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The Effect of the Recent Financial Crisis on Defined Benefit Pension Funds' Asset Allocation

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The Effect of the Recent Financial Crisis on Defined Benefit Pension Funds' Asset Allocation

by
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Chapter 1: Introduction and problem formulation

§1.1 Introduction

What is the effect of the recent financial crisis on DB pension funds' asset allocation? That is the central research question of this thesis. In the current harsh financial times, a large amount of pension funds struggle to meet their liabilities, leaving younger generations in uncertainty about their pensions. Most defined benefit pension funds are underfunded, having fewer assets than what is promised, despite the fact that the valuation of these liabilities is often severely underestimated. (Novy-Marx & Rauh, 2011). Apart from being confronted with financial crises, pension funds have been under tightening regulation, a maturing participant base, decreasing treasury yields and increasing demands for transparency and accountability (Andonov et al., 2012).

Optimal asset allocation is a key factor in realizing expected returns. Pennacchi & Rastad (2011) find that state pension plans gamble their portfolio returns by investing in riskier portfolios in times of poor investment performance. Also, Blake et al. (1999) prove that changes in aggregate portfolio weights are either caused by differential returns, or by shifts in net cash flows across asset classes. Shifts due to the first component arise from a passive investment strategy of buy-and-hold, contrary to the second component which focuses on an active strategy of rebalancing the portfolio by redirecting cash flows across asset groups. Brinson et al. (1986) researched to what extent asset allocation policy explained actual performance, they find that more than 90% of the variability in a typical pension plan's performance over time is the result of asset allocation policy. Ibbotson & Kaplan (2000) confirm the findings by Brinson et al. (1986), arguing that indeed 90% of the variability of a fund's returns *over time* are explained by asset allocation policy, while *among funds* only 40% of the variations in returns are explained by policy differences. It is clear that pension funds should continuously adapt to the financial situation at hand in order to meet their liabilities.

All in all, it is paramount for pension funds to optimize their portfolios; although what internal and external factors influence their decisions? This will be extensively covered in this thesis.

§1.2 Problem formulation and research questions

The main problem definition is:

"What is the effect of the recent financial crisis on DB pension funds' asset allocation?"

In order to answer this question, the following research questions will be discussed:

"What is the definition of asset allocation, and what are the major asset classes for pension funds to invest in?"

"What internal and external factors drive pension funds to change their portfolio weights?"

§1.3 Motivation

Reason for the choice of this topic is my great interest in the liability management of pension funds. In order to meet their liabilities, pension funds have the challenging task of optimizing portfolio returns by investing in different classes of equity and debt. With the impact of the recent financial crisis, pension funds have to alter their asset allocation policy to adapt to the current market situation, else they will be unable to deliver their promises to the pension fund participants.

The choice between DB and DC (respectively defined benefit and defined contribution) pension funds researched in this thesis is primarily based on the task of pension funds to meet their long-term liabilities. Defined benefit pension funds define fixed retirement payouts based on a certain formula, taking into account the participant's salary, rather than depending on investment returns in the case of DC plans. DB pension plans force funds to deliver promised payments, thus it is crucial for pension funds to realize their expected returns by determining optimal asset allocation, especially in times of a financial crisis.

§1.4 Practical and academic relevance

From a practical viewpoint, this research can be useful for pension funds in determining their asset allocation policy. Managers can use the findings of this research in their day-to-day business and strategic decisions to optimize portfolio performance. Apart from practical relevance, the research done in this thesis will add to the existing research on this topic, with a fresh view on the matter, namely in the light of the recent financial crisis. Up until now, research has been mainly focused on just asset allocation in general. This thesis will expand upon prior research and in addition compare asset allocation policies before and during a financial crisis.

§1.5 Research plan

To answer the first research question: *"What is the definition of asset allocation, and what are the major asset classes for pension funds to invest in?"*, a literature review of prior studies will be conducted, providing a broad idea of the concept of asset allocation.

In order to answer the second research question: *"What internal and external factors drive pension funds to change their portfolio weights?"*, a theoretical analysis will be performed. The theoretical analysis will cover the factors involved in asset allocation policy by researching findings of prior studies. This analysis will be backed up by an empirical analysis researching the technical aspect of asset allocation and pension fund funding ratios. As pension fund asset allocation data is scarce and in most cases privately held, this thesis will make use of simulations provided by the Tilburg Finance Tool[1]. The Tilburg Finance Tool allows the user to run simulations of pension fund portfolios given different market conditions. The empirical analysis will be conducted by altering portfolio weights under 'normal' market conditions vis-à-vis market conditions in times of financial crisis, analyzing the funding ratios of the pension fund portfolios, in an attempt to answer the main problem definition.

[1] Tilburg Finance Tool is an application which allows for financial market analysis, portfolio analysis and pension fund simulation developed by Bas Werker, full professor of econometrics and finance at Tilburg University.

Chapter 2: Literature survey

§2.1.1 Diversification

Diversification is a key principle in asset allocation, therefore the concept of diversification will first be covered. The modern understanding of diversification dates back to the works of Markowitz in the 1950s. Markowitz (1952) describes diversification as a means to reduce risk of a portfolio by investing in a variety of assets, such as stocks, bonds and short-term deposits. Investing solely in one asset would expose an investor to idiosyncratic risk, which is unneeded. By investing in a variety of assets, an investor can offset losses of one asset by gains of another, securing a realistic expected rate of return. In order for diversification to work, the underlying assets of a portfolio should not perfectly correlate positively with each other. This is the major finding of Markowitz' studies, the diversification effect; if asset values do not move in perfect synchrony, a well-diversified portfolio will bear less risk than the weighted average risk of its underlying assets, and often less risk than the least risky asset in the portfolio. (O'Sullivan & Sheffrin, 2007).

Deriving the optimal risky portfolio to fully grasp the benefits of diversification is quite complex, though financial theory can be of aid. Considering a financial market with various risky assets, one can identify the opportunity set of risk-return combinations of various portfolios. Given the opportunity set, one can identify the minimum variance portfolio. No investor would want to hold a portfolio below the minimum variance portfolio, as one can obtain a higher return for the exact same level of risk. The section of the opportunity set above the minimum variance portfolio marks the efficient frontier, as described by Merton (1972). In theory, the efficient frontier marks the optimal choice of assets, though not given the availability of risk-free assets. By adding a risk-free asset to the portfolio, one reaps the full benefits of the diversification effect. With the availability of a risk-free asset, such as U.S. treasury bills, and the efficient frontier identified, an investor can choose a position along the capital market line, the tangent line drawn from the point of the risk-free asset to the feasible region for risky assets (see *Figure 2.1*).

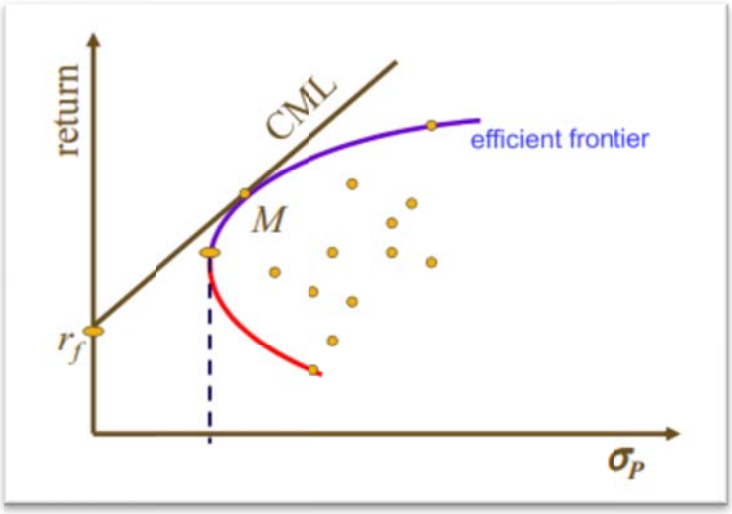

Figure 2.1: Capital market line and efficient frontier (Grinblatt & Titman, 2002)

Markowitz' Separation Theorem (1952) states that investors can separate their risk aversion from their choice of portfolio M, the market portfolio, as seen in the figure above. Investor risk aversion is revealed in the choice of where to position along the capital market line, not in the choice of the line. In theory, all investors have the same capital market line, given the risk-free rate and homogenous expectations. Where the investor chooses to be along this line depends on their risk tolerance.

