Lappeenranta University of Technology
School of Business and Management
Strategic Finance and Business Analytics

The Impact of the 2017 Finnish Pension Reform on Asset Allocation and Expected Returns

Master's Thesis

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1st Supervisor: Professor Eero Pätäri

2nd Supervisor: Postdoctoral Researcher Timo Leivo

ABSTRACT

Author:	Jenna Saarni
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This thesis examines the pension reform taking place in Finland from the beginning of 2017 will be examined. In more precise, the possible impacts of the reform on asset allocations within private pension insurance companies is analysed. The new regulations bring changes to the solvency requirement calculations as well as to the overall structure of technical provisions. The solvency limit will be calculated based on the invested assets, whereas under the current legislation, it is based on the technical provision. This is a shift to a more risk-based capital requirement, which means that risks concerning the overall business should be taken more into consideration.

The research was implemented by using a simulation software model, GLASS, developed by Ortec Finance. To analyse the impacts of the new regulation, a stylised fund representing Finnish pension insurers was created. The balance sheet data was gathered from official publications, providing a representation of the industry sector at the end of 2015.

Simulations on investment returns and balance sheet development, under the current regulation and under the new regulation, were run in order to find comparable data. Under the new regulations, the solvency capital requirements will

be higher. The technical provision will go through structural changes as the three buffer funds, *the equity linked buffer*, *the clearing reserve* and *the equalisation reserve*, are slightly newly defined after the reform.

Running optimisation simulations provide final findings on the possible impacts on allocation strategies. The optimisations suggest that increasing equity weight, while reducing weight on fixed income, would result in higher investment returns, still keeping the risks of insolvency at its current level. Weight shifts among the other main asset classes are also suggested. However, the optimisations regarding these shifts were similar under both sets of regulations, implying that these are not impacted by the regulation change as such, but more due to the scenarios on market developments. Based on the results, pension insurance companies in Finland face a time of change, where asset allocation strategies should be closely analysed and revalued.

ABSTRAKTI

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Tutkielma tarkastelee Suomessa 2017 toteutettavan eläkeuudistuksen vaikutuksia yksityisten eläkevakuuttajien sijoitusomaisuuslajien allokointiin. Eläkeuudistus tuo muutoksia vakavaraisuusvaadelaskentamalleihin sekä yleisrakenteellisia muutoksia vastuuvelkaan. Vakavaraisuusraja tullaan laskemaan sijoitusvarojen pohjalta, kun taas nykysäädösten mukaan raja lasketaan vastuuvelasta. Tämä on muutos kohti riskiin perustuvaa pääomavaadetta, mikä tarkoittaa, että koko liiketoimintaa koskevat riskit tulevat otettua laajemmin huomioon.

Tutkimus on toteutettu käyttämällä Ortec Finance:n GLASS-ohjelmistoa, joka perustuu simulaatiomalleihin. Jotta uuden regulaation vaikutuksia voitiin analysoida, luotiin mallirahasto, joka kuvastaa suomalaisia eläkevakuuttajia. Taseen tiedot kerättiin virallisista julkaisuista, joiden perusteella toimialan tilanne vuoden 2015 lopulla saatiin kuvattua.

Jotta saatiin vertailukelpoista dataa, simulaatiot sijoitustuotoista ja taseen kehityksestä ajettiin sekä että tämänhetkisillä uusilla regulaatiovaatimuksilla. Eläkeuudistuksen jälkeen vakavaraisuuspääomanvaade tulee olemaan korkeampi. Vastuuvelka kokee rakenteellisia muutoksia, sillä järjestelmän kolme puskurirahastoa, *osaketuottosidonnainen lisävakuutusvastuu, tasausvastuu sekä tasoitusvastuu,* määritellään uudistuksen myötä uudelleen.

Optimointisimulaatiot tarjoavat tulokset mahdollisista vaikutuksista allokaatiostrategioihin. Optimointien mukaan osakepainon lisääminen ja samanaikainen korkosijoitusten painon pudottaminen parantaisivat sijoitustuottoja kasvattamatta kuitenkaan maksukyvyttömyysriskiä sen tämänhetkiseltä tasolta. Optimointi ohjaisi myös muiden omaisuusluokkien välisiä painomuutoksia, mutta nämä muutokset olisivat samankaltaisia regulaatiosta riippumatta. Optimointimallien ehdottomat allokaatiomuutokset eivät kuitenkaan johdu suoraan regulaatiomuutoksista, vaan enemmänkin markkinakehitysskenaarioiden muutoksista. Tutkimustulosten perusteella suomalaisten eläkevakuutusyhtiöiden tulisi analysoida tarkasti ja tarvittaessa uudelleen arvioida omaisuusluokkien allokointistrategioita.

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1 Introduction

Pension companies hold and manage large investment funds, with their main focus to invest the pension premiums into profitable and safe assets in order to meet their future liabilities. The investment assets of Finnish pensions added up to EUR 180.9 billion at the end of year 2015 (ETK, 2016a).

Investment decisions can be considered as a decision making problem under uncertainty, and especially for institutional investors, such as pension companies, investment decision making is an enormous part of their risk management process. The performance of an investment portfolio, within the objectives and limits of the investor, depends on the development of economic and financial drivers such as inflation rates, asset returns and interest rates. (van der Schans and Steehouwer, 2015.) By investing the pension wealth so, that the returns equal adequately enough the future pension liabilities, the costs of current pensions and risks could in total be reduced.

From the beginning of year 2017, new regulations on Finnish pension law will come into effect. To mention a few of them, the following changes will take place: the retirement age will rise in a gradual process so that eventually retirement time will decrease from its current level and be more suitable with the current lifetime expectancy; pensions will start to accrue already from the age of 17 and the accrue rate, 1.5% from earnings, will be the same for all age groups; contributions regarding earnings-related pensions will rise from the current level of 24% to 24.4%. However, this will stay constant at least until the year 2060. In addition, the calculations for technical provisions as well as solvency capital requirements will change. All in all, large changes in the overall pension framework might, to some extent, affect investment strategies as well. Based on the Finnish Centre for Pensions, the new regulations will, for example, allow for higher risk taking when it comes to allocating investment assets. (Eläkeuudistus, 2014.)

The overall impacts of the regulation changes have been analysed in various sources. However, there is a lack of research regarding the precise impact on investment allocations within the pension insurance companies. Due to this need, the purpose of this Master's Thesis is to examine asset allocation within the framework of the new solvency regulations, and in more detail, the impact of these changes on pension insurance companies' investment returns.

1.1 Research problem

The research will focus on Finnish pension providers and the solvency regulations. Year 2017 is bringing new challenges to pension insurance companies. As pointed out, the upcoming regulations newly define the calculations regarding solvency capital and solvency limits, creating a possible impact on the pension insurer's asset allocations. The aim of the research is to examine the new regulations and, moreover, the effect they will have on optimum asset allocation strategies and investment returns. To be more precise, the research question for this Master's Thesis is:

- How does the 2017 pension reform influence asset allocation and returns in Finnish pension insurance companies?

Asset allocation in this research is narrowed down to the broader concept of asset classes, and more precisely to the relevant classes for pension companies: equities, cash, bonds, real estate and alternatives. Hence, individual assets, geographical allocations or more detailed portfolio choices are not in the scope of this research. Asset allocation will be considered from a strategic decision-making point of view, whereas tactical, more often short-term investment decisions will not be focused on.

To narrow the scope of the research more in detail, the research will cover solvency regulations for insurance providers in Finland in the private sector, operating under the earning-related pension scheme. The public sector pension providers are also required to follow strict regulations on solvency and technical provisions, which slightly differ from those of the private sector. For the sake of clarity, these two sectors will not be separately discussed instead, the main focus will be kept on the subject of the pension reform impacts on asset allocation and returns in Finnish private pension insurers.

1.2 Research Methodology and Hyphoteses

Before formulating the research objectives, a simplifying assumption regarding pension insurance companies needed to be made. This assumption builds a starting point or base for the research: Finnish pension providers follow past, relatively generalised, investment allocation strategies, and based on the available past data, a stylised pension fund can be created to represent a typical Finnish private pension insurance company. The research objectives are then as follows:

(1): How would this stylised fund perform under the new regulations in comparison to the old regulations?

(2): How could the allocation be changed for the fund to perform better under the new regulations?

In terms of analysing different risks and returns, when it comes to objectives of a Finnish pension provider, maximising investment returns and minimising the risk of insolvency are the two main goals. To analyse the relationship of these variables, the following targets including the relevant risk measures were defined for the stylised fund:

(1): Maximise the relative fund return, while minimising the risk of insolvency.
(2): Minimise probability of reaching solvency limit, while maximising the solvency ratio.

The actual research was conducted in GLASS, a software model developed by Ortec Finance. Ortec Finance is a global provider of technology and advisory services for risk and return management. The company has been established in Rotterdam in 1981 and it is currently operating with 200 employees. Their mission is to improve investment decision making by the help of scenario modelling. The model and the methodology used to derive the scenarios will be discussed in more detail in subsection 1.3.

To begin the research and to have all necessary variables set in place in GLASS, a base case of a stylised pension insurance fund needed to be build. The assets and liabilities for this fund were gathered from publications and reports by the Finnish Pension Alliance (TELA), the Finnish Centre for Pensions (ETK) and the Finnish Financial Supervisory Authority. In addition to the current regulations, the GLASS model was constructed with all the new 2017 regulations, regarding solvency calculations and factors relevant for the technical provision set in place.

To answer the research question on the impact of the new regulations, GLASS was used to run several scenarios in order to analyse possible effects. Future scenarios were then used to draw conclusions on the impact of the new regulations. This was done by running the same scenarios with both the pre- and post- 2017 regulations set in place separately. This allowed for comparison, while keeping other factors constant. As the key assumption behind the research question is that the regulations indeed would have some effect on the allocation strategies, the solvency capital requirement and the probability of insolvency were used as risk measures in the research and the analysis.

The final conclusions are necessary to be based on assumptions that optimum investment decisions are made, and therefore the scenarios can be considered consistent and reliable predictions on investment decision making in pension insurance companies. To begin the study, a static mix strategy was first applied to examine the reforms and answer the research objectives.

The hypotheses for the first research objective are as follows: The actual investment returns will not differ from each other, if assumed that the asset allocation will be static and the same under both sets of regulations. However, the dynamics of the three buffer funds under the total liabilities should change as the regulations allow a lower equity linked buffer, and the equalisation reserve will no longer exist on its own, but will be included in the clearings reserve. The regulation changes on the equity linked buffer seem to provide an opportunity for a higher risk appetite, implying that with the same allocation strategy, the solvency capital requirements could also be slightly lower under the new regulations.

To create hypotheses for the second research objective, the equity linked buffer and the more precise risk categories determined by the new regulations underline the predictions. As the equity linked buffer limits are eased and the overall limit for equity allocation is set to 65% from total assets, the structure and strategies on allocations might probably change. The changes in regulations would suggest a higher allocation in equity and therefore likely a lower allocation for fixed income. Allocation among the rest of the asset classes will most likely not experience any considerable changes. However, as the solvency limit calculations will become more impacted by the actual investment assets, taking into consideration risks and expected returns, a change into riskier asset allocations is not expected to be very drastic.

1.3 GLASS and the Dynamic Scenario Generator -model

Ortec Finance Scenario -sets (OFS) represent the results from continuous innovations and experience in building and applying scenarios for clients around the world. A new scenario set is available every month and it represents the most realistic reflection that Ortec Finance can produce on how economies and financial markets might evolve in the future. Available horizons vary from one month to decades, and the scenario sets hold a worldwide coverage of more than 600 economic and financial market variables. The models that are used include combinations of filtering techniques, Dynamic Factor Models and stochastic volatility. The software runs on a database, has an interactive interface, with multiple automated data sources and uses parallel computing.

The OFS are built with a combination of models and methods referred to as the Dynamic Scenario Generator (DSG). The framework of the whole model is by first built based on six empirical laws, or so-called *stylised facts*. On top of these stylised facts the DSG model is built with *out-of-sample testing of risk and return* as well as *views and expert opinion*. (Steehouwer 2016, 28.) The following three subsectors will go through all of these three building blocks in order to formulated an overall, yet a relatively high level, understanding of the GSD model.

1.3.1 Stylised Facts

The first important stylized fact in the model framework is the concept of “term structure of risk and return”. The notion behind this fact is that risk and return in terms of volatilities, correlations and distributions can differ depending on the investment horizon. For instance, some variables have lower volatility due to “mean reversion” while others have higher volatility due to “trending behaviour”, implying that volatilities increase with the horizon, often not following a pattern implied by the simple random walk model. (Steehouwer 2016, 29.)

The second stylized fact is business cycles, which are based on medium term fluctuations around underlying long-term, structural trends in economies and financial markets. The model takes these into consideration through modelling a system of business cycle indicators, similar to the system of indicators maintained by the Organization of Economic Cooperation and Development (the OECD). (Steehouwer 2016, 30.)

The third stylized fact is time-varying volatility. Assuming constant volatility is not realistic, and therefore any model using constant financial market volatility is unrealistic. This is particularly important when generating short-term scenarios.

