Fund
R^2	0,77519	0,77552	0,772166	0,77550	0,77557	0,77772
Observations	485	485	485	485	435	435

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

In table 14 we see the results of the alternative model, where the forecasted inflation did not impact other variables, but slightly decreased the coefficient for the yield from last year. Since yields have now been lagged the inflation forecast follows, to match the analysis. Next up is the inflation of last year, which increases the lagged yield coefficient slightly and reduces the standard errors. However other changes are very small and significance levels stay the same. By adding the credit rating variable from last year, the standard errors change slightly, and the magnitudes are almost the same. Lastly, by adding the dependency ratio, the standard errors decrease slightly while the coefficient also decreases, but it remains significant at the 10% level.

Therefore, we conclude that the model does not have any, or very limited omitted variable bias.

7.3.2 Sample size robustness

Next, we test the robustness of the sample too see if the results are different with certain sample restrictions. In figure 13 from chapter 7.1, where the share of alternatives is plotted across different funds, we noticed that there was a lot of variability in the allocation among funds, with some close to 45% and others less than 5%.

The intuition is that by removing the pension funds with the highest and lowest allocation to alternatives, we can determine if this trend of increasing alternatives in lower interest rates prevails in more widespread sense. Pension funds that allocate a small fraction to alternatives over the period might for example have different investment preferences with regard to risk than those who allocate somewhere in the mean of the sample (19,87%). It works the other way around as funds with higher risk preferences may increase the share of alternatives as interest rates fall. Further, it could be the case that funds that allocate less to alternatives are experiencing liquidity strains. Therefore, they are unable to increase their investments in that category. Same goes for funds that already have a large fraction (over 40%) of their portfolio, where raising the percentage would have implications on liquidity.

Figure 15 shows the different sample sizes under restriction. Across the full sample, there are tails on both sides of the allocation distribution, with some funds allocating over 45% and some less than 5% to alternatives as noted before. The first restriction is based on 90% of the total sample with the top 5% and bottom 5% omitted, seen in the middle. The second sample constraint is based on 80% of the original sample with 10% on each side removed. Table 15 summarizes the findings, with the first two columns containing the original model, and the rest with restrictions.