§2.1.2 Limits of diversification

As discussed earlier, the diversification effect allows an investor to construct a portfolio that bears less risk than the weighted average risk of its underlying assets, and often even less risk than the least risky asset in the portfolio. Long have academics supported the theory by Markowitz (1952), that internationally diversified portfolios are more efficient, offering a better risk-return trade-off than a regular portfolio with investments solely in domestic assets. Studies of Levy & Sarnat (1970), Solnik (1974), Lassard (1976), and Biger (1979) have all found that international diversification offers a better risk-return trade-off for U.S. investors, these studies are however quite dated. Some academics suggest that Markowitz' theory of the 1950s doesn't hold anymore in these times of international market integration and globalization.

International market integration induces higher correlation across asset classes of countries, while diversification benefits are best realized by constructing a portfolio consisting of unrelated assets with low correlations, thus limiting the diversification effect.

Kalra et al. (2004) have researched the diminishing returns of international diversification. In their studies, they find several issues relating to international diversification. Firstly, the weights of the asset classes of an internationally diversified portfolio drift from their original values because of unequal performances of different markets. To counter this behavior, rebalancing of the portfolio is required to bring the weights back to their original values. The act of rebalancing involves selling components that have become overweight, and buying additional components that have become underweight. The second issue at hand is the existence of transaction costs; with frequently rebalancing portfolios, one is constantly confronted with these costs, limiting the benefits of rebalancing. Kalra et al. (2004) propose a hypothesis that transaction costs of rebalancing portfolios diminish, or even completely eliminate, benefits of international diversification. They ultimately find that the benefits of international diversification are exaggerated in academia and in practice. In presence of transaction costs, results show that a purely domestic portfolio has a superior risk-return trade-off than an internationally diversified portfolio with a 20% international component. Even with a small component of 10%, the benefits are likely to be lost due to taxes, which can be quite cumbersome when having to deal with international tax regulations.

Lewis (2006) has found additional evidence relating to foreign market indices and foreign cross-listed stocks. The study argues that the greatest gains in diversification improvement since 1994 have been in foreign market indices over foreign cross-listed stocks. The analysis performed points to some general trends in foreign portfolio diversification. Firstly, international equity markets have become more highly correlated, which was pointed out earlier. Secondly, foreign stocks in the U.S. have become more correlated with the U.S. over time. Consequently, the achievable diversification benefits from foreign diversification is declining, no matter the fact the investor holds foreign stocks inside or outside the U.S.

All in all, diversification benefits still do exist, but certainly less than decades ago with the research of Markowitz. Investors, pension funds being one of them, should still consider diversifying their portfolio, may it not be fully internationally diversified, but domestically.

§2.2.1 Asset allocation

Pension funds often choose to allocate the wealth of their funds to traditional asset classes, such as stocks, bonds and short-term deposits (cash). Though increasingly, other asset classes including currencies, derivatives, hedge funds and illiquid assets (such as real estate) have become part of the asset allocation problem (De Jong et al., 2008). Asset allocation concerns the choice among a variety asset classes for an investor to invest in, for a pension fund asset allocation policy is the major determinant of their investment risk profile. The asset allocation decision determines a pension fund's exposure to market-wide risk factors such as the business cycle, stock market, interest rates and inflation, which will later be discussed in this chapter.

De Jong et al. (2008) describe several objectives pension funds are faced with when determining their asset allocation. Firstly, the fund is interested in a good risk-return trade-off, similar to all other investors. Secondly, in contrast to traditional investors, a pension fund has specific long-term liabilities in the form of future pension benefits. Retirement payouts are often indexed to price- or wage growth, which adds an additional objective for the fund's manager to counter. Thirdly, pension funds invest on behalf of their members, who often have large investments in, for example, housing and human capital, and thus have to take these factors into account. Bovenberg et al. (2007) have shown that individual investors make risk-return trade-offs over their full life cycle. Essentially, this means that stocks and other risky assets are part of the optimal asset allocation for all age cohorts, as De Jong et al. (2008) notes. They also state that young investors prefer larger equity exposures than older investors do. This is for two reasons, the first being that young investors have a large portion of their wealth consisting of human capital. In their financial portfolio, this can be used to 'leverage up' the equity exposure. De Jong (2008) finds that the correlation between human capital returns and stock returns is positive, implying that young investors should have a higher equity exposure in their financial portfolio than older investors should. The second reason why young investors prefer a larger equity exposure is because they have more ways to buffer financial risks, through either labor supply (Bodie et al., 1992) or consumption smoothing (Gollier, 1996). These factors have to be carefully balanced in order to reach optimal asset allocation.

To what extent does asset allocation policy explain fund performance? This is a crucial question pension funds are faced with, considering time management and resource allocation. Before getting to this question, a framework needs to be developed. Brinson et al. (1991) dissect total plan returns into three components: asset allocation policy, active asset allocation, and security selection. The distinction between asset allocation policy and active asset allocation needs to be made clear first. Asset allocation policy involves establishing normal asset class portfolio weights and is an integral part of an investment policy. Contrary to asset allocation policy is active asset allocation, the process of managing asset class weights relative to the normal weights over time. Once could explain this as an active investment strategy, contrary to passive investment strategy in the case of establishing a broad policy. The aim of active asset allocation is to enhance the risk-return trade-off funds face. *"This distinction is material to understanding the importance of investment policy relative to active management."* (Brinson et al., 1991, p. 40). Blake et al. (1999) acknowledge this and prove that changes in aggregate portfolio weights are either caused by differential returns, the first component, or by shifts in net cash flows across asset classes, the second component. Shifts due to the first component arise from a passive investment strategy of buy-and-hold, contrary to the second component which focuses on an active strategy of rebalancing the portfolio by redirecting cash flows across asset groups. To get back to the pension fund performance framework, Brinson et al. (1991) have developed such a framework in their studies, clearly distinguishing between the main three components, as shown below. (see *Figure 2.2).*

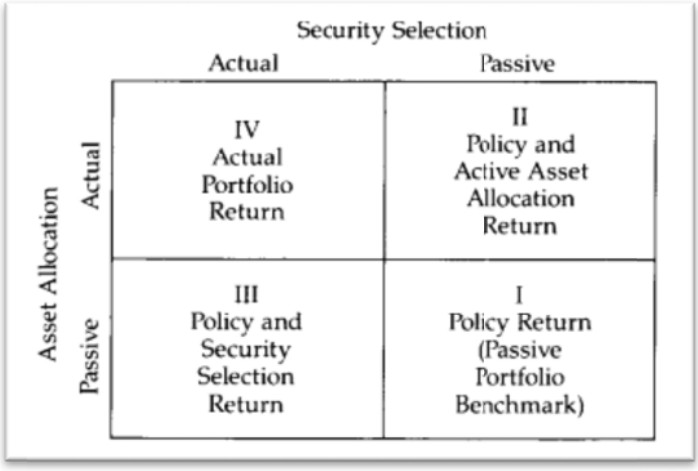

Figure 2.2: A simplified framework for return accountability (Brinson et al., 1991)

Quadrant I indicates the first component, the total return provided by the passive asset allocation policy. The policy portfolio represents the constant, normal asset allocation to passive asset classes. Policy returns are calculated by applying normal weights to each asset class in the portfolio, thus resulting in passive returns. Quadrant II and III make a move to a more active investment strategy. Quadrant II shows a combination of active asset allocation and passive security selection. Active asset allocation results in the under- or overweighting relative to the normal portfolio under asset allocation policy (Brinson, 1988). The total return is calculated by applying actual asset class weights to their passive returns. Quadrant III switches around the active strategy for the passive policy and engages in actual security selection. Instead of applying different weights relative to the normal portfolio in case of price moves or reacting to market disequilibria, security selection involves active investment decisions concerning securities within asset classes themselves. As described before, the three major asset classes for pension funds to invest in are stocks, bonds and cash. Within each asset class, the fund has a variety of assets to choose from, this is what is meant by security selection.