Also highly important in generating realistic short term scenarios is the fourth stylized fact, tail risk. This risk arises in stressful market conditions, as correlations between asset returns typically increase in bad economic and financial conditions. Due to this, the benefits obtained from diversification, spreading investments across asset classes and regions, are actually not there to the full extent, when they would be needed the most. For example, Copula-based modelling can be used to appropriately catch this risk. (Steehouwer 2016, 33.)

The fifth stylized fact is non-normal distributions. Distributions are in reality often not symmetrical. For example, return distributions can be skewed to the left, whereas interest and inflation distributions tend to be skewed to the right. Therefore, realistic scenarios need to incorporate non-normal distributions. (Steehouwer 2016, 34.)

The sixth and final stylized fact covers yield curves and term structures, reflecting to all maturity related variables. Generating realistic scenarios for such variables is more complicated than for regular variables, because their processes are affected by three dimensions: time, value and maturity. Due to the complexity, accurate modelling of yield curves is challenging. (Steehouwer 2016, 34.)

The basic notion behind the stylized facts have been presented above, yet these are just scratches of the surface. To dig in deeper, all stylised facts have even more detailed “*sub-stylized facts*”, or fundamental empirical laws defining them. Steenhouwer (2015) opens all of these facts in to more precise descriptions.

1.3.2 Out-of-Sample Testing of Risk and Return

To continuously expose the model calibrations, referring to the different dynamics imposed in risk and return over time, the model is tested thoroughly. According to Steenhouwer (2016, 36), it is important to perform such tests on an “out-of-sample” basis. This means that when calibrating and estimating models, it is prohibited to use future data that is also used to evaluate the quality of the short- to medium-term risk and return of the scenarios. There is a large-scale back-testing framework put in place in order to estimate the reliability of model.

1.3.3 Views and Expert Opinion

The final building block used in the DSG model are *views and expert opinion*. This is quite different from the first two parts, *stylized facts* and *out-of-sample testing*, which are based on the assumption that historical data contains relevant information for generating realistic scenarios for the future, and that the models used are able to adequately capture this information. In addition to the model based approach, expert opinion is needed in improving the properties of the scenarios. Other information that has not been captured by the models, can be gathered, for example, from model experts, asset class experts or regional experts. Steenhouwer (2016, 39) reminds the fact that no matter how realistic the models can be, the notion that they remain models should not be forgotten. Of course, expert opinion is not applied to all of the variables, but typically on the “difficult” ones for which relevant historical data to base the scenarios on is scarce.

Regarding *views*; there are times when information can be available, but, the information is not, or not sufficiently, contained in the historical data on which the scenario models are calibrated. Nevertheless, these views might be very relevant for the scenarios of the future. Therefore, the DSG contains also flexibility in imposing views on the scenarios.

1.3.4 Scenario Construction by Factor models and other

Based on these three above described building blocks, the DSG model combines horizons and frequencies by decomposing time series data into three components: *trend scenarios*, *business cycle scenarios* and *monthly scenarios*. Then each of the component is calibrated by a suitable Dynamic Factor Model, which produce scenarios for the corresponding components for all variables. Finally, these scenarios are recombined into scenarios of the total variables.

The factor models used differ between the long-term trend component and the medium-term business cycle and short-term monthly components. Modelling long-term trends DSG uses a more structured method which is described by Boer et al. (2016). A more general factor model approach is then used for the medium- and short-term components, which is described by Lee & Steehouwer (2012).

To capture all of the stylised facts in the overall model, a few more modelling approaches are included in the DSG. To model equities, indirect real estate, commodities, credit spreads and excess returns and interest rates across countries, high dimensional stochastic volatility modelling is used. High dimensional tail risk modelling is applied for all variables that do not suffer from the curse of dimensionality. And lastly, government bonds, swap spreads, break even inflations and credit spreads are modelled by the Nelson-Siegel based term structure or yield curve modelling.

To describe in more detail, the DSG model and its full complexity would require a separate paper. Therefore, describing the model in this thesis is kept relatively high-level and limited. To acquire deeper understanding, Steehouwer (2016) explains the full methodology used in constructing the DSG.

1.4 Structure of the Study

This thesis will first discuss the key concepts and theory regarding asset allocation, whereas subsections 2.1 and 2.2 will bring out the main findings from earlier studies relevant to the subject matter. Subsection 2.3 represents the literature review and this part will cover findings conducted by earlier research on regulatory changes and their impacts on asset allocation or optimal portfolio choice. For example, requirements such as Solvency II came applicable for the whole European insurance industry from the beginning of 2016. The impact and expectations of these new regulations have been discussed by scholars, such as Höring (2013), Niedrig (2015) and van Bragt et al. (2010). Earlier research regarding the effects of introducing regulatory risk-based capital requirements on insurance companies' investment portfolios include cases on the U.S. Risk-Based capital requirements (introduced in 1994) and the Swiss Solvency Test (SST), which was introduced in 2006. The papers regarding these subjects will briefly be discussed.

Section 3 will cover the solvency regulations applicable to Finnish private pension providers. After discussing the current regulations, section 4 specifies the changes in the new regulations. The empirical research, including the gathered data and the balance sheet of the stylized fund is then presented in section 5. After the specifications of setting up the stylised fund, the actual simulations conducted with GLASS are implemented. Section 6 discusses the expected investment returns, the performance of the stylised fund and portfolio optimisations achieved through the simulations.

After the results of simulations have been presented, the overall results and analysis is discussed in section 7. This part will also include findings with evidence to support or contradict the hypotheses. Finally, section 8 provides overall conclusions. In addition, some possible future applications, as well as future research suggestions on the topic are discussed.

1.5 Background

In Finland, the earnings-related pension model is defined as a partially funded benefit scheme. One part of the future pensions, under the private-sector pension acts for employees (Employees Pensions Act and Seafarer's Pensions Act), is pre-funded, while the rest of the pensions are financed through payed pension contributions. According to law, a pension provider needs to surpass its technical provision by owning enough of assets, i.e., by having an adequate amount of solvency capital to surpass its liabilities. The technical provision is an estimate of the total amount of future funded pensions which the pension insurer is liable for. Investment assets of pension providers are required to cover the technical provision. (ETK, 2016b.)

Pension providers must invest their funded assets profitably and securely, which means that investments need to be spread among different categories with different risks. This means that investments must be spread across different asset classes and geographical regions. According to the Finnish Centre for Pensions, at the end of year 2015, the largest share of assets was invested in shares (41%), following 33% in bonds, 9% in other interest-bearing instruments, 9% in real estate and 8% in hedge funds. From the total wealth, around 27% was invested in Finland, 23% in the euro area and 50% outside the euro area. (ETK, 2016b.) The aim of diversifying the investment portfolio is to gain as good a return on the investments as possible, while simultaneously keeping the risks at a manageable level. Earnings-related pension providers in the private sector are subject to solvency regulations that limit the risks which can arise from their investments.

Since the 2008 financial crisis, regulations on financial operations have become more tightened and demands on transparency as well as risk control have brought the industry and its operations an increasing amount of impact. Solvency regulations on pension insurance companies set their own limitations, when it comes to constructing the most profitable strategy with asset allocation. The solvency ratio, which is calculated by dividing the solvency capital with the technical provision, ranged between 14.3% and 31.4% among the five largest pension insurance companies in Finland at the end of 2015 (TELA, 2016b). Hilli & Pennanen (2012) state that the current regulations on solvency limits bring challenges to appropriate risk management, as well as to the desired strategic asset allocation. Calculations of the solvency limit are based on discounting the future pension liabilities and modelling the investment allocations based on a one-year investment horizon.

When considering the nature of future pension liabilities and their long duration, Hilli & Pennanen (2012) argue that the current method of calculating the funded pension payments and the technical provision used in calculating solvency limits, does not take into consideration the uncertain future cash flows consistently enough. Hilli & Pennanen also refer to recommendations provided by the International Association of Insurance Supervisors (IAIS) and the Solvency II directive, stating that the technical provision should be based on the cash flows generated by the insurances. The current solvency limit, based on the one-year investment horizon planning, does also not take account of some characteristics of certain long-term financial instruments. Since the short-sighted view was recognised during the 2008 financial crisis, several authorities such as the Ministry of Social Affairs and Health suggested means to reduce the pro-cyclical aspect from the solvency framework. (Ibid.) The earnings-related pension scheme also faced criticism due to its complexity and lack of transparency, which naturally created discussion on the possible improvements on the system.

Based on Hilli & Pennanen (2012), the technical provision, the level of the insurance payments and the solvency framework, until the new upcoming regulations, have all been built by quantitative means and according to the following three subjective factors:

1. *Probability distribution*: the views on pension liabilities and investment returns development and the uncertainty related to these. Due to the long duration of pension liabilities, the related cash out-flows are prone to enormous uncertainty – insurance risks. In addition, the investment market also carries its own uncertainties (market risks), which highly affect the adequacy of the assets covering the future liabilities. The most relevant risks concerning a pension insurance company include life expectancy risk and pension related index rise risk, as well as market risks, such as interest rate risk, equity risk and debt risk.

2. *Risk preferences*: the accepted risk level used to cover pension liabilities. As the cash flows on pension payments and the investment returns both are uncertain, there always exists the risk that the investment returns fall below the required level to be sufficient enough to cover the liabilities.

3. *Hedging strategy*: the investment strategy that is used in investing the assets covering the technical provision. The allocation of the assets naturally affects the adequacy to cover future liabilities. Choosing and managing an investment strategy is among the most important tasks a pension provider faces.

Based on these three factors, Hilli & Pennanen (2012) also argued that a new simpler method, a real cash flow focused model, would be more suitable for calculating solvency capital and the correct technical provision.

Improvements and changes on the current earnings-related pension system were introduced by multiple sources, and finally in 2015, laws regarding the calculations of solvency limits and technical provisions were set in place. These new regulations will be in effect as of the 1st of January 2017.

2 Key Concepts and Literature Review

This section will first cover the key concepts relevant to the research, followed by a literature review on earlier studies. First, the theoretical framework on asset allocation will be shortly discussed, including the concepts of static mix and portfolio insurance allocation strategies, as well as a brief distinguishing of the differences between strategic and tactical asset allocation.

2.1 Asset allocation

Asset allocation is a process of strategically combining securities across a range of different asset classes and geographical regions. Asset allocation suggests the relative weights of each asset class in such a way that one can create an optimal portfolio with the maximum expected return for a given risk level, or the minimum risk for a given expected return. (Lexicon, 2016.) Portfolio diversification helps to reduce risk and remain a stable performance. The investor's investment horizon and the ability to tolerate risk highly determine the appropriate allocation mix.

Strategic asset allocation, defined by UBS Financial Services (2009), specifies the proportion of different asset classes in a portfolio designed to provide a desired risk and return profile over a long period of time. The framework of a strategic asset allocation specifies the range of allocations adequate for different risk tolerance levels. For example, investors with lower risk tolerance should have lower exposure to more volatile, higher risk assets, such as shares and commodities, and higher holdings to less volatile and lower-risk assets, such as bonds and cash. Strategic asset allocation is designed for long-term return and risk expectations, however, the framework should be periodically evaluated and adjusted when necessary. Necessary adjustments on allocation arise from investment landscape material changes, such as shifts in longer-term growth rates, shifts in risk premiums or changes in inflation expectations. (UBS, 2009.)

Tactical asset allocation is defined as; a measure of engaging in short-term and tactical deviations from the strategic allocation to profit on unusual or exceptional investment opportunities. This adds more flexibility and a market timing component to the portfolio, providing the opportunity to participate in economic conditions more favourable for one asset class than for others. (Lexicon, 2016.) The purpose of tactical asset allocation is to identify asset classes that are expected to outperform in the short-term or underperform in their longer-term expectations. This is done by focusing on key drivers, such as relative valuation of assets, momentum, business cycles, sentiment, and fiscal and monetary factors. Portfolio performance can be enhanced by temporary underweighting or overweighting components of the longer-term strategic asset allocation framework. Despite the differences between the two strategic and tactical allocation, they should be implemented so that they work as complementary components in an overall comprehensive investment framework. (UBS, 2009.)

Multiple research papers and theories covering the subject of asset allocation portfolio theories can be found. According to most researchers, such as Campbell & Viceira (2002) for instance, modern finance theory is believed to have started with the mean-variance analysis of Markowitz (1952). Markowitz described how investors should choose assets, caring only about the mean and variance of the portfolio returns over a single period. Figure 1 shows the results of his analysis as a diagram.

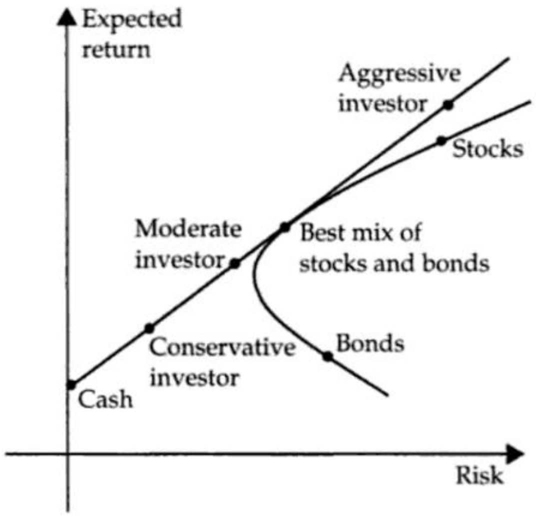

Figure 1. Mean – Standard deviation diagram (Markowitz, 1952. In: Campbell & Viceira 2002, 2.)