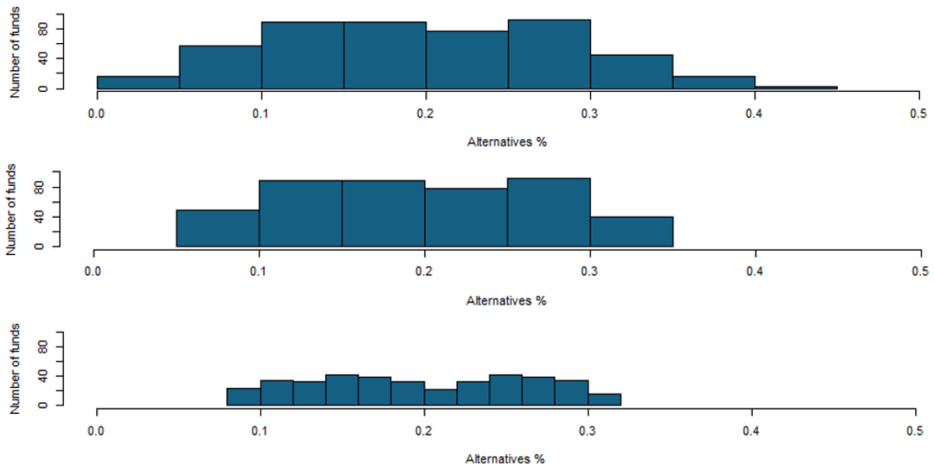


Figure 15 15 Sample size robustness check

Table 15 Sample size robustness check15

Alternative assets %	Baseline model (1)	Baseline model (2)	90% (1)	90% (2)	80% (1)	80% (2)
$Yield_t$	-0,3362	-0,4068	-0,2810	-0,3668	-0,1634	-0,2913
	(0,5608)	(0,4345)	(0,4619)	(0,4511)	(0,4896)	(0,4788)
Complex	0,0237***	0,0246***	0,0219**	0,0226**	0,0202*	0,02011*
	(0,0097)	(0,0098)	(0,0092)	(0,0094)	(0,0104)	(0,0118)
Size(log)	0,0241***	0,0182*	0,0259	0,0198	0,0275	0,02049
	(0,0107)	(0,110)	(0,0204)	(0,0201)	(0,0223)	(0,0206)
DB	-0,0737***		-0,0774***		-0,0869***	
	(0,0092)		(0,0089)		(0,0109)	
Active		0,2936**		0,2947**		0,2545**
		(0,0859)		(0,1273)		(0,1117)
R^2	0,77048	0,77223	0,73244	0,74915	0,74801	0,76911
Observations	485	443	435	399	386	351
Alternative assets %	Baseline model (1)	Baseline model (2)	90% (1)	90% (2)	80% (1)	80% (2)
$Yield_{t-1}$	-0,9544**	-0,9920**	-0,8949 *	-0,9487**	-1,180**	-1,194**
	(0,4597)	(0,457)	(0,4880)	(0,4772)	(0,4448)	(0,4564)
Complex	0,0215**	0,0228**	0,0204**	0,0214**	0,0196*	0,0206*
	(0,0094)	(0,0059)	(0,0089)	(0,0093)	(0,0103)	(0,0102)
Size(log)	0,0249**	0,0194*	0,0259	0,0238	0,0270	0,0247
	(0,0102)	(0,0107)	(0,0203)	(0,0201)	(0,0215)	(0,0212)
DB	-0,0747***		-0,0788***		-0,0868***	
	(0,0089)		(0,0086)		(0,0108)	
Active		0,2828**		0,2944**		0,2516**
		(0,1427)		(0,1260)		(0,1148)
R^2	0,77519	0,77557	0,73697	0,75354	0,75500	0,77494
Observations	485	443	435	399	386	351

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

Table 15 shows that although the coefficient for $yield_{t-1}$ changes somewhat with the whole sample, the broad patterns remain the same. When past yields are lower, pension funds increase their allocation to alternatives. The current yields remain insignificant, with a lower coefficient and a higher standard error. The size variable loses its significance, with the standard errors almost doubling. As predicted by the model, larger funds invest more in alternatives on average. Thus, by removing the largest and smallest funds the variable loses its predictability. This is evident in the standard errors of size, where they almost double when we exclude 10% of the sample, but the change is much less drastic when moving from 90% of the sample to 80%.

7.4 Summary and overview of results

Throughout this chapter we have examined the relationship between interest rates and allocation to alternative assets among pension funds in the world's highest rated pension systems. Using fixed effects estimation for data collected from the annual reports of 50 pension funds, from four countries during the period 2010 to 2020, we demonstrate that lower interest rates lead to an increase in alternative asset allocation, both when it comes to the amount invested but also as a fraction of assets under management. We also demonstrated that depending on the type of occupational scheme, the allocation will differ, meaning funds that guarantee future pension benefits tend to allocate less to alternative assets in lower interest environment. Thirdly, we confirmed the hypothesis that pension funds who take advantage of asset distribution invest more in alternatives. Finally, we showed that when the proportion of active participant who actively contribute to the fund goes up, more is invested in alternatives.

For domestic volatility we are not able to accept the hypothesis that increased volatility on domestic equity markets leads to higher allocation in alternatives. The model estimates that as volatility on global stock prices goes up, pension funds decrease their investments in alternatives, but the coefficient is not significant. One reason might be that pension funds invest in international markets to spread the risk in their portfolio. These investments are intended for a long time and have yielded a generous return over the course of the years. Even though the funds are aware international equities can fluctuate in price they tend to rise over medium to long term horizon. If the volatility can be explained by a positive fluctuation which has been the case for the years covered in this thesis that means, ceteris paribus, other variables in the balance sheet are decreasing as a percentage of the portfolio.

8. Discussion

In accordance with our research question, we examined how changes in interest rates affect the investments in alternative assets. We also examined how fund characteristics impact allocations and investments, that is the different size, different member structure and what type of occupational scheme the fund is running. To put our findings into context, in this chapter we outline the implications and changes this can have in the future. Further, we present our findings in light of previous research and discuss the limitations of our study.