Lastly, Quadrant IV represents the actual realized return by the pension fund over time. This marks the final result of the pension funds' actual asset class weights interacting with actual asset class returns.

The theory of asset allocation policy has been discussed, though there is still a question left regarding this topic: To what extent does asset allocation policy actually explain fund performance in practice? In earlier research of Brinson et al. (1986), the results suggest that more than 90% of the variability in a typical plan's performance over time is explained by asset allocation policy. The conclusion is that asset allocation is indeed very important if one wants to explain the variability of returns *over time*. Ibbotson & Kaplan (2000) note however that the Brinson et al. studies are often misinterpreted, with the results being applied to questions that the studies never intended to answer. Specifically the question how important asset allocation is in explaining the variability of returns *among funds*. Although asset allocation is evidently important over time, without benchmarking comparison firms, these results alone don't tell enough about the real effectiveness of asset allocation. Ibbotson & Kaplan (2000) as aforementioned, have research this specific question.

By carrying out a cross-sectional regression of compound annual total returns on compound annual policy returns, they found that asset allocation policy explains only 40% of the variation of returns among funds, the remaining 60% is explained by other factors, such as asset-class timing, security selection and fees.

To sum up, Brinson et al. (1991) identified three major components of total plan returns, i.e. fund performance, namely asset allocation policy, active asset allocation, and security selection. In their studies they find that 90% of the variability in plan returns is a result of asset allocation. Further research by Ibbotson & Kaplan (2000) suggests that although this is true, the variation of returns among funds is much smaller, being only 40%. All in all, it can be concluded that although asset allocation is of less influence on fund performance across comparison funds than it is over time, it is still a major factor in the realization of pension funds' returns.

§2.2.2 Alternative asset classes

The three main asset classes for pension funds to invest in are stocks, bonds, and short-term deposits. Most of the existing academic literature on pension fund asset allocation covers just these three asset classes, mainly for simplicity, as it is usually difficult to evaluate long-term investment performance. However, pension funds' balance sheets consist of a very large portion of long-term liabilities, as retirement payment obligations last over the lifetime of the participants in the plan. It is vital for pension funds to match these long-term liabilities by investing in long-term assets, as continuously reinvesting in short-term assets may induce transaction costs and be a cumbersome practice in general.

One of the alternative asset classes for pension funds to invest in is venture capital. *"We define 'venture capital' […], as an investment by specialized venture capital organizations […] in high-growth, high-risk, often high-technology firms that need capital to finance product development or growth and must, by the nature of their business, obtain this capital largely in the form of equity rather than debt."* (Black & Gilson, 1998, p. 245). Firms seeking venture capital are often young, start-up firms that grow over a long time span, in theory ideal for pension funds' long-term liability matching. U.S. venture capital funds obtain their capital from a range of sources, but pension funds are by far the largest contributor, Black & Gilson (1998) find.

According to their research, pension funds have provided roughly 40% of the capital raised by venture capital funds between their sample period of 1992 and 1995. Venture capital investment is a very viable option for pension funds to invest in, although risky, as most ventures are dependent on quick growth, which may stagnate during for example the recent financial crisis.

Another long-term investment opportunity for pension funds is real estate. Broadly speaking, pension funds began investing in equity real estate since the 1970s, as Ennis & Burik (1991) describe. During an unanticipated burst of inflation between 1973 and 1974, real estate returns skyrocketed to 10% a year. Real estate was a highly demanded investment, for two reasons: diversification and hedging against inflation. Many studies argue that pension funds should allocate at least 20% of their wealth in real estate, considering the great diversification benefits and superior risk-return trade-offs. However, this large of a percentage allocated to real estate was never seen in practice, in fact, it was at most 4% of pension funds' total assets. Firstenberg et al. (1998) confirm this, with results showing that real estate, even with an upward risk adjustment, may belong in efficient portfolios at significant higher levels, up to 20%, compared to the allocation of 3.6% in 1986 for the top 200 public and private pension funds in the U.S.

The question here is why pension funds allocate this less to real estate, while multiple studies found that greater allocations result in superior risk-return trade-offs. Ennis & Burik (1991) find that the shift in the foreign stock and real estate proportions of the market portfolio are attributable to the difference in their respective rates of return, obviously. The difference in returns accounts for about 70% of the shift in proportions of the market portfolio. During the 1980s, as they note, foreign stocks earned a total return of 22.8% per year, while domestic real estate experienced a constant return of 10.5%, just as it was in the 70s. This may explain, to a certain extent, why pension funds don't invest as much in real estate as theory suggests, but there are more factors involved than just a difference in returns over time. The real estate market is very different from the traded securities market, Ennis & Burik (1991) list three principal differences between these two. Firstly, each property is unique, and ownership interests are mostly impartible. In practice, most investors are precluded from owning properties up for bid. Secondly, the real estate market is far from transparent as the traded securities market is. Information is not freely available, and trading on information is deemed legal.

By many observers, the real estate market is believed to be less efficient than the securities market. Lastly, there is no national exchange or auction market for real estate. Real estate transactions are negotiated between buyer and seller, finding a buyer or seller can be difficult. Apart from that, trading is infrequent. Consequently, transaction costs are largely relative to those of the traded securities market, the market itself is illiquid, and the pricing is not transparent.

Even when pension funds consider investing in real estate as part of their diversified portfolio, estimating the rates of return can be quite troublesome. Due to the nature of the market for real estate, rates of return can be difficult to measure. With marketable securities, transactions are easily tracked and returns are calculated even on a daily basis. Real estate transactions however, are not publicly reported. Actual market value relies on appraisals, which introduces ambiguity.

In conclusion, theory suggests pension funds should at least invest one fifth of their aggregate assets in real estate, while reality shows otherwise. Investments in real estate are time-consuming and may be risky to due to intransparency of the market. Still, the major benefit of real estate investments is the hedging opportunity against inflation. Though, considering the real estate bubble of 2007 and the aftermath it has caused, pension funds should be careful in their decisions when opting for real estate investments. Apart from venture capital and real estate investment, pension funds have a wide array of long-term investment opportunities to choose from, such as investments in infrastructure, derivative products and mutual funds.

§2.3 Internal and external factors affecting portfolio weights

In this section, various internal and external factors affecting portfolio weights will be discussed. Under normal conditions, pension funds set their portfolio weights according to their asset allocation policy, as has been discussed before. Though, pension funds also need to adapt to certain events, such as changes in their liability structure, government regulation, the business cycle, and demographics of their plan participants.

§2.3.1 Internal factors

First and foremost, changes pension funds make in their portfolio weights are driven by their liability structure, or asset liability management. Falling stock returns and low interest rates have resulted in a downturn of the financial position of many pension funds. It is of high importance to manage the risks that arise due to mismatches in assets and liabilities of a pension fund. Most funds conduct an Asset Liability Management (ALM) study, as Bauer et al. (2006) note. This involves investigating the impact of decisions regarding investment, contribution, and indexation policy on the various stakeholders of the fund. By conducting an ALM study, one manages and models the future financial position of the pension fund, with the starting point being the balance sheet. The balance sheet simply lists the fund's asset and liabilities on either side, and as a result the surplus and funding ratio. The funding ratio is defined as the pension fund's assets to its liabilities. Funding ratios above one indicate that the pension fund can cover all its obligated payments, which is the core aspect of managing a fund.

Bauer et al. (2006) argue that the future financial position of a pension fund is dependent on three endogenous policy decisions: contribution, indexation, and investment policy. And thus, pension funds should change their portfolio weights according to these variables, of which we have discussed one already, the investment policy. The contribution policy of a pension fund contains set contribution levels, which are usually dependent on the current and future financial health of the fund. Contributions by plan participants ultimately lead to the investment opportunities a fund has, i.e. the investment pool available, and can be regarded as cash inflows. A pension fund's indexation policy concerns the cash outflows, the retirement payments. Indexation refers to the pension fund's choice of correcting retirement payments by taking into account either wage inflation, price inflation, or both. This ensures retirement income rises with economic welfare.