The curved line in Figure 1 represents the set of means and standard deviations which can be accomplished with different combinations of stocks and bonds in a risky portfolio. When cash, or cash equivalent investments are added to the portfolio, the set of means and standard deviation that can be achieved forms a straight line. Here, the straight line then represents the mean-variance efficient frontier, which offers the highest mean return for any given standard deviation. (Campbell & Viceira 2002, 2.)

Even though, the model presented above is relatively simplified and does not take into consideration the time horizon of the investor, and therefore lacks the analysis of effects on return over time, among other relevant factors, it is the most commonly-used portfolio theories still today.

Ibbotson and Kaplan (2000) find in their research that about 90% of the variability in returns of a typical fund across time is explained by strategy, around 40% of the variation of returns among funds is explained by strategy, and the return level is explained roughly 100% by the required return level. Campbell and Viceira (2002) also point out the impact of the investors character and why portfolios of risky assets might be appropriate for different investors, depending on either their personal policies or policies that have been set by their employer. Investors differ with backgrounds and objectives: One’s investment horizon might be relatively short, whereas for others, it may be longer, such as saving for retirement. All of these would require a different approach for asset allocation. In addition to different investment horizons, investors also differ in their characteristics of their labour income. As Campbell and Viceira (2002) put it, young investors may expect many years of income, while older investors may need to finance a part of their consumption from their accumulated financial wealth.

Finnish pension insurance companies’ assets are most often divided into five main classes: cash, bonds, stocks, real estate and others, as this follows the asset class division specified in the current regulations (ETK, 2016c; 395/2006, 6 §). *Others* here is mostly referring to alternative assets, such as; commodities, derivatives, foreign currency, REIT’s, private equity and hedge funds. (Wilcox & Fabozzi, 2013.)

According to Campbell and Viceira (2002), conservative investors are often encouraged to hold more bonds, relative to stocks, than aggressive investors. This seems to be contradicting with earlier theoretical assumptions on asset allocation. The mutual-fund separation theorem, a building block of the basic Capital Asset Pricing Model (CAPM), tells us that more risk-averse investors should hold more of their portfolios in the riskless assets. However, the composition of risky assets should be the same for all investors. Canner et al. (1997) brought out this contradiction between reality and economic theory by introducing the concept of an *asset allocation puzzle*.

The Capital Asset Pricing Model depicts how rational investors should combine risky assets with a certain returns distribution. However, the CAPM model, as explained by Canner et al. (1997), is based on four important assumptions:

1) All assets can be freely traded.
2) Investors operate over a one-period horizon of planning.
3) Investors can hold long or short positions in all assets.
4) Investors are indifferent between any two portfolios as long as the means and variances are identical.

Based on these assumptions, one is able to derive a strong conclusion that regardless of the amount of assets in the economy, two mutual funds comprise the set of efficient investment portfolios. By adding a fifth assumption that *a riskless asset exists,* Canner et al. (1997) conclude that the riskless asset and a single mutual fund of risky assets are enough to produce all efficient portfolios. Holding these conditions, it would also be evident that all investors hold risky assets in the same proportion. Therefore, the ratio of bonds to stock would in this case be the same for every investor. The appropriate balance of risk and return would be achieved by merely varying the proportion of the riskless asset within the portfolios. (Canner et al. 1997.)

Canner et al. (1997) argue that popular advice on asset allocation does not follow the simplified textbook theory, however it is more complicated than indicated and yet systematic. By relaxing the five assumptions underlying the CAPM based mutual-fund separation theorem, Canner et al. (1997) try to explain the discrepancies between portfolio theory and the recommendations of popular financial advisors. Canner et al. conclude that explaining popular advice is difficult using models of rational investors, and that this is hardly the only puzzle that comes across in financial economics.

2.2 Investment Assets and Allocation Strategies

According to the Finnish Centre for Pensions, there are no large fluctuations in the realised return for different types of investments in the long-run. The annual nominal average return from interest-bearing investments, shares and share-like instruments has been over 4%, whereas investments in real estate have brought an annual yield of slightly under 6%. (ETK, 2016a.) At the end of year 2015, the investment portfolio for the whole sector was distributed among the main categories as follows: investments in equities and equity-like instruments, 48.9%, amounting to EUR 88.5 billion; fixed-income investments, 41.6%, amounting to EUR 75.3 billion; and real estate investments, 9.5%, which amounted to EUR 17.1 billion. (TELA, 2016b.)

Based on statistics by TELA (2016b), the structure of the investment portfolios of the private sector pension providers has changed throughout the years. The share of equities and equity-like instruments has clearly risen throughout the years. In 2005, the allocation into these category types was only around 33.5%, compared to the level of 48.6% of total investments in 2015. This indicates that the willingness to take higher risks and search for investments with higher returns has increased. Diversification among equities and equity-like instruments has also increased, as clear internal shifts within this category have taken place. Statistics also show that the percentages in other subcategories of equities and equity-like instruments have risen during the past ten years. These subcategories include hedge funds and other equity investments, such as unlisted stocks and venture capital investments. (TELA, 2016b.)

The same statistics also show that the share of fixed-income investments had declined from 2014 by 0.3 percentage points in the private sector. At the end of 2015, the share of fixed-income investments was 39.8%. At the same time, the share of money market investments had risen by 0.7 percentage points. Over a longer period of examination, a clear trend can be outlined, the share of bonds and convertible bonds has fallen nearly every year, particularly from 2004 until 2010. In 2004, the share was over 50%, whereas since 2010, the share has stabilized at roughly around 30%. (TELA, 2016b.)

TELA statistics (2016b) also indicate that the share of investments in countries outside the euro area is showing a rising trend from the past ten years, whereas the relative shares of Finland and other euro countries have in correspondence decreased in the total investment portfolio. The changes in the long-run can be explained in part by the fact that pension insurers have diversified their geographical exposure, therefore, also managing related risks more efficiently than earlier. Moreover, as pension assets have grown larger, the search for sufficient investments also requires heading outside the Finnish markets. When it comes to investing pension assets, the cornerstones, as mentioned before, are profitability and security. One should always bear this in mind, because profitability and security can be achieved best by diversifying effectively and by searching for the best possible investment opportunities all around the world. (Ibid.)

Two of the most widely studied dynamic allocation strategies include the static mix (or *fixed-mix*) and *portfolio insurance* strategies, discussed in works of Cesari & Cremonini (2003), as well as in Perold and Sharpe (1995) among others. Koivu et al. (2005) evaluate, by the means of a stochastic model, pension companies long term solvency and bankruptcy risk by considering the two allocation strategies mentioned.

In a static mix strategy, the portfolio is frequently rebalanced to a pre-determined asset distribution. This is not the most dynamic approach to investment decision making, as whenever the relative values of assets change, purchases and sales are needed to return the portfolio to the desired mix. The portfolio insurance strategy, or constant proportion portfolio insurance as in Perold and Sharpe (1995), is formed according to the following:

$$Dollars\ invested\ in\ equities\ =\ m\ (\text{assets} - \text{floor}), \qquad (1)$$

where *m* is a fixed multiplier. In this strategy, the multiplier and the floor below which the portfolio value should not fall are selected by the investor. The decision rule here can be considered as determining a constant multiple to a “cushion” in order to manage the exposure to equities. (Perold and Sharpe,1995.)

In a long-term solvency evaluation study, Koivu et al. (2005) determine the static mix strategy by means of a vector of five numbers to compromise the portfolio weights for cash, bonds, equity, property and loans. Statutory restrictions set upper bounds for equity and property, and the proportion of loans is kept almost at zero, 0.145% of the reserves, each year. The varying weights (excluding loans) were chosen as follows: *cash* from 0 to 0.03; *equity* from 0 to 0.5; and *property* from 0.1 to 0.4. Bond investments were then chosen so that the total weights of the portfolio added up to 100%. In the portfolio insurance strategy, the weights for cash and property are varied in the same manner as in the static mix strategy, and then the rest of the wealth is allocated between bonds and equity, representing the more liquid assets. In this setup, the proportion of equity at time *t* is formulated by:

$$w_{S,t} = \begin{cases} \min\left\{(1 - w_C - w_P) min\left\{\rho\left(\frac{W_t - L_t}{W_t}\right), 1\right\}, 0.5\right\} & if \;\; W_t - L_t \geq 0 \\ 0 & if \;\; W_t - L_t < 0, \end{cases} \qquad (2)$$

where ρ represents a risk tolerance parameter, which indicates how the equity proportion increases with the company’s solvency ratio, $(W_t - L_t) / W_t$, where W_t denotes the company’s assets and L_t the reserves, in the beginning of the year *t*. The percentage that is invested in equity is a constant multiple of the pension company’s solvency ratio, where, the higher the ρ is, the higher the stock market allocations are, bearing in mind the constraints, in this case, of having at most 50% of the total wealth invested in equity. If the company’s wealth W_t turns less than the value of its reserves L_t, representing the floor, the allocations in equity are set to zero and investments are shifted in bonds. (Ibid.)

According to Koivu et al. (2005), the portfolio insurance strategy is a realistic decision making approach for pension insurance companies because they allocate more wealth to risky assets when the solvency ratios improve and reduce their exposure to stock markets as they draw close to insolvency. Koivu et al. perform 1 000 simulations for each strategy with a 20-year time horizon, and conclude that the best portfolio insurance strategies clearly dominate the best performing static mix strategies at all adequate risk levels. The more dynamic allocation strategy of portfolio insurance allows the initial equity allocation to be kept higher compared to the static mix portfolios with equivalent probabilities of insolvency. (Ibid.)

These two different examples of allocation strategies were presented in order to provide the reader an understanding of possible approaches in developing allocation strategies. However, in practice there exists as many strategies as there are investors. For the purpose of this research, the simulations presented later on follow only a static mix allocation rule. This has been defined purely for simplicity, as it is sufficient enough for the purpose of this research. Catching the impact of the pension reform should not be dependent on the allocation strategy.

2.3 Literature Review

The effects of introducing regulatory risk-based capital requirements on insurance companies' investment portfolios have been discussed by many scholars. Studies on impacts of the Solvency II regulation provide some implications on how similar regulatory changes have affected asset allocations in insurance companies.

Solvency II regulations have come in effect across European countries on the 1st of January 2016. Therefore, earlier research at the point of conducting the study at hand, mostly covers the expected effects. Höring (2013) argued that the Solvency II regulations would not significantly influence the insurance companies' investment strategies. According to his findings, companies with a good credit rating and regulatory solvency position are not expected to change their asset allocations significantly due to Solvency II (Höring 2013, 270). Niedrig (2015) discusses optimal asset allocation under Solvency II and Basel III in the current low interest rate market environment. He finds that life insurer's portfolio composition will change over the mid-term as the need to engage in investments with higher risk increases. Based on his findings, the risk appetite of life insurers will increase, as the gap between the return on assets and the average guaranteed return on policyholder's accounts will become smaller. In addition, he also states that life insurers need to increase the amount of equity capital to cope with the change in their asset allocation and the given economic conditions. (Niedrig 2015, 68.)

Van Bragt et al. (2010) simulate the results of the fourth Qualitative Impact Study (QIS4) parameterisation to examine a typical insurance company undertaking different investment policies. They conclude that the asset allocation and asset duration have a major impact on the regulatory capital requirements. Under Solvency II requirements the investment policy has a clear impact on the solvency ratio, unlike with Solvency I. This alone implicates that investment policies need thorough planning in order to be optimised under the requirements brought by Solvency II. (van Bragt et al. 2010, 108.)

Earlier studies on regulatory changes affecting insurance companies have been done on the U.S. risk-based capital requirements and the Swiss Solvency Test (SST). Petroni and Shackelford (1996) studied the effects of the risk-based capital requirements, introduced in 1994, on U.S. life insurers' investment portfolios. In their results, no significant evidence was found for a major restructuring of the insurer's investment allocations. In Switzerland, Eling at al. (2008) discuss the impacts of the SST for Swiss insurance companies' asset and liability management, corporate financing and product design. The authors conclude that the SST will motivate insurance companies to make changes in their asset allocations. The expected changes were: shifts towards long-term bonds in order to reduce duration gaps, increase in the rating quality of bond portfolios, as well as a decrease in real estate exposure.

To conclude, regulatory changes impacting the investment policies through tightening risk-based capital requirements most likely do influence asset allocation strategies. The extend is dependent on the nature of the new regulations, the insurance company's solvency standing and credit rating, as well as the possible impact of other external factors acting simultaneously on the insurance or banking markets.

3 Regulations on Finnish Pension Providers

The Employees Pensions Act (TyEL) and the Seamen's Pensions Act (MEL) regulate the financing of the private-sector pensions. In the partially funded system the paid pensions are divided into two components depending on how the pensions are financed. The funded component represents a part of the pension which has been financed in advance through invested assets, and the part of the pension which has not been funded is referred to as the pooled component. Partly funded benefits include the old-age, disability and unemployment pensions. (Hietaniemi & Ritola 2007, 66-67.)

The regulatory setup for the pension providers is mainly divided into two parts: the technical provision and solvency requirements. From a balance sheet perspective, the technical provision represents the liabilities side, whereas the solvency capital represents the assets side.