8.1 Times are changing

In Chapter 7, we have shown that lower interest rates lead to an increase in the allocation of alternatives. Additionally, we observed differences in the allocation, depending on whether the occupational scheme was a DB or DC. With lower allocation percentages towards alternatives in DB. We argue that DB funds have more sensitivity on the pension liability side, and therefore allocate more of its investments into long term bonds, or swaps. The reason is that low interest rates (market rates) increase the present value of future liabilities. Because of low interest rates and increased longevity, many funds in The Netherlands have struggled to maintain their funding ratio, that is, being able to settle all current and future pension liabilities. Reforms had to be made, which were approved in 2019, and are expected to begin in 2023. That means the Netherlands will move away from DB to a fully funded DC scheme in the future. The shift is bound to affect how the Dutch funds invest. By implementing a DC scheme, the funds are relieved of the guaranteed pension benefits, which means that the interest rate sensitivity will steadily decline over time. Thus, their investment options become more flexible. Due to its size on the bond market (75% of all European bonds held by occupational pension funds in 2020), the change is also expected to impact future investments in fixed income securities, at least in Europe. How the Dutch funds will allocate their investments once the shift towards DC is complete is hard to tell but putting the timing of it into perspective might give some ideas.

Between 2010-2021, the S&P 500 index grew approximately by 312% (Yahoo Finance, n.d), which by itself does not tell investors much, other than the value of the assets has grown. But how are the assets priced and is the price likely to keep rising, resulting in higher returns if held for the long run? Or is it possible that the market is overpriced? One estimate that has been mentioned when trying to compare stock prices historically to see if they are overvalued, is by comparing the p/e ratio of an index or individual stocks historically.

The p/e ratio, or the price earnings ratio divides the stock price by the earnings of the company, therefore a higher ratio means that the stock/index price is high, relative to the earnings of the that particular investment. The intuition is that as the ratio is higher, the likelihood of the stock being "overvalued" is higher.

As of December 2021, this ratio for the S&P 500 was 39.98, compared to 22.4 in December 2010. To put these numbers into perspective the p/e ratio was around 43 when the dot.com bubble burst in 2000 (Nasdaq, n.d). Without sounding too dramatic, this is something that the Dutch funds might want to consider when planning their new policy future allocation and deciding how much to allocate to equities. In chapter 1 we saw that in 2020 the Dutch system had 31% of total assets in equity, 47% in fixed income and 19% in other assets, noting that unallocated insurance contracts and derivatives are also included in the 19%. As a result, there is ample room them expand their allocation of alternatives in the future. The impact on future demand for alternative assets should be felt, at least in European markets, due to the sheer size of the Dutch system (2.060.775 USD million).

Another potential factor that can impact future demand of alternatives is the rising popularity of ESG investing, that is investment that prioritizes environmental, social, and governance factors. ESG investing is generally regarded as a way of investing sustainably, where investments are made with consideration of the environment and human welfare, as well as economic performance. It is based on the growing assumption that environmental and social factors are increasingly affecting financial performance of organizations (Daugaard, 2020).

The rising popularity of ESG investing can be related to the debate on global warming, which should not have gone unnoticed. At the United Nations Climate Conference which took place in Glasgow in 2021 an agreement to increase investments in environmentally friendly assets was announced among Nordic and UK pension funds. At the council, the pension funds made a commitment to allocate 130 billion USD to clean and renewable energy in total until 2030, with the aim of supporting and accelerating green transition by establishing a wave of socially responsible investment.

The best way to put the numbers into context and get an understanding of what this means for the pension funds is to give an example. In Denmark, the pension funds have committed to allocate 55 billion USD until 2030, where total assets of the system in 2020 were 888,2 billion USD. Their counterparts from Iceland have pledged to increase their investments in green energy investments

by 5,4 billion USD throughout the decade where assets in 2020 were 88,2 billion USD. Although initially they may not appear to be significant, they represent future commitments based on large uncertainties regarding future markets. It is very likely that these investments will find their way to a large extent into unlisted instruments as the commitment is both made up of listed and unlisted equity investments, infrastructure as well as green bonds and debt (Climate Investment Coalition, 2021).