After the short introduction of ALM variables for pension funds, the question is how pension funds deal with the dilemmas of balancing these variables. In harsh financial times, pension funds can either increase contributions, or reduce indexation, as Bauer et al. (2006 describe. However, this decision relies heavily on the liability structure. Generally speaking, younger pension funds have a relatively larger gross salary sum than mature funds, as they have more working participants.

From a purely financial perspective, a young fund could opt to increase contribution levels. Total contributions amount to the gross salary sum of the participants in the fund multiplied by the percentage contribution level. If this amount is relatively large, it might be more effective to raise contribution levels to untangle from deficits. The opposite is true for mature funds, which naturally have more retirement payments than younger funds, so in that case, indexation policy is much more effective by cutting costs instead of increasing benefits. From a social perspective, pension funds have to decide who bears the risks of the potential financial distress: the working participants in the form of contributions, or the retired in the form of indexation.

Asset liability management is by far the most important internal factor that drives pension funds to change their portfolio weights. Many other minor factors are of course present, but won't be covered in this thesis. Although one, quite interesting, internal factor that has barely been mentioned throughout academic literature is window dressing by pension fund managers. Conventional wisdom tells that fund managers are reluctant to show annual reports of stocks that have drastically declined in value. As quoted by Jansson (1983, p. 139): *"Nobody wants to be caught showing last quarter's disasters. You throw out the duds because you don't want to have to apologize to clients even though your investment judgment may be to hold."*. Window dressing in this context is the practice of selling such stocks at the end of the year, ultimately changing the portfolio weights of the fund. The question is why would fund managers engage in this practice? Fund managers are partly compensated by investment performance, and thus attempt to greatly improve their benchmarks year end. Lakonishok et al. (1991) have further researched this trend, and find that the average pension fund is contrarian, in the sense that it buys those stocks that have performed poorly, and sells a disproportionally amount of stocks that have performed well. Furthermore, the pace of dumping 'mistakes' accelerates rapidly in the fourth quarter, year end, which is consistent with the window dressing strategy. It is obvious that this practice is more often seen for small funds, as their portfolios are less frequently monitored.

§2.3.2 External factors

One external factor pension funds are confronted with when optimizing their portfolio is government regulation. Pension funds are monitored by government agencies to ensure the wealth of their participants isn't invested solely in risky assets, for example. In general, there are two alternative approaches to portfolio regulation for long-term institutional investors, such as pension funds, identified by Davis (2000). These two approaches are prudent person rules, and quantitative portfolio restrictions. Prudent person rules concern portfolio diversification and asset-liability matching, while quantitative portfolio restrictions encompass limits on holdings of certain asset classes within a portfolio. However, these two approaches to portfolio regulation are not polar opposites, and share some main principles. Apart from that, public pension funds in the U.S. were often obliged to invest a fraction of their assets to state specific projects, aiding the government in building a stronger job and tax base. (Mitchell & Hsin, 1994). Results showed that these funds earned lower returns overall, in comparison to others, which points to inefficient investment.

Discussing the two alternative approaches to portfolio regulation in detail, quantitative portfolio restrictions impose limits on the holdings of certain asset classes. The asset classes concerned are often those with high volatility and low liquidity, as Davis (2000) notes. Moreover, the proportion of assets exposed to a single borrower or piece of real estate is also restricted. Prudent person rules, being the second approach, are less quantitatively expressed and build more upon the idea of investments being handled carefully. Adequate diversification and proper asset liability management are key principles in this approach. Both approaches constrain pension funds, though as Davis (2000) argues, prudent person rules are favored for being more loose and allow pension funds some discretion in their portfolio choice.

These types of regulation mechanisms are outlined in various directives, such as Basel III for banks, Solvency II for insurance companies and IORP II for pension funds. In the Netherlands, pension funds are bound by the Financial Assessment Framework (FTK), the IORP II Dutch equivalent. As an example of the restrictions imposed, the FTK outlines two core solvency conditions. The first condition is a funding ratio of at least 105%. If the funding ratio is lower than this specific percentage, the pension fund has to draw up a recovery plan to reach this ratio within three years; if it fails to do so, pension cuts will follow.

Furthermore, the FTK requires a so-called solvency buffer, this buffer has to be large enough such that the probability of underfunding (funding ratio lower than 100%) within one year is lower than 2.5%. These conditions make clear that pension funds deal with long-term guarantees on their balance sheet, thus it is crucial for the functioning of the financial system that individuals can trust these guarantees. Risk management and solvency legislation are of vital importance.

Another external factor influencing pension funds' portfolio weights is the demographics of participants in the fund. As has been noted earlier, pension funds invest on behalf of their members, who often have large investments in housing and human capital. These types of exposures have to be taken into account, as some investors prefer larger equity exposures than others, as has been researched by De Jong (2008). Prudent person rules, as described above, are also applicable in this context.

The last external factor discussed, is the occurrence of business cycles. Burns & Mitchell (1946) provide the following definition of business cycles: *"Business cycles are a type of fluctuation found in aggregate economic activity […], a cycle consists of expansions occurring at about the same time in many economic activities, followed by similarly general recessions, contractions and revivals which merge into the expansion phase of the new cycle; […] business cycles vary, […] they are not divisible into shorter cycles of similar characteristics."* (p. 3). The cyclical economy can be difficult to adapt and react to, and as such should pension funds carefully evaluate their portfolio decisions. Policies should be weighted on both a procyclical and countercyclical basis. That is, should pension funds work against the cyclical tendencies in the economy, or magnify economic fluctuations? This will be analyzed in the subsequent paragraph, where the effect of the financial crisis on DB pension funds' asset allocation will be studied.

§2.3.3 Effect of the recent financial crisis

Having identified several internal and external factors affecting pension funds' portfolio weights, the effect of the recent financial crisis has yet to be discussed. The 2007-2009 financial crisis has severely impacted numerous financial institutions, pension funds being one of them. Funds have reported massive unrealized investment losses, having trouble meeting their liabilities and deliver promised retirement income.

Portfolio reallocations were made on an unparalleled scale. The crisis has dealt a major blow to the financial position of pension funds, especially those funds with high exposures to equity.

The impact of the crisis on pension funds is mainly attributable to three factors, as Pino & Yermo (2010) argue, namely: severity, contagion, and length. Financial markets started to fall considerably mid-2007, lasting until the beginning of 2009. The length of the crisis has exhausted many resources, causing severe losses. Investment performance plummeted with record lows of minus 35% in 2008. With equities underperforming bonds, pension funds experienced the worst returns the past decade. Contagion is also a major factor in the downfall of funds; with globally integrated financial markets, one link after another is affected by economic fluctuations.

Getting back to the financial performance of pension funds; those with high equity exposures have suffered tremendously from the crisis. Equity has performed very poorly over the course of the financial crisis, as can be seen in the graph below.