3.1 Technical Provision

Pension providers are obligated to pay out and fund the pensions that they are responsible for, no matter the circumstances. To prepare for the risks related to investments and insurance operations, pension providers are required to have solvency capital as a so-called buffer fund. Each pension provider needs to have a sufficient amount of solvency capital to meet their risks, meaning that the company needs to have enough of assets to exceed their technical provision. The technical provision of each pension provider is calculated as an estimate of the full amount of future funded pensions. (ETK, 2016c.) The amounts are determined so that they will, on average, be sufficient for paying the funded part of the pension when the interest and mortality are taken into account (TELA, 2016d).

When calculating the technical provision, the future funded pension compensation is discounted with a technical interest rate of 3%. The fluctuating surpluses generated from investment returns are annually used to increase the funded old-age, disability and unemployment pensions. According to the fund transfer obligation, the size of these increases are determined by three components: discount rate, supplementary factor and equity linked factor. The supplementary factor is defined on the basis of the pension providers' average solvency and constitutes 18 per cent of the average solvency ratio of all authorised pension providers, calculated under certain restrictions, then weighted by pension liabilities, and reduced by the 3% discount rate. (ETK, 2016d.)

To have a buffer against fluctuations on equity returns, pension providers are required to have an *equity linked buffer,* which as a system allows equity risk to be spread among all the pension providers. The required transfer amount to the equity linked buffer is calculated yearly, based on each pension provider's equity returns. The amount is proportional to the technical provision and corresponds to 10% of the equity linked factor. The equity linked factor is determined after each quarter for the whole pension liability. The basis for the calculations of the factor is the average rate of return on listed shares in which pension providers have invested on during that calculation quarter. (TELA, 2016c.) This fund can be at minimum -10% and at maximum +5% of the technical provision. If the buffer fund exceeds the upper limit the excess amount is transferred to the old-age pension liability. Conversely, if the fund falls below the lower limit, the pension providers need to increase the fund from their solvency capital. (ETK, 2016d.)

The unfunded assets used to finance yearly pension expenditure are accumulated through the pooled component. The surplus or deficit of the pooled component formulates the so-called clearing reserve, which is a buffer fund to secure the pension providers liquidity. The Ministry of Social Affairs and Health has regulated the minimum amount of the clearing reserve to be 30% of the following year's pension expenditure. (Hietaniemi & Ritola, 2007, 73.)

In addition to the mentioned clearing reserve and the equity linked buffer, the technical provision includes one more buffer fund called the equalisation reserve. This reserve is a buffer for possible losses in the insurance business, and it is increased with the yield requirement rate. The reserve also has an upper and a lower limit, which are defined by the government and differ across pension insurance companies. If falling below the lower limit, investment returns are used to compensate the required difference. If the limit is exceeded two years in a row, the pension provider should compensate by increasing its customer bonuses.

To conclude the main concepts relevant in understanding the construction of technical provisions, there are three key factors to keep in mind. The technical provision needs to be adjusted by each pension provider with: a discount rate of 3%, the supplementary factor and the equity linked factor. (ETK, 2016d.)

3.2 Solvency Regulations

The solvency regulations on solvency limit calculations as well as the covering of technical provisions steer the diversification of investments in some detail. The limit is defined so that the amount corresponds to one year's need for solvency capital and attention is paid to the risks of the underlying business and the overall distribution of the investments (TELA, 2016a). According to the current regulations (1114/2006), when calculating the adequate solvency, investments are divided into five different categories based on their risks: money market instruments, bonds and debt certificates, real estate, shares and other investments (Figure 2). Within these categories the investments are then further divided into 20 different subcategories. These include for example, investments' geographical location, currency and credit rating of a bond's issuer.

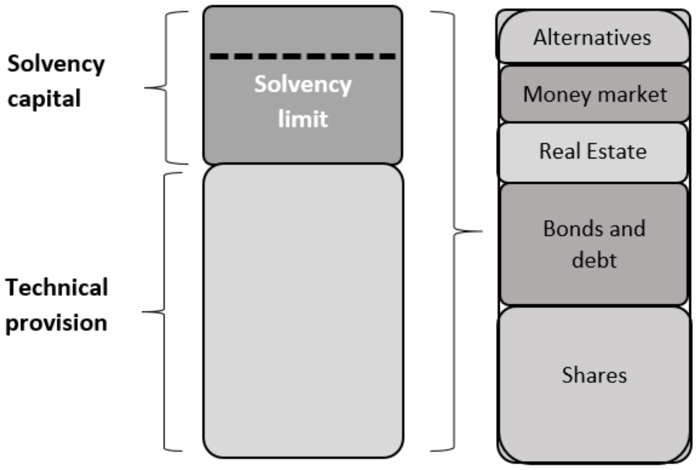

Figure 2. Solidity and Solvency limit (English translation from figure in: ETK, 2016c.)

The investment strategy, the expected return of each investment instrument's category as well as the inter-group dispersion and correlations on return, all affect the level of the solvency limit. According to the currently valid regulations, the solvency limit is calculated from the technical provision by multiplying the technical provision with value p, which at minimum is 0.05, and comes from the following formula:

$$p = \frac{1 + (k + Cb - \lambda)/100}{1 + (\mu - a\sigma)/100} - 1, \quad (3)$$

Where,

$$\mu = \sum_i \beta_i m_i, \quad (4)$$

$$\sigma_0 = \sqrt{\sum\nolimits_{i,j} \beta_i \beta_j s_i s_j r_{ij} + \lambda^2 S^2}, \tag{5}$$

and

$$\sigma = \sqrt{\sigma_0^2 \sigma_d^2 + 2\rho\sigma_0\sigma_d}. \tag{6}$$

β_i is the share of investments made in category i, from where, the first sub-group's share is reduced the value λ. This first sub-group (under category IV in 6 §), includes *stocks, shares and other equivalent commitments, traded publicly in the ETA and OECD -states*. The Council of State regulates the different investment categories (i): expected rate of return m_i, standard deviation of assets (in category i) s_i, correlation r_{ij} between the investment categories of i and j, volatility of the insurance business σ_d, and the correlation between the insurance business and investment returns ρ. (1114/2006, 10 §.)

In formula (3), k is the discount rate of 3% used to calculate the technical provision and b is the supplementary coefficient (also referred to as the b16 factor) on the pension liability determined by the Employees Pensions Act (395/2006) 171 §, valid from the day following the calculation day. λ is equal to 0.1, representing the required rate determined for the *equity linked buffer*, defined in the Employees Pensions Act (395/2006) 168 §. S, represents the deviation of the return on equity compared to the pension providers' average return on equity, and it receives a value of 4.5 in the formula. The chosen risk level for the multiplier a receives a value of 1.96, referring to a 95% confidence level under normality, and C is determined with a value of 0.5. (1114/2006, 10 §.) The fixed values have been defined by the Finnish government in Act (447/2015).

The solvency ratio, which is calculated by dividing the solvency capital with technical reserves, ranged between 14.3% and 31.4% among the five largest pension insurance companies in Finland at the end of 2015. Solvency can also be described by using the solvency position, which is calculated as the solvency capital in relation to the solvency limit. If a pension provider fails to attain the solvency limit, it will be subject to regulatory action. (TELA, 2016b.) If the solvency capital falls below the minimum requirement, which is one third of the solvency limit, the pension provider is required to submit a short-term financial plan to the Financial Supervisory Authority. Running out of solvency capital means a bankruptcy for the pension company. (TELA, 2016a.)

The Financial Supervisory Authority is in charge of supervising that these regulations on solvency and on the coverage of the technical provision is followed by the Finnish pension providers (ETK, 2016c). The ultimate aim of the investments is to reduce future pension contributions. According to the Finnish Pension Alliance (TELA), if the average annual return on investments rises by half a percentage point, the earnings-related pension contribution can be reduced by one percentage point. (TELA, 2016a.)

4 Changes under the 2017 Pension Reform

The new pension law, effective from the 1st of January 2017 onwards, includes changes on clauses which prescribe updated methods on calculating the solvency limit, clauses on efficient diversification of assets (315/2015), as well as reforms in the technical provision calculations. This section will go through all the relevant updated clauses and point out the differences, which then the GLASS model also implements in its pre- and post- 2017 regulation set ups.

4.1 Technical Provision

Under the new regulations the technical provision will experience some structural changes concerning the buffer funds.

The equalisation reserve will no longer exists on its own, but it will become part of the solvency capital and, therefore, the buffer for investment business fluctuations will not be treated separately. This will also slightly impact the mathematics of the solvency ratio, due to the fact that the equalisation reserve will technically be removed from the denominator and added into the numerator. The minimum amount of the clearing reserve will be decreased from 30% to 20% of the following year's pension expenditure.

The required transfer amount to the equity linked buffer will change from 10% of the equity linked factor, first into 15% in 2017 and then into 20% from 2018 onwards. The purpose is to allow an increase on equity stake in the whole earnings related pension system. Thereby, the change provides an opportunity to aim for higher rates of return. And, because of this collective equity linked buffer, the investment risk can also be increased in a controlled way. The weight of the equity linked factor used for calculating the yield requirement will also be increased from the current level of 10% into 20%. The fluctuation levels of the buffer fund are changed to an upper limit of +1% and a lower limit of -20%. (Kautto & Risku, 2015; 395/2006, 168 §.) The maximum limit on equity weight from all investments within a single pension insurance company will be set to 65% (315/2015, 7a §).

4.2 Solvency Capital Requirement

The new calculations on the solvency limit will take more precisely account of different risks involved in each investment decision and the insurance business. In comparison to the current, the new regulations base the solvency limit calculations on the invested assets, and not directly to the technical provision. The law no longer defines the five main asset classes to be used, but instead it divides the relevant risks related to investment assets into 18 different risk categories:

1. Equity risk; economical region of Europe and markets regulated by Switzerland

2. Equity risk; United States of America and Canada
3. Equity risk: other developed markets
4. Equity risk; emerging markets
5. Equity risk; unlisted equity, shares and private equity funds
6. Interest rate risk
7. Credit risk; government issued bonds or loans with credit rating AAA to AA
8. Credit risk; other than government issued bonds or loans with credit rating AAA to AA
9. Credit risk; bonds or loans with credit rating A to BBB
10. Credit risk; bonds or loans with credit rating B or below
11. Real estate risk; residential and land
12. Real estate risk; commercial and other
13. Currency risk
14. Commodity risk
15. Yield requirement risk
16. Insurance risk
17. Residue risk (hedge funds)
18. Other relevant investment risks

When determining the solvency limit, a risk value and an expected return are calculated for each risk category. In addition, the solvency calculations take account consideration dependencies among the different risk categories into. (315/2015.)

Each risk category j receives a risk value, which is calculated by:

$$V_j = \sum_i A_i \min[(1 + \tau L_i) S_j; 1]. \tag{7}$$

A_i referring to the amount of an individual investment i in a certain risk category j and L_i referring to leverage regarding the investment. S_j is the expected loss defined for the risk category j. The expected loss and the constant τ, which describes the ability to take debt, are both regulated by the Council of State. (315/2015, 12 §.)

Each risk category j also receives an expected rate of return calculated by the following formula:

$$\mu_j = \sum_i (m_j + L_i(m_j - m_6))A_i, \tag{8}$$

where m_j is the expected rate of return for category j and the constant m_6 refers to the expected rate of return for the interest rate risk category. m_j is regulated by an act from the Council of State. (315/2015, 13 §.)

When calculating interest rate and debt margin risk, the duration of the investment is also taken into consideration:

1) When calculating the expected rate of return for the category of interest rate risk, m_j is replaced with the product of m_j and the duration of the investment exposed to interest rate risk, which is squared with power of y. The constant y, depicts the shape of an interest rate curve used for discounting future cash flows, and it is regulated by an Act from the Council of State. 3 § (447/2015) states that the value of y is 0.134;
2) When calculating the risk value for the category of interest rate risk, S_j is replaced with the difference of the product of S_j and the duration of the investment exposed to interest rate risk, with the expected rate of return of the risk category while setting A_i to the value of one;
3) When calculating the risk value for the category of debt margin risk, S_j is replaced with the difference of the product of S_j and the duration of the investment exposed to debt margin risk, with the expected rate of return of the risk category while setting A_i to the value of one.

To calculate the risk value for the yield requirement category, the following formula is applied:

$$V_j = (k + bC - \lambda S_j)A_j, \quad (9)$$

here k represents the discount rate used for calculating the technical provision, and b is the supplementary coefficient on the pension liability determined by the Employees Pensions Act (395/2006) 171 §, valid from the day following the calculation day. S_j is the expected loss defined for the category and A_j is the technical provision or pension liability, from which additional insurance reserves have been deducted.

The expected return on the yield requirement risk is calculated with the formula:

$$\mu_j = -(k + b + D + \lambda m_j)A_j, \quad (10)$$

where m_j is the expected rate of return defined for the required rate of return risk, A_j is the technical provision or pension liability and λ is the required rate determined for the *equity linked buffer*, defined in the Employees Pensions Act (395/2006) 168 §.

Both, constant C in equation (7), depicting the decline of solvency, and constant D in equation (8), representing the expected growth of the supplementary coefficient, will be regulated by an Act from the Council of State. (315/2015.)