Another potential future factor that can impact the demand for alternatives is the increased emphasis on portfolios having net zero emissions. According to Aviva Investor´s real asset study (2021), 50% of pension funds have committed to ensuring that their portfolios are net-zero emissions by 2050. Moreover, 67% of pension funds have made a net zero commitment, which represents a 20% increase from the last year. As the report acknowledges, achieving such targets is not easy. One of the major obstacles is the growing popularity of infrastructure as a stable investment choice and the lack of supply.

8.1.1 From Russia with love

On the 24th of February in 2022, Russia invaded Ukraine. Following that, the European Union reacted by imposing sanctions on imports and exports of Russian goods.

The largest exporting good in Russia is natural gas, which is used to produce electricity. In 2021, the European Union imported 155 billion cubic meters of natural gas from Russia. This accounts for around 45% of its total gas imports and close to 40% of its consumption in the area. As the European Union is already moving towards net zero ambitions, it is trying to gradually reduce consumption and imports of gas, but how the conflict in Ukraine impacts the pace of change is unclear (IEA, 2022).

As a result of Russia´s invasion of Ukraine, the European Union proposed on the 8th of march 2022, an outline of a plan, labelled RepowerEU, to make Europe independent from Russian fossil fuels by 2030**,** starting with gas (EC, 2022).

Therefore, countries like Germany, Italy, and The Netherlands which are dependent on Russian gas to some extent must make large investments in infrastructure, given that they do not switch to other fossil fuels, which contradicts the net zero ambitions.

The amount of potential infrastructure investments in those countries should therefore be substantial in the coming years. This potential supply of future investments fits the demand for

alternatives, considering the COP26 commitment and the change in the occupational Dutch pension system if interest rates remain low.

8.2 Results compared to prior research and limits

This thesis was heavily influenced by Defau and Moor (2020), who concluded that pension funds invested more in alternatives when interest rates were higher. To the best of our knowledge, and theirs, this is something that has not been researched empirically before, so the results of their paper came as a big surprise, given that it goes against dominant theories in the field. That is that pension funds invest more in alternatives when interest rates are lower. Their conclusions are based on the current yield, but not from last years like in our case, meaning that the pension funds showed active management behavior over the years. Since their dataset is more detailed with respect to individual asset classes, they can distinguish the effects of interest rate changes on real assets, private equity, and hedge funds. The only asset class which showed significance was hedge funds, with a 99% significance level whereas the other two categories were insignificant. As we mentioned in chapter 3, hedge funds are usually with an open-ended structure making active management of such assets possible. Since it is the only significant coefficient with regards to current interest rates it suggests that it is the only alternative class that is traded actively. This can also be partially explained by the popularity of hedge funds in the US compared to Europe and Australia, since the majority of their data was gathered from the US.

We also found that DB funds allocate less to alternatives on average, which an overwhelming percentage of the dataset used by Defau & De Moor was based upon. Therefore, it is not inconceivable that we would have obtained similar results if we had included a larger proportion of DB funds in our sample. Even though we came to the opposite conclusion, they are still intuitively the same.

While this study provided robust results in support of our hypothesis, it does not come without its limitations. Most of our study originates from data taken from the annual reports of 50 various pension funds from four separate countries. Although each asset class was meticulously examined, allocations to different asset classes had to be made which are subject to error. To reduce the risk of error, we created a document which contained all the different asset classes and their subcategories that would normally appear in an annual report. Among the examples of this would be bank deposits, which we allocated to other assets and infrastructure, which we placed in the

alternative category of assets. For Denmark and Iceland there was complete synergy among the funds in each respective country, as the data was prepared in the exact same way. The reporting of Australia and the Netherlands varied a lot, with some funds providing a lot of information while others were less explicit. In the process, there were often many details to work through, increasing the possibility of a calculation error. To minimize the possibility of that happening, we carried out our work in the following way: Each researcher collected half of the data, and then oversaw the data that the other researcher collected.