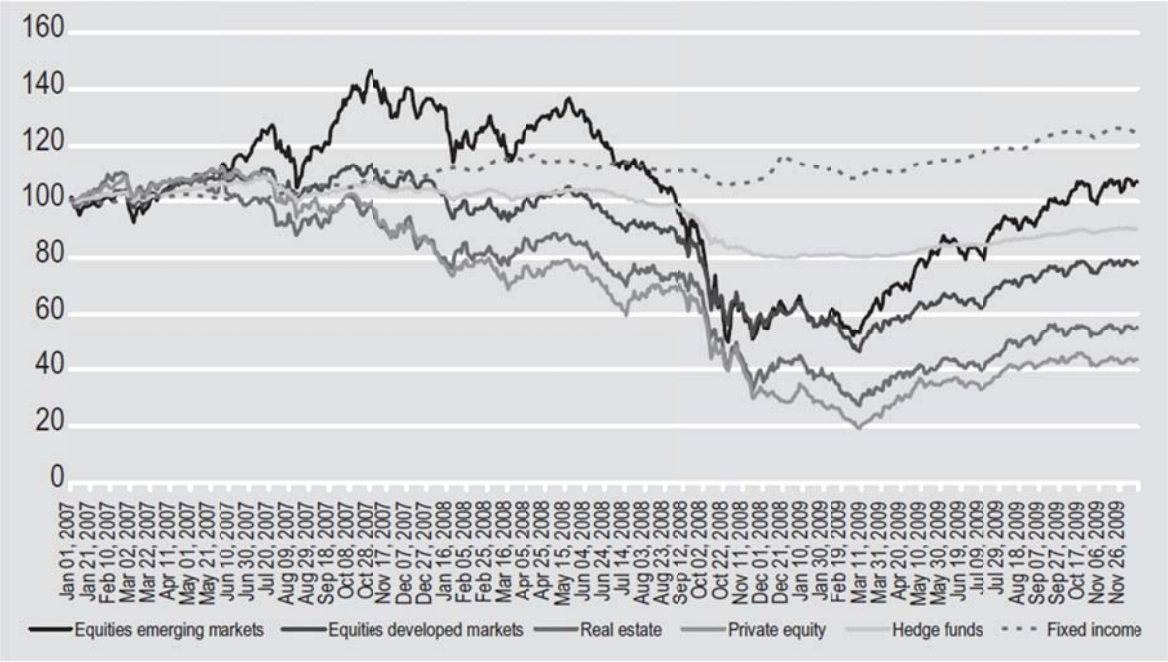

Figure 2.3: Asset classes performance (Pino & Yermo, 2010)

Looking more detailed at the graph presented, one notices the steady performance of fixed income. Fixed income, such as bonds, have performed considerably well throughout the crisis, and even saw an increase in performance.

This marks the great importance of a pro-active asset allocation policy, where fund managers should constantly adapt to the current economic situation at hand. Adequate security selection is evidently one of the most important factors concerning policy.

Defined benefit pension funds, as Pino & Yermo (2010) note, have had a doubly negative impact by the crisis, in that not only portfolio returns have been negative, but in many cases the near risk-free discount rates used for calculating liabilities have fallen, leading to an unexpected rise in pension fund's obligations. This can be seen in practice, with defined benefit pension funds having record low funding ratios. The funding ratio is expressed as the fund's assets to its liabilities. A below one funding ratio is the worst scenario a pension fund can imagine, especially considering the long-term character of its liabilities.

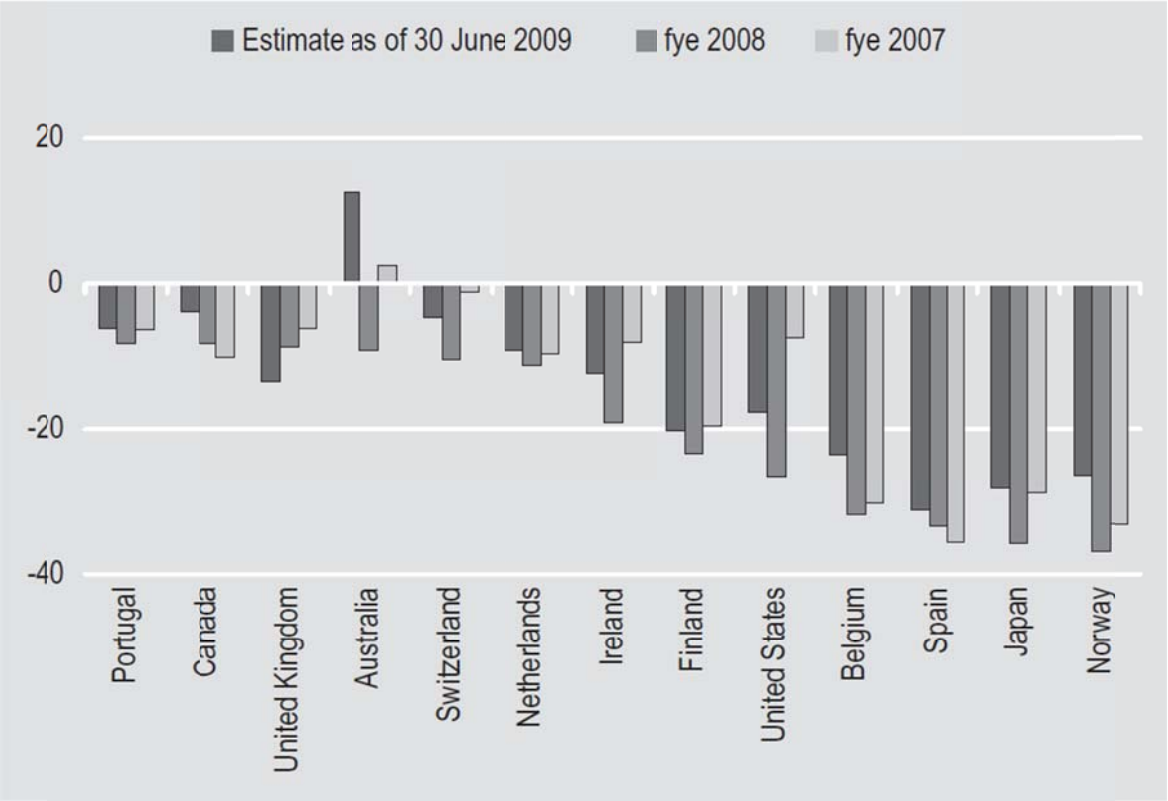

Figure 2.4: Estimated median deficit percent of companies' aggregate defined benefit obligations (OECD, 2009)

The figure above is constructed by analyzing financial reports of listed companies that sponsor defined benefit pension funds. Using these reports, one can derive the funding ratios of the pension funds sponsored, as they rely on their contributions.

One can see a steep decline in the funding levels throughout 2007 and 2008, with a minor recovery in 2009 as market performance increased. Nonetheless, maintaining healthy funding levels are crucial, especially when faced with a maturing participant base.

All in all, the recent financial crisis has made aware that traditional risk management approaches are not sufficient. Failures to design an appropriate asset allocation policy reveal broader problems, such as a lack of adaptability and inadequate skills among fund managers to rebalance security selection. Risk management strategies should also need to be revisited, implementing procedures against extreme, unforeseen events, such as a financial crisis. In the subsequent chapter, an empirical analysis will be conducted to back up the statements made in this theoretical part of the thesis.

Chapter 3: Empirical findings

§3.1 Methodology

The methodology used in the subsequent simulations is the Black-Scholes model. The Black-Scholes model is a mathematical model of a financial market. The model is renowned for its derived formula for pricing options, which led to a boom in options trading when the formula was first derived. The model itself was first presented by Black & Scholes in their paper titled *'The Pricing of Options and Corporate Liabilities'*, published in 1973, and is still widely used in option pricing and financial market simulations, of which the latter will be studied.

The Black-Scholes model assumes that the price of a stock is a stochastic process. To be more specific, the model follows a geometric Brownian motion: a continuous-time stochastic process of which the logarithm of the random variable, the stock price, follows a Brownian motion (or Wiener process), with drift (Ross, 2007). A stochastic process S_t is said to follow a geometric Brownian motion if it satisfies the following stochastic differential equation:

$$dS_t = \mu S_t d_t + \sigma S_t dW_t$$

where μ denotes the drift rate (the percentage change of the average value of the stochastic process), σ the percentage volatility, both constants, and lastly W_t which denotes the Brownian motion. This equation is the basis of the simulation of a financial market (which is used in the Black-Scholes model, incorporated in the Tilburg Finance Tool).

§3.2 Scenarios

In this empirical analysis, different scenarios will be simulated for a fictitious defined benefit pension fund. The main goal is to analyze what options pension funds have in order to improve their funding ratio, which is the most important factor when measuring solvency. After having identified these options, the effectiveness of them will be tested under the effects of a financial crisis: will traditional strategies hold?