One step before finally calculating the solvency limit is calculating a concentration risk for all the different equity risk classes (2015/315, 11 §). This is done by calculating the expected loss S_j for each of the equity risk classes using the following formula:

$$\alpha \sum_i max\,[(w_i - \varepsilon); 0], \tag{11}$$

where w_i is the weight of the investment i exposed to the equity risk class j**.** The limit ε and the constant α depicting the risk increase caused due to crossing the limit, are both regulated by an Act from the Council of State.

The solvency limit is finally then calculated by combining the risk values and the expected returns from all the risk classes by the formula:

$$V_{total} = -\sum_i \mu_i + \sqrt{\sum_i \sum_j \rho_{ij}\,(V_i + \mu_i)(V_j + \mu_i) + \sum_j \beta_j^2 B_j^2} + \sum_k K_k. \tag{12}$$

V_j is the risk value of the risk category j, and μ_j is its expected return. ρ_{ij} is the correlation between the risk classes j and i, B_j is the smaller value, from risk class j, of the sum of the long positions and the sum of the short positions. Finally, K_k is the amount the counterparty risk k limit is exceeded (set in 2015/315, 8 §). The constant β_j, representing the risk exposure due to the difference of long and short positions, and the correlation among the risk classes ρ_{ij} are both regulated by an Act from the Council of State. Furthermore, the solvency limit is at minimum 5% of invested assets. (2015/315.)

5 Setting up a Stylized Fund in GLASS

As briefly introduced in subsection 1.2, a base case of a stylised pension insurance fund, representing a typical setup of a Finnish pension insurance company, works as a baseline for the research. The assets and liabilities for this fund were gathered from publications and reports by the Finnish Pension Alliance (TELA), the Finnish Centre for Pensions (ETK) and the Finnish Financial Supervisory Authority. To answer the research question on the impact of the new regulations, same scenarios with both the pre- and post- 2017 regulations separately set in place, needed to be run in GLASS. In practise this required building up two stylized fund variants otherwise identical, part of, one defined with the regulations in place before the changes of 2017 and the other defined with the new reformed regulations.

In order to start the simulations from the moment of the latest available official data on Finnish pension insurance companies and to avoid simulating performance, while having a transition phase of regulations set in place, the setup in the model was implemented so that the regulatory differences started straight from year one. To clarify, this means that the simulations that were run represent market expectations starting from the end of 2015. Nevertheless, the impact of the regulation changes could be analysed regardless of the implementation time.

To have a starting point for the stylized pension fund, the first steps included determining its assets and liabilities, thus gathering data over Finnish private pension providers in order to create a beginning balance sheet. The following two subsections will continue by describing this.

5.1 Assets

The assets of a pension company are composed of the contributions made by its clients, solvency capital and the investment assets. To start from the investment assets, the relevant asset classes, as well as the weights used for the allocations must be defined. The asset classes employed were determined based on the division used by TELA and, therefore, also used in most official reporting. These classes are equity, fixed income, real estate, cash and alternatives, which in this study comprised of hedge funds and private equity. The allocation weights were determined by the reporting of the total allocation of assets at the end of year 2015 by the private pension sector (available from TELA 2016e, 1). The allocation is presented in Table 1.

Table 1. Asset allocation as of December 31, 2015

Asset allocation	
Total	**100,0%**
Equity	**32,8%**
Europe	5,7%
Emerging Markets	8,6%
Finland	9,8%
Developed Markets	8,6%
Fixed income	**35,4%**
Government Bonds	12,1%
Bonds Non-Euro	5,4%
Bonds Euro	6,7%
Credit	23,3%
Alternatives	**15,7%**
Hedge Funds	9,8%
Private Equity	5,9%
Real Estate	**11,2%**
Cash	**4,9%**
MM investments	4,9%

A generalised in-depth allocation strategy was not available from any public source; therefore, the sub-categories include some assumptions. These assumptions were made under the allocation of equites in the developed markets, the division between non-European bonds, categories defining credit investments, and division among hedge fund and private equity investments. The more detailed asset allocation can be found from Appendix 1. For simplicity, bonds in the euro area were divided into two sub-categories, Finland and Germany. The returns on German and Finnish government bonds are considered in this research to represent the returns from European government bonds in general.

To simulate performance of the asset classes, each class was defined with a benchmark index to mimic portfolio behaviour. The benchmarks used for equites where MSCI Daily TR Gross country specific indices. Fixed income was divided into two categories: bonds and credit, respectively referring to government bonds and corporate credit bonds. GLASS models the return on government bonds using government term structures, based on nominal government interest rates. The total return on corporate credit bonds were modelled using a combination of government term structures and corporate spread term structures. All of the stylised bonds were created to follow a five-year maturity, based on an assumption that pension insurance companies divide their allocations into short term and long-term bonds, which, on average, vary with roughly a maturity of 5 years (this maturity also used by Koivu et al. 2005).

The real estate class was divided to follow two benchmarks, the total return indices of offices and residential housing in the Netherlands. Even though these indices do not directly track the Finnish real estate market return, these indices were used as the Finnish benchmarks were not available. Nevertheless, the Finnish real estate market is relatively close to the Dutch market and, therefore, the returns represent closely the returns of the Finnish sector. Cash, or money market investments, were modelled through the Finnish government interest rate by using a maturity of one year. The alternatives were divided in two, hedge funds and private equity investments. Hedge fund investments were further divided into four different categories, based on statistics of common hedge fund allocation strategies reported by Pictet (2015, 5), gathered from the HFR Global Hedge Fund Industry Report. These four strategies that are: *Equity hedge*, *Event-driven*, *Macro* and *Relative value* all represent different risk categories determined under the new 2017 regulations. Private equity was simply divided into venture capital and buy-out style investments.

Data for future pension contributions was gathered from estimations published by ETK (2016e; 2016f) and the Financial Supervisory Authority (2016a). A beginning salary sum, representing the total wage level of the contributors at the end of 2015, was required in order to create future cash flow calculations. The data was available from publications by Financial Supervisory Authority (2016a).

5.2 Liabilities

The total liabilities constitute of the technical liability, representing the discounted future pension payments, and the three buffer funds; clearing reserve, equity linked buffer and the equalisation reserve. The technical liability is calculated through future cash flow expectations, where future contributions by policyholders are calculated by taking a fixed 24% of expected salary sums. 24% is the average contribution of wages (ETK, 2016f), and it includes the average client bonus of 0.5% (ETK, 2016g). Based on statistics provided by the Financial Supervisory Authority (2016a), the salary sum in Finland at the end of 2015 was around EUR 51 billion. By using this value, the price index expectations as well as wage inflation data, the future contribution cash flows could be estimated.

From the total contribution, a pooled component of 19.9% represents the percentage that goes to the clearing reserve (ETK, 2016f). At the end of 2015 the clearing reserve was roughly EUR 9.3 billion (ETK, 2016e). The equity linked buffer was around EUR 3.7 billion (Financial Supervisory Authority, 2016c), and the latest equity linked factor used for the buffer was 12.32% (Työeläkelakipalvelu, 2016). The equalisation reserve held was roughly EUR 3 billion at the end of 2015 and the solvency capital in total was EUR 23.7 billion. Total liability level was EUR 84 billion, and a solvency ratio of 28.2%. (Financial Supervisory Authority, 2016b.)

5.3 Balance Sheet at the end of 2015

As a summary of the stylised fund, Figure 3 represents the setup of the balance sheet at the end of year 2015. The assets consist mainly of the investments, and the solvency capital is the difference between the assets and liabilities.

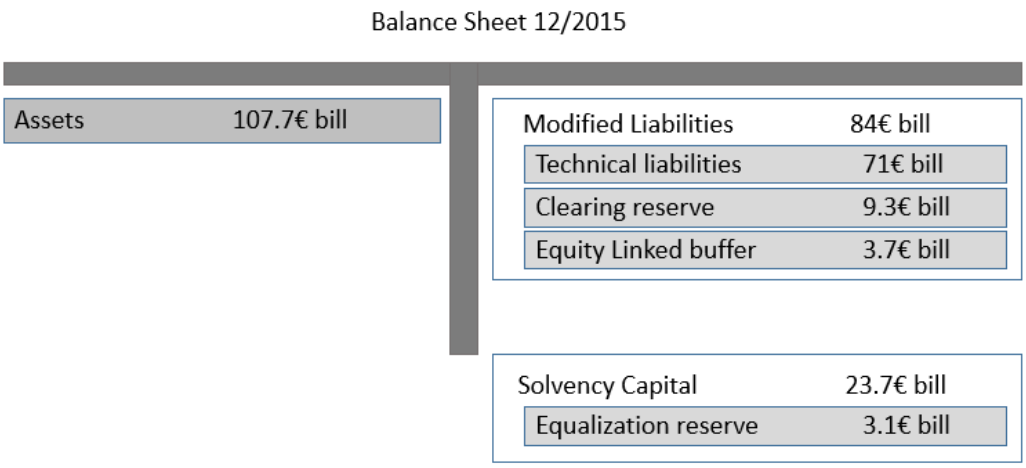

Figure 3. The Balance Sheet of the stylised fund at the end of 2015

Finally, after the data for the stylised fund, representing a typical Finnish pension insurance company, was collected, the two fund variants, set with the two sets of regulations, could be built in GLASS. Having everything set in the system, running the simulations and analysis could begin.

6 Running the Simulations

By running the simulations, results could be drawn for the first objective: *How would the stylised fund perform under the new regulations in comparison to the old regulations?*

This section introduces the descriptive data and statistics obtained about the stylised fund performance under the two different regulations, later referred to as the pre- and post-2017 regulations. The results have been gathered with GLASS by running various simulations using 2 000 scenarios each. The asset allocation has been set to the static mix presented in Table 1 (section 5.1), and the allocation strategy was set to be balanced annually. The investment horizons being analysed are one year, five and ten years.

6.1 Statistics on Investment Returns

Statistics on investment returns could be retrieved by running the stochastic simulations on GLASS. The figures in table 2 present the expected returns, while having the specified static allocation mix in place and minimizing the tail risk measured by 5% conditional value at risk (CVaR). As the horizon for this study focuses on one, five and ten years, the investment returns have also been analysed within these periods. Table 2 shows the expected returns for the first year, years from one to five, respectively years from the beginning of 2016 to the end of 2020, and then years from one to ten, representing years 2016 to the end of 2025.

Table 2. Investment return statistics

	1 Year			1-5 Years			1-10 Years		
Investment return statistics	Geometric return	Volatility	Cum CVaR	Geometric return	Volatility	Cum CVaR	Geometric return	Volatility	Cum CVaR
Total	**6.3%**	**9.0%**	**-14.0%**	**4.9%**	**9.6%**	**-11.3%**	**5.2%**	**10.0%**	**-0.8%**
Equity	**12.3%**	**18.3%**	**-26.6%**	**7.4%**	**19.3%**	**-39.2%**	**7.0%**	**19.8%**	**-42.5%**
Euro area	10.7%	17.2%	-25.1%	6.6%	17.9%	-44.0%	6.2%	18.2%	-43.6%
Emerging Markets	13.6%	24.3%	-33.4%	7.4%	25.2%	-45.1%	7.1%	25.6%	-46.4%
Finland	14.1%	26.4%	-37.3%	6.8%	27.8%	-58.5%	5.8%	28.2%	-72.0%
Developed Markets	9.9%	15.7%	-23.5%	6.5%	16.7%	-36.7%	6.4%	17.3%	-43.2%
Fixed income	**2.1%**	**3.8%**	**-8.2%**	**1.8%**	**6.7%**	**-7.2%**	**2.7%**	**7.3%**	**7.3%**
GovBonds	1.3%	2.3%	-3.4%	0.5%	3.4%	-7.6%	1.4%	3.9%	-0.3%
Credit	2.5%	5.2%	-11.1%	2.5%	9.1%	-10.1%	3.3%	9.7%	8.0%
Alternatives	**7.3%**	**17.2%**	**-22.1%**	**6.1%**	**16.8%**	**-24.5%**	**6.0%**	**17.4%**	**-10.1%**
Private Equity	10.3%	33.0%	-36.6%	6.0%	30.9%	-47.7%	6.3%	32.8%	-42.2%
Hedge Funds	5.4%	14.3%	-19.7%	5.2%	14.5%	-27.2%	4.6%	14.5%	-15.4%
Real Estate	**3.7%**	**5.0%**	**-6.6%**	**4.8%**	**5.8%**	**-2.7%**	**4.8%**	**6.0%**	**7.6%**
PropertyHousing	4.3%	5.5%	-8.1%	4.8%	6.4%	-5.2%	4.8%	6.5%	4.3%
PropertyOffice	3.1%	5.6%	-8.1%	4.8%	6.6%	-6.3%	4.7%	6.9%	6.5%
Cash	**-0.4%**	**0.0%**	**-0.4%**	**0.0%**	**0.9%**	**-4.5%**	**1.0%**	**1.5%**	**-4.2%**
MM investments	-0.4%	0.0%	-0.4%	0.0%	0.9%	-4.5%	1.0%	1.5%	-4.2%

The expected future returns represent quite closely to what can be found from past returns reported by the Finnish Pension Alliance (TELA, 2016e, 3). According to the simulations, the total return over a one-year investment period brings a return of roughly 6%, and for a ten-year investment horizon, around 5,2%. TELA (2016e, 3) reports a return of 5% for the year 2015 and for a ten-year investment horizon, from 2006 to 2015, a return of 4,6%. The simulated future scenarios seem to predict slightly higher returns than what has been achieved in the past years. Nevertheless, these expected figures are indeed realistic. The volatilities of the different asset classes follow the expectations defined for each benchmark index.