A pension fund's investment allocation decision regarding alternative investments has many factors influencing it and is a complicated process. As a result, it is likely that our model did not capture all the effects. There is therefore a potential omitted variable bias present, which could lead to incorrect conclusions from hypotheses tests. By using the fixed effects method for estimation, we believe that we minimized the risk of the omitted variable bias. In addition, our model passed the robustness tests with factors we believed that could have impacted the model. Furthermore, given that we find higher allocation to alternative assets in low interest environments, our research would greatly benefit from a better differentiation between the alternative asset categories. By doing so, we would be able to make inferences about individual asset classes, for example, whether real estate has increased more in high inflation times than private equity funds or where the funds are more likely to hedge inflation risk. Unfortunately, due to lack of data, we are not able to tell.

In addition to that, we would have benefitted from including some survey data from the pension funds regarding the relationship between the policy allocation and interest rates. From there we could have gained more insight into their perspectives and verified fully that most of their alternatives, which are not hedge funds, are not actively traded. Since our results, which were unexpected at first, came at a late stage of the thesis, the attempt to carry out such survey was unfortunately thwarted due to time.

Finally, there is the issue of information about the policy allocation. It is caused by lack of data and sometimes poor-quality information regarding how the funds allocate their investments prior to the investment year. As an example, there are some Icelandic funds which provide information on allocations. However, they only provide insight into asset categories, such as stocks and bonds but do not disclose if they are listed or not. In an ideal world, we would also be able to estimate the relationship between the policy allocation and interest rates to further strengthen our results of

passive management of alternatives but also determine if interest rates were biasing our results, since they affect the valuation of assets on the balance sheet and therefore the allocation percentage.

9. Conclusion

In this thesis we investigated the relationship between changing interest rates and allocation to alternative investments among pension funds. Previous research conducted by Defau & De Moor (2020) showed that a positive relationship exists, namely that higher interest rates lead to more investment in alternatives for pension funds. Since they only analyzed alternatives as a fraction of assets under management it is unclear whether the change was due to actual increase in alternatives or due to relative changes in the portfolio.

Using data for 50 pension funds in four different countries for the period 2010-2020 we analyzed the asset allocation with a particular emphasis on non-traditional assets. By building a fixed effect model we found evidence that a fall in long term nominal interest rates, leads to an increase in alternatives, both in amounts and as a fraction of total assets under management, opposite to the findings of Defau and De Moor.

Even though interest rates are a key component when investing in alternatives, there are other factors at work as well. The different asset classes within alternatives generally have the common feature of being illiquid and traded infrequently. Our study found that current nominal long term rates did not have a significant relationship with alternatives. However, by looking at the interest rate of the previous period, a significant relationship emerged. A result that rhymes well with the illiquid characteristics of alternatives and indicates that pension funds consider this type of investment long-term, where passive investment management is more suitable.

The benefits of alternative investments to pension plans include the ability to generate stable cash flows while at the same time having low correlation with traditional investments such as listed stocks and bonds. Asset diversification plays a key role when pension funds build their investment strategies and vast majority of the funds in our sample distribute their assets well over different categories. Since alternatives are long term investments with higher expected returns than liquid assets, due to the illiquidity premium, they are an appealing option to pension funds that have constant capital inflows and a great need for new investments. In low interest rate environment where bonds become less attractive to investors, including alternatives in the portfolio can boost their returns over the medium and long-term horizon, while reducing the volatility at the same time.

Our results also showed that there is a difference between the two occupational schemes when it comes to how much they allocate to alternatives on average. With DC funds allocating more to

alternatives in times of lower interest rates. This raises the question of how the transition of the largest DB scheme in Europe, The Netherlands, to DC will affect the demand for alternatives in the future if interest rates remain low.

This thesis analyzed how alternatives developed from 2010-2020 which was characterized by a downward trend in interest rates where alternatives become more prevalent in pension funds. The future may hold a number of uncertainties. Is it plausible to assume that diversification arguments, together with the increasing popularity of ESG, will outweigh the effects of interest rate changes in the future? At this point in time, it is hard to predict, but future researchers may extend our ideas with new methodologies, over a longer period of time to further expand the knowledge in the field.