In order to measure the effects of different policies, a benchmark pension fund has to be defined. Fictitious pension fund 'DB', is a pension fund with equally divided investments in both stocks and five-year zero coupon bonds, with both a duration of five years. The total time span of nominal liabilities (i.e. retirement payments) is fifteen years. The indexation policy of the fund is a Dutch 'staffel' 110%/140%. If the funding ratio lies between these bounds, the indexation level is linearly interpolated between these bounds. Indexation should therefore only be preferred if the pension fund is in a safe solvency position. The pension premium amounts to a total of 25%, which is accurate for a regular Dutch pension fund in 2013. The state variables are left at the default parameters; inflation 2%, nominal short rate 4%. Stock returns are normally distributed (mean 8%; standard deviation 20%) according to the Black-Scholes model. Below is a cumulative distribution graph of the nominal funding ratio of the benchmark pension fund.

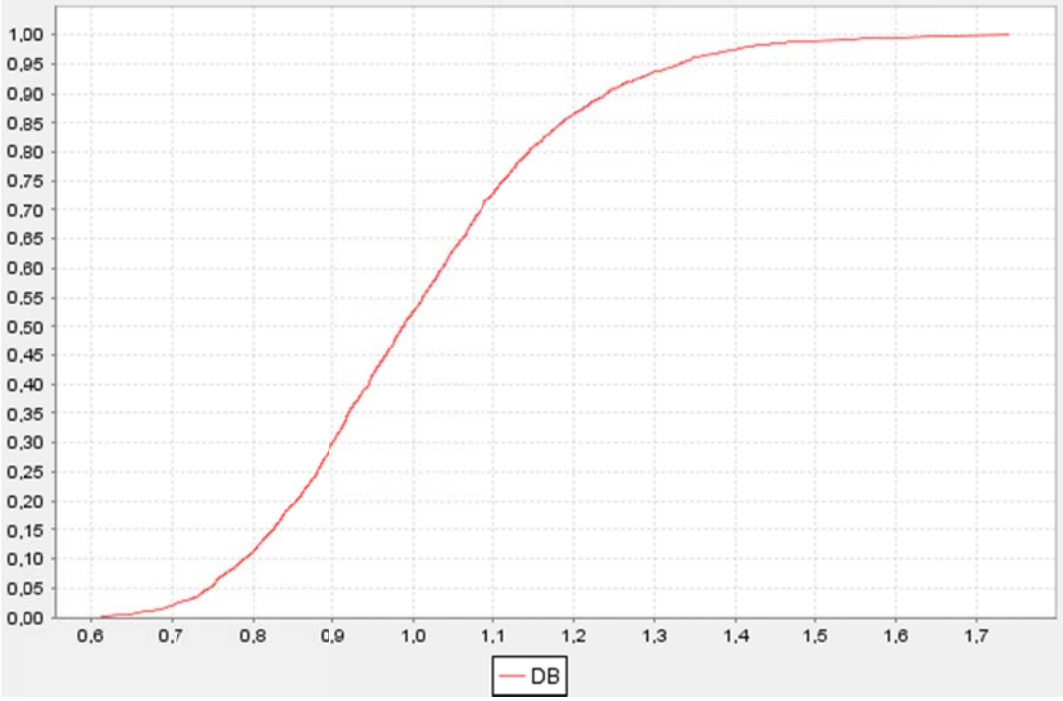

Figure 3.1: Cumulative distribution of nominal funding ratio (3 year period)

As can be seen, there is a 50% cumulative chance of the nominal funding ratio being 99% within three years, with a standard deviation of 14%. As noted before, the Financial Assessment Framework (FTK) requires a funding ratio of at least 105%. Under the current situation, 'DB' would reach this funding ratio within four years, which is not sufficient.

In order to realize this funding ratio on time, the effects of several options will be analyzed, namely increased premium, indexation policy, rights cut, and asset allocation.

§3.2.1 Increased premium

The most obvious solution to increase the funding ratio would be to increase pension premium for the participants of the pension plan, who will have to fully bear the costs. The past decade, pension premiums in the Netherlands have risen at an incredibly fast pace, opting to increase premiums even more could potentially diminish the possibility of altering other variables such as indexation, as increased premiums are devastating on their own. On top of that, Dutch pension funds are dealing with a maturing participant base, which leads to increased liabilities, decreasing the effectiveness of increased premiums to improve the funding ratio.

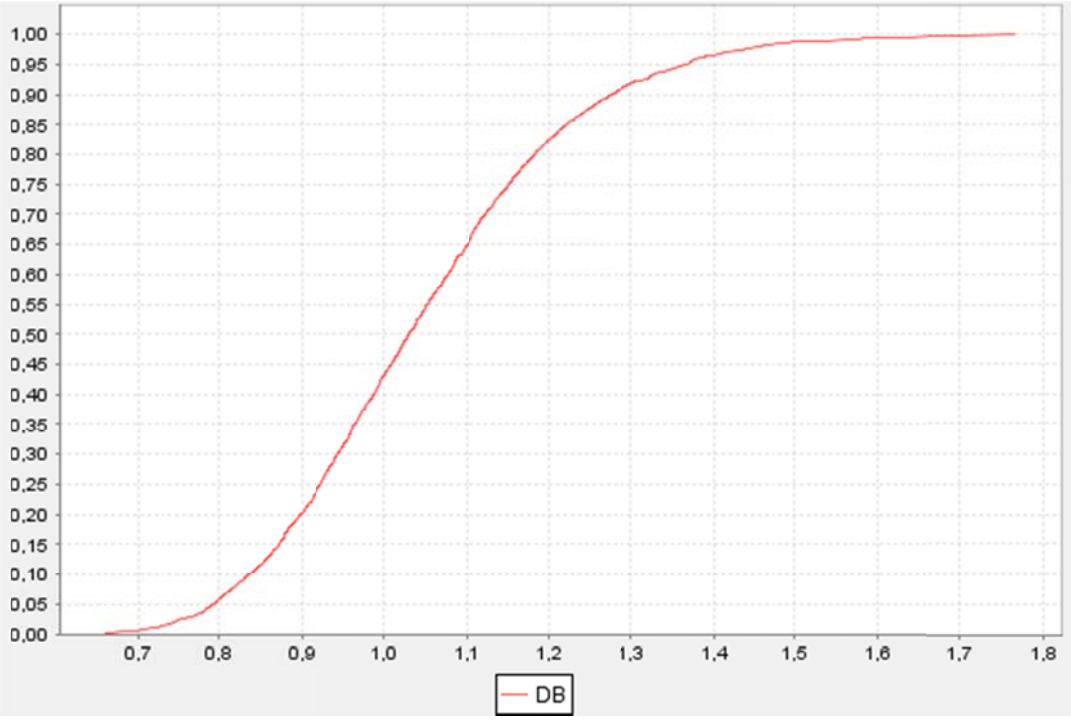

Figure 3.2: Cumulative distribution of nominal funding ratio
(3 year period, with increased premium of 15 percentage point)

Under the standard situation, pension fund 'DB' maintains a cost-based pension premium, with a maximum of 25%. In order to raise the current average funding ratio of 99% within three years to 105%, ceteris paribus, 'DB' would have to raise the premium to 40%, an increase of 15 percentage point, which seems unacceptable.

Indeed, the short-term effectiveness of increasing premiums is not optimal, as increased contributions will only start to pay off in the long run. Of course, this is under ceteris paribus conditions, never should pension funds solely increase premiums in order to improve their funding ratio.

§3.2.2 Indexation & rights cut

The increasing ineffectiveness of pension premiums as a means to improve the funding ratio leaves pension funds with only three more options, two of which will be discussed in this paragraph: indexation policy and rights cut. Indexation policy, however, does not affect the nominal funding ratio, but the real funding ratio. Thus, it would be of no use if seeking to meet the FTK conditions. Still, for the internal organization of the fund, it is important to cut costs if possible.

Another option is to cut the pension rights of the participants in the fund. This strategy is highly effective, as opposed to increasing pension premiums. Cutting pension rights by a mere 2% results in a nominal funding ratio of 109% within 3 years under the standard situation, which is quite the improvement (up from 99%).