6.2 Balance Sheet Development

To analyse the stylised funds balance sheet items, both with the pre- 2017 and post- 2017 regulations set in place, 2 000 simulations were run for the both two fund variants for a ten-year horizon. This enabled to make an overall analysis on possible changes and developments for multiple variables, including future solvency ratios and solvency limits, future liabilities and assets, as well as development of the different buffer funds.

Comparing the two sets of measures, it seems the solvency ratios between the fund following the old regulations and the fund following the new regulations, do not differ much. The scenario clouds in Figures 4 and 5 show the most likely development of the solvency ratio under the old and the new regulations. The line going through the cloud shows the mean value from all the scenarios. Starting with a ratio of 28,2%, with minor fluctuations in both of the set ups the solvency ratio is around 23% at a ten-year average.

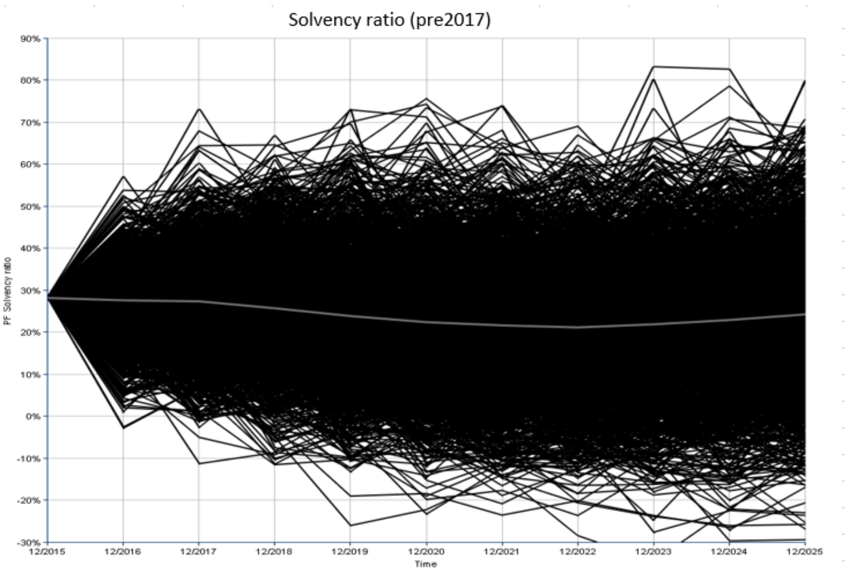

Figure 4. Solvency ratio under pre -2017 regulations

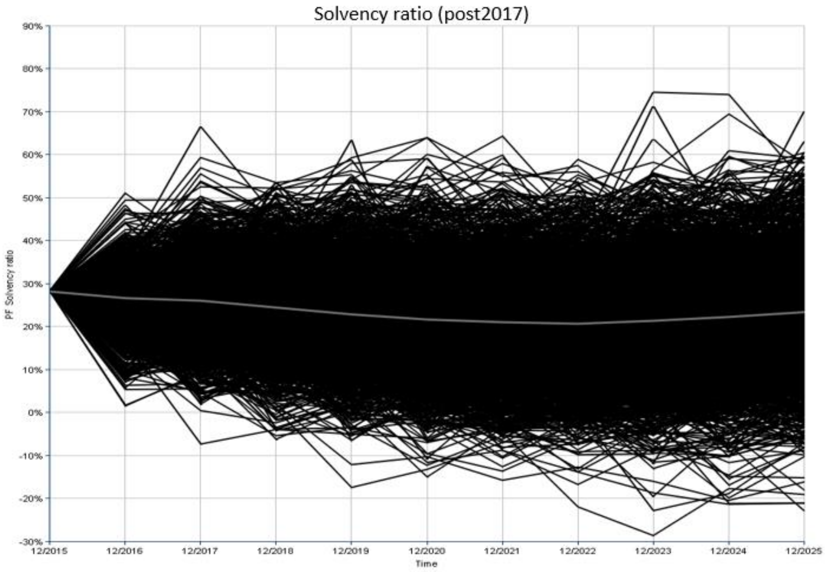

Figure 5. Solvency ratio under post- 2017 regulations

According to statistics by the Financial Supervisory Authority (2016b), at the end of 2015 the solvency limit for the pension providers was on average 14,6%. Creating similar scenario clouds from the end of 2015 onwards, the impacts of the regulation change can be seen on the solvency limit.

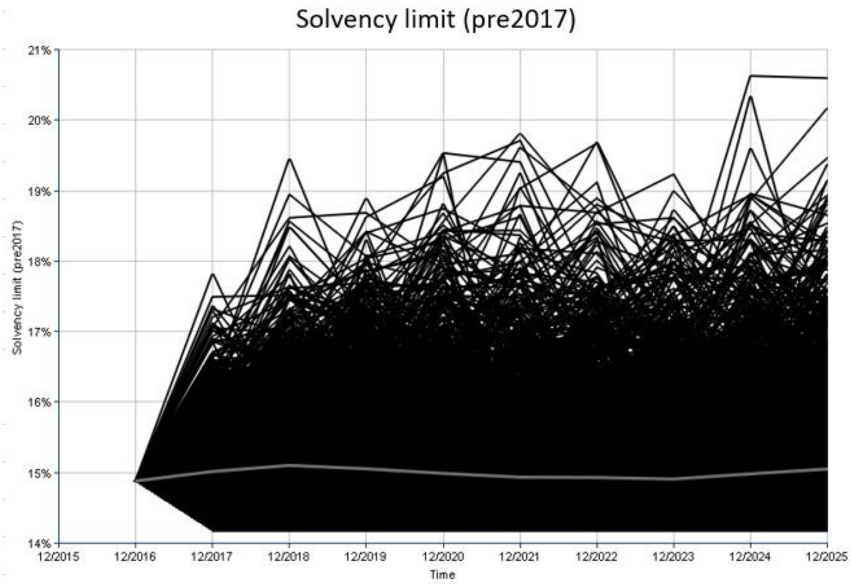

Figure 6. Solvency limit under pre- 2017 regulations

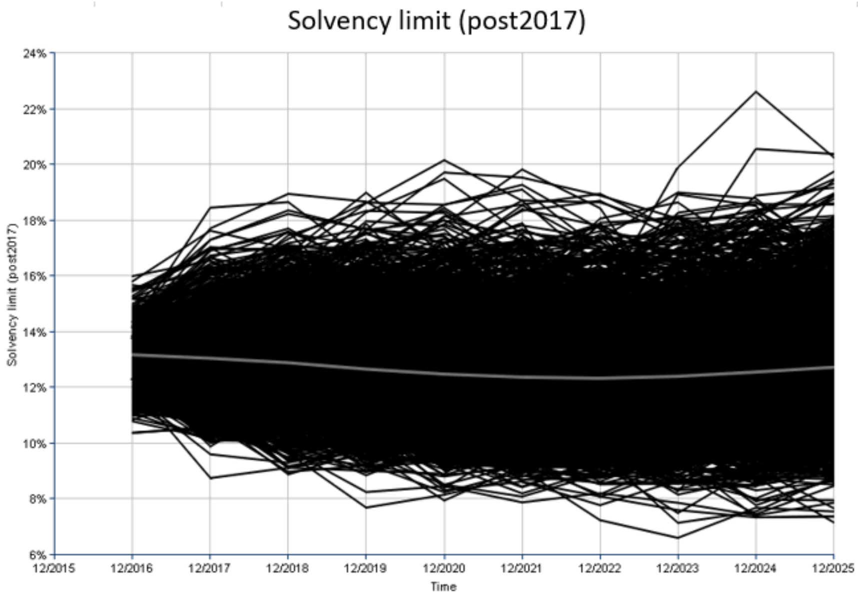

Figure 7. Solvency limit under post- 2017 regulations

Based on the scenario clouds, the solvency limit would seem, on average, to stay relatively stable under both cases of regulations. However, with the same allocation of assets, under the new 2017 regulations the limit is slightly lower. An important difference in the regulation change to bear in mind, is the fact that the new limit is calculated from the invested assets, unlike under the current regulations, where the limit is calculated from the technical provision. Therefore, even though the percentage of limit is lower under the new regulations, the capital requirement will actually be higher. This also means that comparing the solvency limits between each other should be done with caution, as they are not straightforward comparable any longer. In addition, it is noteworthy that under the current regulations, depicted in Figure 6, the solvency limit does not drop below 14.2%. This is due to the fact that the current formula for calculating the solvency limit (in section 3.2 equation (7)) includes the supplementary coefficient, b16 factor, which is set to have a minimum value of 0%. Thus, the floor of this variable creates a minimum floor to the solvency limit as well. Under the new regulations, the b16 factor is no longer included in the solvency limit formula. Therefore, the solvency limit seen in the scenario cloud, in Figure 7, does not have a similar minimum boundary. Nevertheless, the ultimate limit of 5% of the invested assets does exist, although, based on the current expectations, it is not probable that this limit would be broken.

The new regulations bring ease to the equity linked buffer and it seems the overall buffer size will relatively decline during the next ten years. Figure 8 shows two scenario clouds representing the size of the equity linked buffer under the current pre-2017 and the new post-2017 regulations.

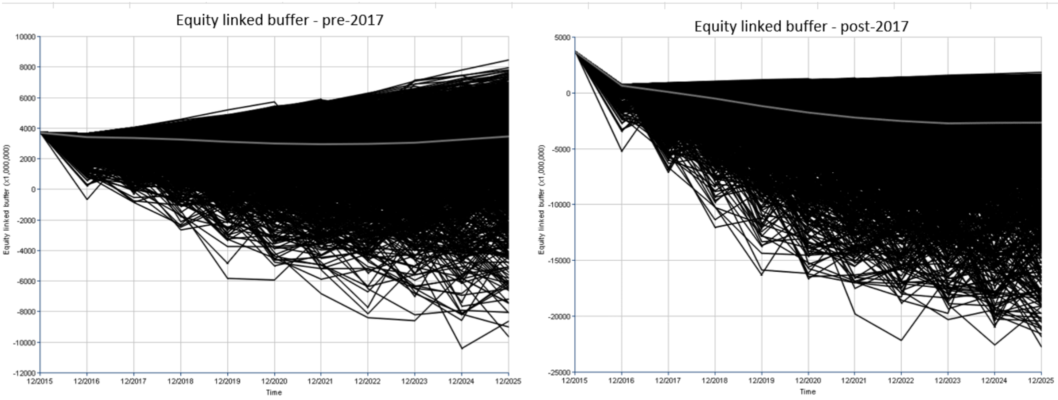

Figure 8. Equity linked buffer pre- and post- 2017 regulations

The limit changes of the buffer, where the upper limit changes from +5% to +1% and the lower limit from -10% to -20%, clearly has an impact on the size of the buffer fund. Under the new regulations, it seems that pension insurance companies are likely to have the fund on the negative side. This allows for higher risk taking, and therefore also a higher weight on equity investments.

The clearing reserve and the equalization reserve are expected to roughly follow the same path regardless the change in the regulations. This can be seen from the scenario clouds presented in Figure 9. Nevertheless, following the new regulations, the equalization reserve will be included in the clearing reserves, contributing to the actual total increase of the clearing reserve. This cannot be seen in the scenarios as such, because under the new regulations the equalization reserve does not actually exist on its own any longer. The liabilities and assets in total develop in the same manner under both regulations, which naturally should be the case as these are unaffected by merely regulations.

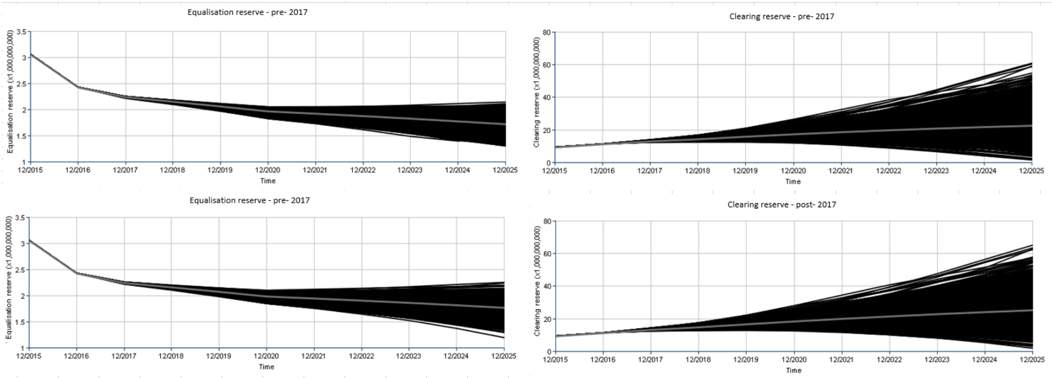

Figure 9. The equalisation and clearing reserve under the pre- and post-2017 regulations

To look at the short-, medium- and long-run predictions on the fund performance, Tables 3 and 4 summarise all the main findings. Along with predicted figures, probabilities for certain events have been added in order to better analyse the impacts of the new regulations. Table 3 shows how the performance would most likely be under the current regulations for the following ten years, whereas Table 4 shows how it would most likely be under the new regulations for the following ten years. Assuming that the investments follow the same static mix under both regulations, the returns are naturally expected to be the same. In reality, the allocation strategies are of course much more dynamic and often dependent on the development of the solvency ratio. However, for simplicity, the static mix is assumed to be used. The following section will then focus on finding the optimal portfolios, which will also provide us implications on the impact of the regulation change.