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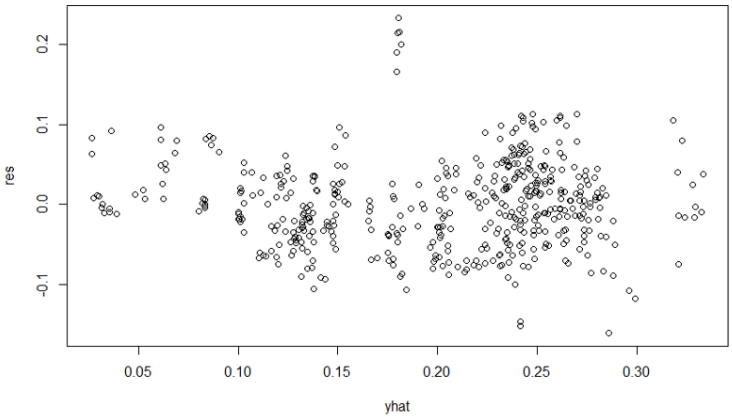
Appendix

Original OLS estimation

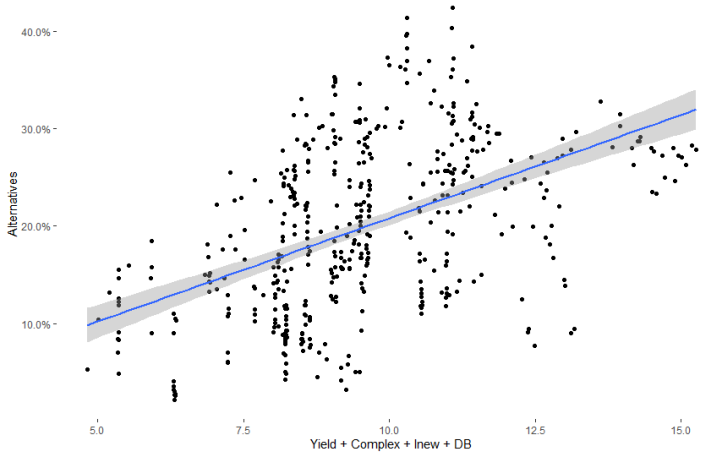
	Alternative assets %
$Yield_t$	-0,392* (0,177511)
Complex	0,062*** (0,0,007302)
Log size	0,016*** (0,002383)
DB	-0,051*** (0,006748)
R^2	0,6095
Observations	485
BIC	-1.595,8

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.

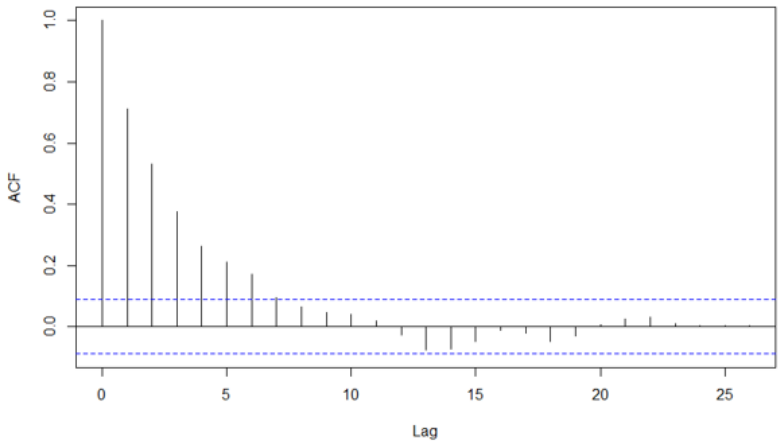
OLS residuals:



Plot of the OLS regression



ACF of OLS



FD estimations:

	Alternative assets %	
	Model 1	Model 2
$Yield_t$	-0,30732 (0,33704)	
$Yield_{t-1}$		-0,73022** (0,3712)
Complex	0,019240* (0,011502)	0,019228* (0,011498)
Log size	0,021217** (0,010102)	0,021198** (0,010871)
DB	-0,05884** (0,02838)	-0,05794** (0,02856)
R^2	0,17288	0,18234
Observations	435	435

Note: SEs are reported in parentheses. *, **, and *** indicate statistical significance at the 10, 5, and 1% levels, respectively.