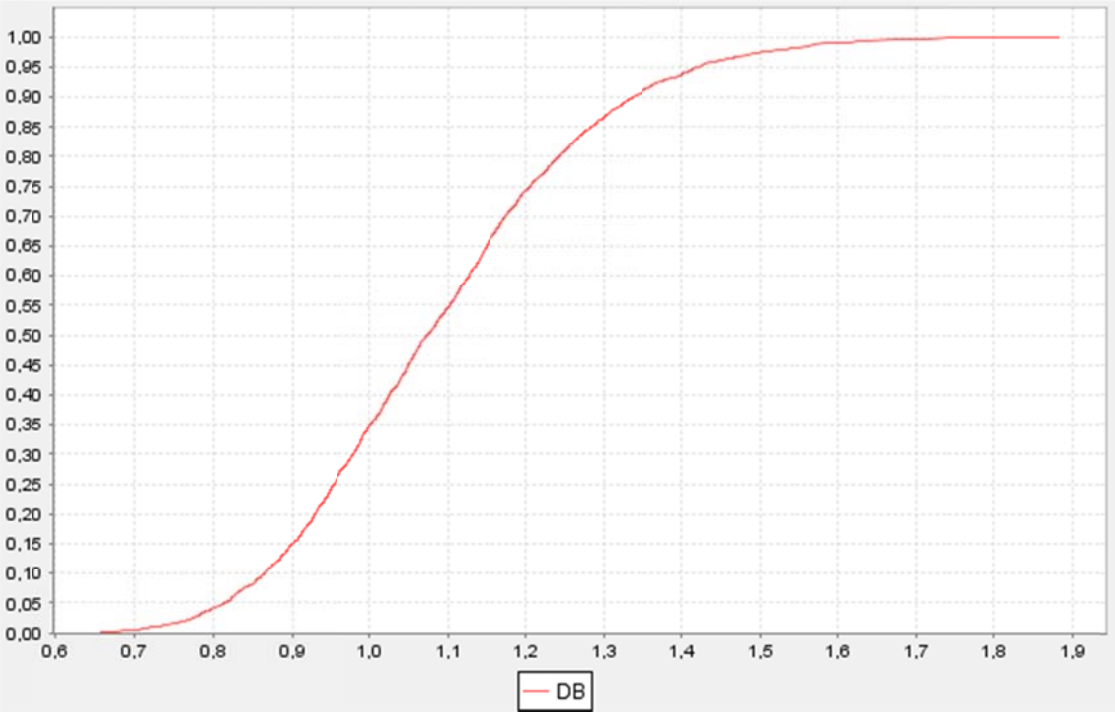

Figure 3.3: Cumulative distribution of nominal funding ratio (3 year period, with rights cut of 2%)

§3.2.3 Asset allocation

Years after the initial impact of the financial crisis of 2007-2009, pension funds have slowly started to invest in stocks again, following declining interest rates and rising stock returns. The topic of asset allocation has extensively been discussed throughout this thesis; one of the major conclusions being that asset allocation does play a significant role in the performance of pension funds. In the following scenario, the standard 'DB' fund with 50/50 stocks and bonds allocation is compared to both a 100% stocks and 100% bonds portfolio.

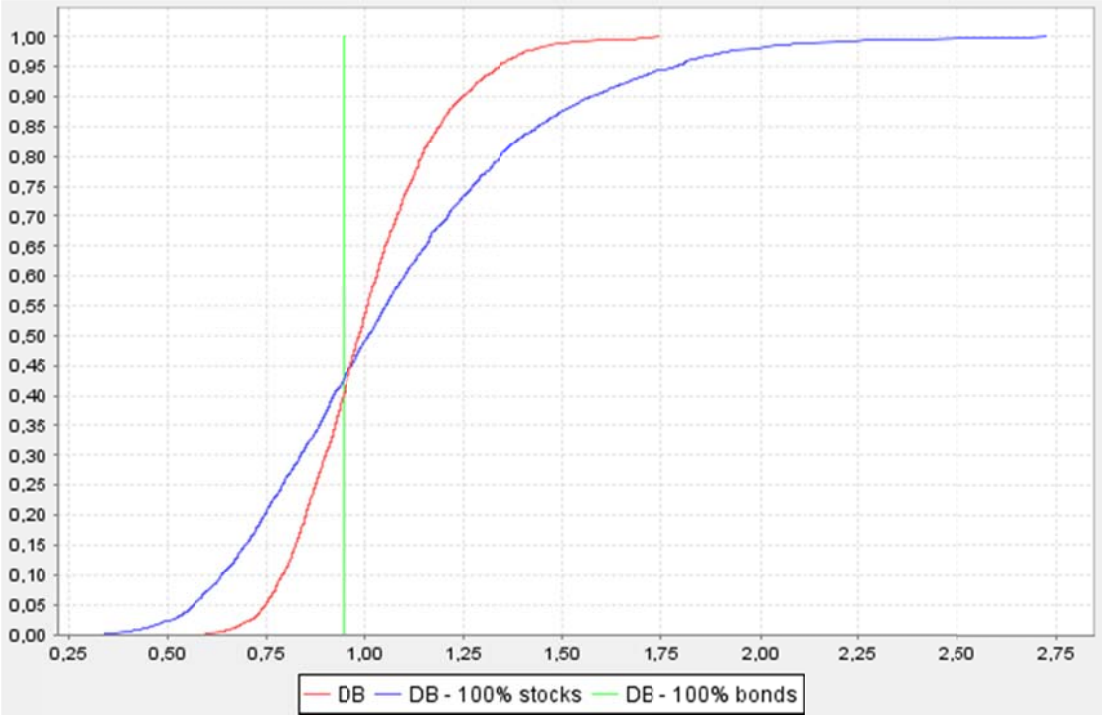

Figure 3.4: Cumulative distribution of nominal funding ratio (3 year period, with different asset allocations)

The above graph portrays the funding ratios given different asset allocations. The average funding ratio for a portfolio consisting of only stocks is 106%, while investing solely in bonds would result in a funding ratio of 94%, over three years. Notably however is the standard deviation, the measure of risk. For the benchmark portfolio 'DB', the standard deviation of the nominal funding ratio is 14%. The standard deviations for 'DB – 100% stocks' and 'DB – 100% bonds' are respectively 38% and 0%. A greater fraction invested in equity induces increased volatility, though this is a matter of risk-return trade-off. In order for pension funds to reach the FTK requirements, equity investments should seriously be considered as they are highly profitable.

§3.2.4 Effect of the recent financial crisis

Having identified various options pension funds can consider in order to improve their funding ratio, the effects of the recent financial crisis has highly impacted the effectiveness of these options. The Tilburg Finance Tool is quite limited in terms of state variables, as one can only alter stock price, nominal interest rate and inflation. To simulate a financial crisis, lowering the stock price would obviously decrease the funding ratio, which is not interesting to research. Instead, the nominal interest rate will be lowered to simulate the recent financial crisis. In times of crisis, economic activity decreases over a period of time, which is consistent with decreasing demand for borrowing. The lack of demand pushes interest rates down; additionally, in the U.S. the Federal Reserve aims to increase money supply to push down interest rates even further. This is in line with research by Christiano et al. (2004).

To put this to practice, instead of the standard situation with a nominal interest rate of 4%, an interest rate of 2% is chosen. At first glance, a reduction in interest rate increases the funding ratio: bond values are discounted at a lower rate, resulting in higher values. However, under market valuation of liabilities, a reduction in interest rates also increases the value of liabilities: the retirement guarantees to plan participants. The latter, the denominator, has a greater impact on the funding ratio than the former, therefore decreasing it. The question is how pension funds can try to negate this effect.