Table 3. Predictions and probabilities under the pre-2017 regulations

Pre- 2017 Regulations	Year 1	Years 1-5	Years 1-10
Returns			
Total	6.0%	5.2%	5.7%
Equity	10.9%	8.4%	8.5%
Fixed Income	2.3%	2.0%	3.0%
Real Estate	4.0%	5.2%	5.2%
Alternatives	7.7%	7.2%	7.6%
Cash	-0.4%	0.0%	1.0%
Yield Requirement	5.3%	5.2%	5.1%
Return Probabilities			
Return < 0%	23.2%	28.9%	28.1%
Return > 5%	55.6%	51.7%	53.4%
Return < Yield Requirement	44.6%	49.3%	46.8%
Solvency			
Solvency ratio	27.6%	25.4%	23.9%
Solvency limit	14.9%	15.0%	15.0%
Solvency Capital (M)	24,861	25,861	27,889
Total Assets (M)	114,444	125,996	140,598
Total Liabilities (M)	89,583	100,135	112,709
Clearing Reserve (M)	11,253	14,362	17,556
Equalisation Reserve (M)	2,426	2,170	1,998
Equity Linked Buffer (M)	3,418	3,230	3,184
Solvency Probabilities			
Solvency capital < Solvency limit*	11.4%	56.2%	76.9%
Solvency capital < 10% *	2.2%	29.8%	51.8%
Solvency capital < 5% *	0.6%	16.8%	34.3%
Solvency capital < Solvency limit	11.4%	23.8%	28.9%
Solvency capital < 10%	2.2%	10.4%	15.8%
Solvency capital < 5%	0.6%	5.1%	9.1%

* path probability: the probability that in a scenario there is at least one year in which the underlying variable is below x

Table 4. Predictions and probabilities under the post-2017 regulations

Post- 2017 Regulations	Year 1	Years 1-5	Years 1-10
Returns			
Total	6.0%	5.2%	5.7%
Equity	10.9%	8.4%	8.5%
Fixed Income	2.3%	2.0%	3.0%
Real Estate	4.0%	5.2%	5.2%
Alternatives	7.7%	7.2%	7.6%
Cash	-0.4%	0.0%	1.0%
Yield Requirement	6.0%	5.3%	5.1%
Return Probabilities			
Return < 0%	23.2%	28.9%	28.1%
Return > 5%	55.6%	51.7%	53.4%
Return < Yield Requirement	48.8%	49.9%	46.2%
Solvency			
Solvency ratio	26.7%	24.3%	23.1%
Solvency limit	13.2%	12.8%	12.7%
Solvency Capital (M)	24,211	25,064	27,190
Total Assets (M)	114,444	125,988	140,586
Total Liabilities (M)	90,233	100,923	113,396
Clearing Reserve (M)	11,277	14,874	18,805
Equalisation Reserve (M)	2,426	2,178	2,019
Equity Linked Buffer (M)	652	-537	-1,546
Solvency Probabilities			
Solvency capital < Solvency limit*	2.4%	32.9%	55.0%
Solvency capital < 10% *	1.7%	27.0%	47.7%
Solvency capital < 5% *	0.1%	10.7%	24.4%
Solvency capital < Solvency limit	2.4%	11.3%	16.9%
Solvency capital < 10%	1.7%	9.0%	14.2%
Solvency capital < 5%	0.1%	2.9%	5.9%

* path probability: the probability that in a scenario there is at least one year in which the underlying variable is below x

Even though the returns on investments do not differ, the yield requirement under the different sets of regulations slightly does. In the short and medium term, the yield requirement is slightly higher under the new regulations. This is most likely due to the changes in how the yield requirement is calculated. The yield requirement is based on weighted values of the supplementary coefficient and the equity linked factor, and under the new regulations there will be an increase on the weight of the equity linked factor, from 10% to 20%. This might explain the higher figures seen on the short term, as the yield requirement becomes more dependent on the actual market returns on investments. Under both regulations, the probabilities of having a higher than 5% return are over 50%, and achieving a lower than required return is slightly under 50%. Unfortunately, these probabilities as such do not really provide assurance on how the fund would actually perform. However, we can at least assume that the probability of making a loss is quite small.

By contrast, the solvency indicators under the two different regulations do differ. As seen from the scenario clouds presented earlier, the solvency ratio stays relatively even under both regulations. On the other hand, the solvency limit clearly differs. As shown in Table 4, the solvency limit in percentages is notably lower under the new regulations, but, as mentioned earlier, because the limit is a percentage of the assets under the new regulations, and not a percentage from the technical provision, the actual capital requirement amount in EUR should be the value of interest. Computing out the capital requirement amounts under both regulations, shows that the solvency limit in EUR is actually higher under the new regulations.

The development of the three buffer funds can be seen under the liabilities. The clearing reserve and the equalisation reserve are just slightly larger under the new regulations, but any dramatic changes cannot be seen. The equity linked buffer, just as seen already from the scenario clouds, is impacted with the new regulations, as it seems to fall and stay on the negative side.

Based on the probabilities regarding the solvency capital, it seems that it is more likely for the fund to stay solvent under the new set of regulations. The path probabilities in this case refer to the probability that there is at least one year in the scenario in which the solvency ratio falls below the required target. Compared with the so-called normal probability, which is measured over all scenarios and for the whole evaluation period, the path probabilities are much higher. To value risks, the path probability is more commonly used just because it is stricter. Based on the probabilities of falling below the solvency limit under the current and the new regulations, it would be clearly more likely to fall below under the current system. At the ten-year estimate, the path probability is already at roughly 77%. The reasons behind the differences between these probabilities are likely due to the two main changes: the increase of the equity linked factor to 20%, and the revised calculation of the solvency limit provides an incentive to invest more in equity. Together, from a solvency risk perspective, these two changes cause the fact that additional risks are partly mitigated.

Nevertheless, under both sets of regulations, insolvency is highly unlikely to occur, i.e. the probabilities of the solvency capital falling below the limit of 5% are relatively small. It is also noteworthy that according to the current regulations the minimum of 5% is calculated from the technical provision (1114/2006, 10 §), whereas, according to the new regulations, the minimum solvency requirement of 5% is calculated from the invested assets (315/2015, 23 §).

After having an overall view on how this stylised fund might perform and develop in the short and long run, the study continues in finding an optimal portfolio structure, and finally analysing the results for the research question.

6.3 Portfolio Optimisation

By analysing what would be an optimal portfolio under the two sets of regulations, conclusions on possible future allocation changes could be made. To begin creating optimised portfolios, some basic restrictions needed to be defined. Regulations regarding different weights for different assets exist only under the new 2017 law. The current system does not have any limits on weights as such for investment assets, whereas, the new regulations bring a maximum weight of 65% to equity investments. In addition to this restriction, the law states (under the current and the new regulations) that pension insurance companies are required to diversify their investments in a manner that takes into consideration the certainty, return, liquidity and versatility of their investments (315/2015, 4 §; 1114/2006, 3 §). To follow this clause and to avoid unrealistic portfolio structures, a few more constraints were added to the portfolio setup. These are specified in Appendix 2. The result of an optimisation with purely the constraint regarding the maximum equity investment weight in place suggested strategies to invest merely into equity (with 65%) and the rest to alternatives. Therefore, to take all the five asset classes into consideration, additional constrains needed to be defined. The constraints used try to somewhat give guidance for typical pension fund allocation strategies based on near history allocation structures with pension insurance investors. However, they were determined as loosely and broadly as possible in order to define optimal weights for the different asset classes under the new regulations.

The portfolio optimisation simulations, again using 2 000 scenarios, were run in GLASS for the same short, medium and long run investment horizons. The optimisation of portfolio return was done by using a mean-CVaR technique, with a 2.5% CVaR. To compare the optimum portfolios under the two regulations, the optimisation simulations were again run for both fund variants. As a result, ten optimised portfolios were created for the three time horizons of one, five and ten years; and for the both fund variants, which were named '*BaseOld*' (pre-2017 regulations) and '*BaseNew*' (post-2017 regulations). The optimised allocations and detailed results of the relevant scores and probabilities of the optimisations can be found from Appendices 4-6.

7 Analysis and Results

In this final analysis and results part, firstly, the second research objective will be answered: *How could the allocation be changed for the fund to perform better under the new regulations?* And secondly, the results will conclude findings regarding the actual research question on the overall impacts of the new solvency regulations.

7.1 Optimal portfolios under the New 2017 Regulations

The analysis of the portfolio optimisation results will begin by discussing the short term predictions. The actual allocation structures can be seen in Appendix 3, where the first table presents the optimal portfolios for the first year. The risk level of the portfolio grows from *OP1* being the least risky to *OP10* the riskiest optimal portfolio. Appendix 4 shows the performance of the ten optimal allocations both under the pre- and post-2017 regulations. The portfolios under the post-2017 regulations are shown on the upper part named as '*BaseNew*' and under the pre-2017 regulations on the lower part named as '*BaseOld*'. When analysing the portfolios, one can start by focusing on the yield requirements and then the total returns that each different portfolio option would achieve. The portfolios with a return above the yield requirement, can then be looked more deeply into. Table 5 shows how the stylised fund would perform in one year under the current, pre-2017 regulations ('*BaseOld*'), and for comparison, how it would perform under the new regulations with the optimal portfolio allocations of *OP6* to *OP10*. The path probability (*) in tables 5-7 refers to the same as explained earlier (in Tables 3 and 4), and the balance sheet items; solvency capital, assets, liabilities and the three buffer funds, are all expressed in millions of euro.

Table 5. Optimal portfolio allocations for year one

Score	BaseOld	OP6	OP7	OP8	OP9	OP10
Return Total	6.0%	6.3%	6.9%	7.5%	8.1%	8.7%
Yield Requirement	5.3%	6.0%	6.0%	6.0%	6.0%	6.0%
Investment return < 0% Prob	23.2%	22.9%	23.1%	24.4%	24.8%	25.5%
Investment return > 5% Prob	55.6%	57.3%	58.9%	60.3%	61.2%	61.6%
Total return < Yield Requirement Prob	44.6%	46.5%	42.9%	41.3%	39.8%	39.0%
Solvency ratio	27.6%	21.1%	21.4%	21.7%	22.0%	22.2%
Solvency limit	14.9%	13.4%	15.8%	18.2%	21.2%	25.0%
Solvency capital	24,861	24,532	25,174	25,816	26,458	27,100
Assets	114,444	114,765	115,407	116,049	116,691	117,333
Liabilities	89,583	90,233	90,233	90,233	90,233	90,233
Clearing Reserve	11,253	11,277	11,277	11,277	11,277	11,277
Equalisation Reserve	2,426	2,426	2,426	2,426	2,426	2,426
Equity Linked Buffer	3,418	652	652	652	652	652
Solvency capital < Solvency limit*	11.4%	2.3%	6.9%	17.9%	36.4%	68.7%
Solvency capital < 10% *	2.2%	1.1%	2.2%	3.1%	4.8%	6.3%
Solvency capital < 5% *	0.6%	0.1%	0.2%	0.7%	1.8%	2.7%
Solvency capital < Solvency limit	11.4%	2.3%	6.9%	17.9%	36.4%	68.7%
Solvency capital < 10%	2.2%	1.1%	2.2%	3.1%	4.8%	6.3%
Solvency capital < 5%	0.6%	0.1%	0.2%	0.7%	1.8%	2.7%

With roughly the same or even lower probabilities of falling under the solvency requirements, the portfolio allocation could be changed to *OP7* under the new regulations. The achieved returns would most likely be higher, over the yield requirement and with smaller risks regarding the solvency limits. Figure 10 shows the efficient frontier of the different portfolio structures. The different allocations would not have any substantial impact on the solvency ratio or the other balance sheet items in the short term. However, it is worth noting the increase in the solvency limit as the portfolio turns riskier. Nevertheless, it seems that under the new regulations, pension insurance companies could make slightly higher allocations to riskier assets, in order to chase for higher returns. The optimal portfolio *OP7* would have investments of roughly 48% in equity, 21% in fixed income, 10% in alternatives, more precisely in hedge funds, 20% in real estate and 1% in cash (Appendix 3).