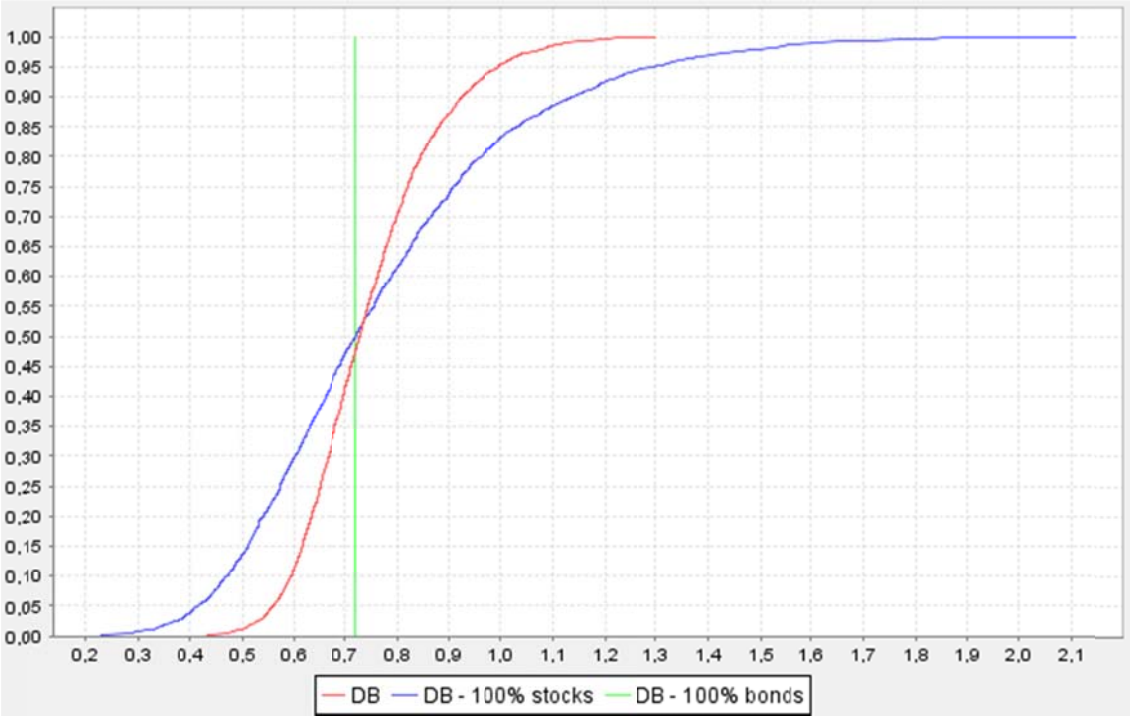

Figure 3.5: Cumulative distribution of nominal funding ratio
(3 year period, with different asset allocations, and decreased interest rate of 2%)

Evidently, asset allocation is the most important factor affecting pension fund performance, and does not directly hurt the plan participants like pension premium, indexation policy and rights cut; therefore this variable will be the focus of the analysis. On the previous page, *Figure 3.5* illustrates the different asset allocations under the financial crisis scenario; *Table 3.1* below shows the corresponding values.

Fund	**Nominal funding ratio**	**Standard deviation**
DB	74%	13%
DB – 100% stocks	77%	28%
DB – 100% bonds	72%	0%

Table 3.1: Nominal funding ratio & standard deviation values for Figure 3.5

Taking a close look at the different values, the nominal funding ratio is almost equal in every situation: 50/50 and both 100% scenarios. The interest rate decrease has surely impacted the funding ratio. The standard deviations differ however; the stocks portfolio has dropped down in volatility, though the risk-return trade-off has become way worse. The portfolio consisting of only bonds performs considerably well, given the performance of the market. The benchmark 'DB' scenario remains constant in terms of standard deviation.

The funding ratios are nowhere near the 105% as required by the FTK, which is understandable during a financial crisis. The question on how pension funds can negate the effects of the crisis is a tough one, but it is definitely clear that a portfolio selection consisting of mainly bonds is a viable option during a crisis. This conclusion is the complete opposite of the standard scenario, where a portfolio with an emphasis on equity is preferred. As the nominal funding ratios are all about equal, one has to take a closer look at the standard deviations. As fixed income is considered riskless, this asset class is the top performer, as was seen before in the theoretical analysis on the effects of the financial crisis. Fixed income has performed steadily over the course of 2007-2009. In addition to changing asset allocation strategies, pension funds can attempt to improve their funding ratio by means of the options discussed earlier in this analysis. The scenarios researched were all based on ceteris paribus conditions, pension funds however should try to find an optimal mix of these variables to get through the harsh times of a financial crisis.

Chapter 4: Summary & conclusions

§4.1 Conclusions

The aim of this thesis was to study the effect of the recent financial crisis on defined benefit pension funds' asset allocation. The recent financial crisis has severely impacted the performance of pension funds all over the world. Pension funds struggle to meet their liabilities, having serious trouble maintaining a respectable funding ratio. In order to answer this main problem definition, several research questions were discussed.

The first research question concerned the definition of asset allocation and the major asset classes for pension funds to invest in. Prior to discussing this question, the topic of diversification was covered, a key principle in understanding asset allocation. For a pension fund, asset allocation policy is the major determinant of their investment risk profile. Investing in a variety of assets brings diversification benefits along with it, lowering the exposure to idiosyncratic risk. The choice of assets to invest in is heavily reliant on the liabilities of the fund. Pension funds have long-term liabilities on their balance sheets, in the form of retirement guarantees. These liabilities have to be matched adequately by investing in assets of similar nature, such as real estate and venture capital. It can be concluded that asset allocation as a whole is of vital importance to pension funds.

Having discussed the basic principles of diversification and asset allocation, the second research question posed the question what internal and external factors drive pension funds to change their portfolio weights. Pension funds cannot simply rely on their passive policy, they also need to adapt to certain events, such as changes in their liability structure, government regulation, and the demographics of the participants. More interesting however is the effect of the recent financial crisis, which leads us to the main problem definition.

The 2007-2009 financial crisis has triggered portfolio reallocations on an unparalleled scale. The length of the crisis has exhausted most of pension funds' resources, causing severe losses. Investment performance plummeted with record lows of minus 35% in 2008. Where traditional strategies suggested a greater weight on equity investments, equity actually underperformed bonds during the crisis. Pro-active asset allocation is paramount, as sudden unexpected economic fluctuations require swift action.

In the empirical analysis of this thesis, several simulations were conducted under different scenarios. Firstly, traditional methods to improve the funding ratio of pension funds were analyzed, such as increased premium, indexation policy, and rights cut. The results have shown that these traditional methods cause too much financial damage to the participants of the fund, with meager improvements to the funding ratio in contrast to the severe damage caused. Asset allocation proved to be more effective, as theory suggested. In the financial crisis scenario, the benchmark pension fund was compared to two other funds, both investing their assets solely in either stocks or bonds. Quite remarkably, the nominal funding ratios were all about equal (respectively 74%, 77%, and 72%) for all three funds. The most important difference was the risk factor however: the fund fully exposed to equity proved to be the most risky, while the fund fully invested in bonds can be considered riskless, with a comparable funding ratio. These findings support the theoretical analysis of the effect of the financial crisis, where was shown that indeed fixed income performed steadily over the course of 2007-2009.

All in all, the effect of the recent financial crisis has contested traditional asset allocation policies and has made clear that portfolio rebalancing is a major part of managing a pension fund. During a financial crisis, pension funds should consider shifting from a predominantly equity invested portfolio to a portfolio with a greater exposure to bonds. In order to carefully guide this change, pension funds should implement clear procedures and develop adequate recovery plans to ensure they can meet their liabilities and maintain a healthy funding ratio.

§4.2 Limitations & future research

Although the findings of this thesis are in line with the research conducted by prior studies on the topic of pension funds' asset allocation, one limitation applies. The major limitation is the lack of actual data. Pension fund asset allocation data is scarce and often privately held, with restrictions on publishing results. The empirical analysis in this thesis was based on simulations provided by the Tilburg Finance Tool, and thus do not fully reflect reality.

Future research on the effect of the recent financial crisis on pension funds' asset allocation is needed, as most research is based on regular market conditions. In addition to that, using actual portfolio data, one could fully support the findings of this thesis.

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