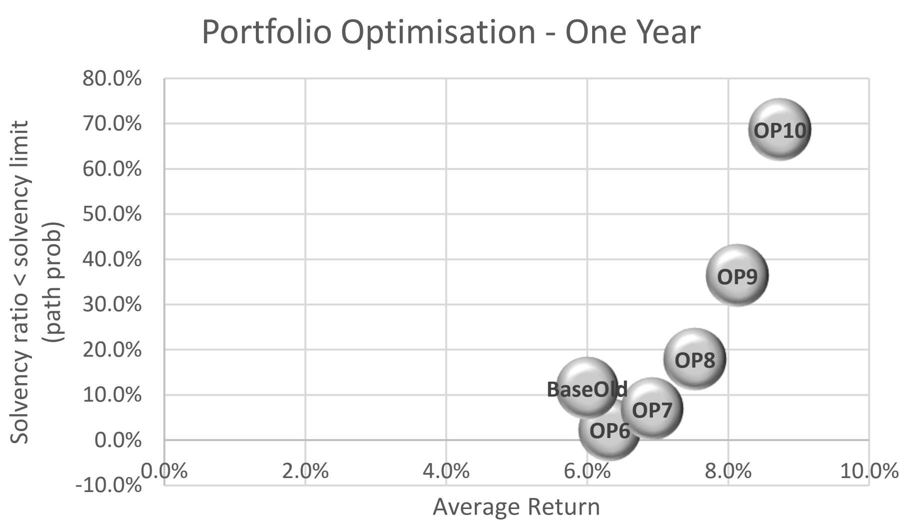

Figure 10. Efficient frontier on one-year portfolio optimisation

Already in the short run the regulation changes seem to provide more flexibility to some riskier investments, as more weight can be added to equity while keeping the related solvency risks under the current level. However, to bear in mind, the model does not take into consideration counterparty risk, which would increase as a result of heavier weights on alternatives. A higher counterparty risk would indeed increase the solvency limit, as well as the probabilities of falling below the solvency requirements. In the short run, the optimisation would, however, suggest to have slightly less invested in alternatives. Therefore, there would actually not be any increasing impact due to that account. In most of the optimised portfolios, the level of cash would be held at the defined minimum level due to the low current interest rate levels.

When looking at the five-year optimal portfolios and comparing these with the current allocation mix, similar implications as before can be drawn. Table 6 presents statistics on the four most optimal portfolios obtained through the model, in comparison to the current static mix allocation. The detailed portfolio allocations can be found again from Appendix 3. In a five-year period *OP8* would seem to be the most optimal portfolio. With a lower probability of falling below the solvency limit or even falling insolvent, this allocation structure would more likely also bring higher returns.

Table 6. Optimal portfolio allocations for five years

Score	BaseOld	OP7	OP8	OP9	OP10
Return Total	5.2%	5.8%	6.2%	6.7%	7.1%
Yield Requirement	5.2%	5.3%	5.3%	5.3%	5.3%
Investment return < 0% Prob	28.9%	28.5%	29.0%	30.3%	32.3%
Investment return > 5% Prob	51.7%	53.5%	54.7%	55.2%	55.1%
Total return < Yield Requirement Prob	49.3%	46.6%	44.2%	44.3%	44.3%
Solvency ratio	25.4%	20.3%	21.1%	21.5%	21.5%
Solvency limit	15.0%	15.1%	17.2%	20.4%	25.1%
Solvency capital	25,861	27,688	29,541	31,403	33,530
Assets	125,996	128,611	130,465	132,327	134,453
Liabilities	100,135	100,923	100,923	100,923	100,923
Clearing Reserve	14,362	14,874	14,874	14,874	14,874
Equalisation Reserve	2,170	2,178	2,178	2,178	2,178
Equity Linked Buffer	3,230	-537	-537	-537	-537
Solvency capital < Solvency limit*	56.2%	39.3%	49.1%	67.1%	87.7%
Solvency capital < 10% *	29.8%	24.9%	26.8%	31.7%	38.6%
Solvency capital < 5% *	16.8%	12.5%	14.3%	20.2%	27.5%
Solvency capital < Solvency limit	23.8%	16.4%	22.7%	36.9%	59.8%
Solvency capital < 10%	10.4%	9.3%	10.3%	13.4%	17.5%
Solvency capital < 5%	5.1%	4.0%	5.0%	7.4%	11.5%

Compared to the current allocation mix, meaning the allocation weights at the end of 2015 reported by TELA (2016e, 1) and shown in Table 1 (pp.44), *OP8* would by first suggest a higher equity weight of 49%. Fixed income weight should be lowered by 15.4 percentage points, alternative weight by 5.7 percentage points, and cash by 3.9 percentage points. Real estate weight should be increased by 8.2 percentage points (Appendix 3). To visualise the optimal portfolios, Figure 11 shows the efficient frontier on a five-year optimisation.

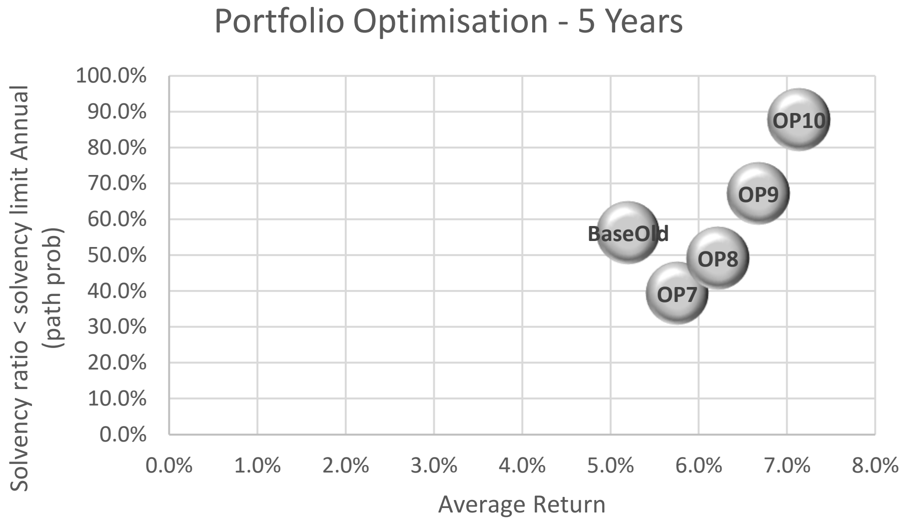

Figure 11. Efficient frontier on five-year portfolio optimisation

OP7 and *OP8* would both be more efficient compared to *BaseOld* as can be seen in Figure 11. Both of these portfolios would have smaller probabilities of falling under the solvency limit and yet bring higher returns than the stylised fund with its current allocation structure.

Finally, to see long term effects, the optimisation was done on a ten-year investment horizon. Again, significantly higher equity allocations would seem more optimal. *OP7* or *OP8* would be the structures that could be suggested, firstly, because the returns are above the yield requirement and above the return of the stylised fund, and secondly, because the risk measures of falling behind the solvency requirements are notably lower. Table 7 again summarises the performance of the optimal portfolios in comparison to the current stylised fund and the asset allocation strategy it holds. The portfolio structures are in Appendix 3.

Table 7. Optimal portfolio allocations for ten years

Score	BaseOld	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	5.7%	5.2%	5.7%	6.2%	6.7%	7.1%	7.6%
Yield Requirement	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%
Investment return < 0% Prob	28.1%	26.9%	27.8%	28.7%	29.3%	30.2%	31.8%
Investment return > 5% Prob	53.4%	51.0%	52.8%	54.1%	55.5%	56.0%	56.0%
Total return < Yield Requirement Prob	46.8%	50.2%	46.7%	44.7%	43.1%	42.5%	42.6%
Solvency ratio	23.9%	20.5%	23.4%	26.4%	29.3%	31.9%	34.2%
Solvency limit	15.0%	9.7%	12.0%	15.0%	17.9%	21.2%	25.7%
Solvency capital	27,889	23,789	27,684	31,997	36,050	39,809	43,524
Assets	140,598	137,180	141,079	145,392	149,445	153,204	156,917
Liabilities	112,709	113,392	113,395	113,396	113,396	113,396	113,394
Clearing Reserve	17,556	18,801	18,804	18,805	18,805	18,805	18,803
Equalisation Reserve	1,998	2,019	2,019	2,019	2,019	2,019	2,019
Equity Linked Buffer	3,184	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546
Solvency capital < Solvency limit*	76.9%	39.6%	47.6%	58.4%	67.5%	78.0%	91.4%
Solvency capital < 10% *	51.8%	49.9%	45.1%	44.2%	44.5%	47.1%	53.0%
Solvency capital < 5% *	34.3%	21.3%	23.6%	27.1%	29.5%	34.2%	41.9%
Solvency capital < Solvency limit	28.9%	11.2%	15.7%	22.9%	29.6%	39.3%	55.9%
Solvency capital < 10%	15.8%	15.5%	14.9%	15.9%	16.3%	18.0%	21.7%
Solvency capital < 5%	9.1%	5.3%	6.4%	8.3%	9.4%	11.7%	15.7%

The efficiency frontier in Figure 12, also shows that *OP6, OP7* and *OP8* perform better than the stylised fund *BaseOld*. Looking the most efficient structure, *OP8* would suggest to increase equity with 13.5 percentage points, so roughly to a weight of 46%, decrease fixed income by 15.4 percentage points, decrease hedge funds by 9.4 percentage points, increase private equity weight by 3.7 percentage points and increase real estate by 8.8 percentage points. Cash holdings should be decreased by 1.2 percentage points.

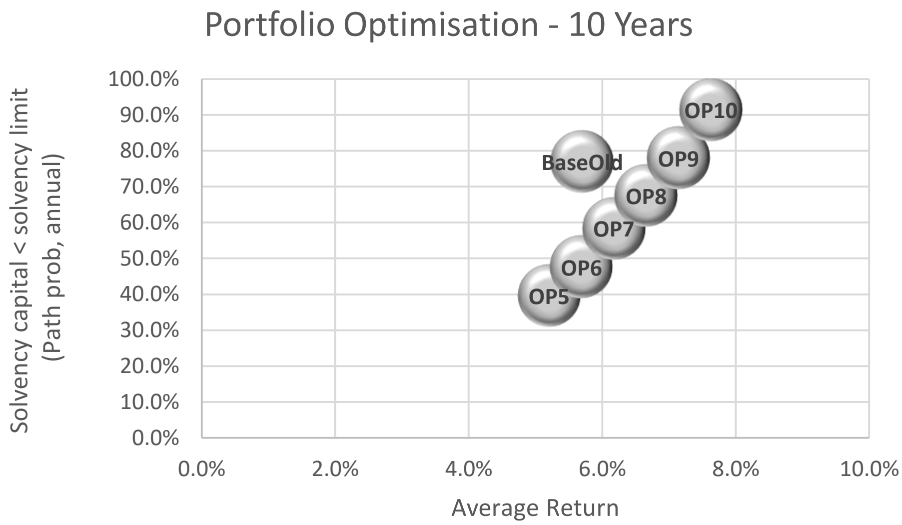

Figure 12. Efficient frontier on ten-year portfolio optimisation

By restructuring the assets as suggested by *OP8* the average fund might increase its returns by one percentage point as well as significantly reduce its risks falling below the solvency limit. However, this study by no means would suggest to have any static allocation mix put in place, as its ultimate goal is to just point out the possible impacts of the new regulations.

The overall structural change can neither be explained merely by the regulations, but instead due to the expectations on market developments brought to the optimisations through the 2 000 scenarios used in the simulations. Therefore, it is also useful to compare how the optimised funds would differ under the two regulations. These can be seen in Appendices 4-6. For example, by comparing the path probabilities of the solvency capital falling below the 5% minimum requirement, we can see that the current, pre-2017 regulations bring significantly higher, i.e. more unfavourable, estimations. Based on the optimisations, the optimal portfolio would differ under the current regulations as well. Compared to the most optimal portfolios under the new regulations, and in all of the three investment horizons, the optimisation simulations under the current regulations would suggest relatively even allocations for alternatives and real estate. The most significant differences between the two sets of optimisations are the higher allocations in equity and lower allocations in both fixed income and cash. According to these findings, the allocation strategies in the Finnish pension insurance companies should be impacted by the new upcoming regulations.

7.2 Overall Impacts to Allocation Strategies

Even though the asset classes and the diversification within these classes were kept quite narrow in this study, some overall conclusions on the effects of the new regulations can be made. Based on these short-, medium- and long-term portfolio optimisations, it seems that the new 2017 regulations bring motivation or at least an opportunity for pension insurance companies to increase weight on equity in their portfolios. This, as mentioned earlier, has been planned intentionally, by making changes to mechanisms regarding the equity linked buffer, as well as the yield requirement. Moreover, to control pension insurers not to have too high equity risk, the upper limit has been set to 65% of invested assets.

In all of the three time spans, the increase on equity weight from the current level of roughly 33% to something in between 40-46%, proved to be most optimal. In the long term the suggested increase in equity investments would be 13.5 percentage points. As expected, the counter reaction to an increase in equity, would be a decrease in fixed income. The optimisations for all the three different time horizons suggest a decrease from the current level of roughly 35% to a level of roughly 20%. As 20% was determined as a minimum constraint for fixed income (Appendix 2), it might be that with even less weight more optimal portfolios could be created. Nonetheless, holding an even lower position in fixed income could likely already start to contradict with the clause on diversification.

Alternative investments were not seen as tempting as they are currently with the Finnish pension insurer's. At the end of 2015, investments in private equity and hedge funds in total was roughly 16%, whereas the optimised portfolio structures would suggest a lower investment percentage of roughly 10% in all presented *OP* cases. On the other hand, real estate investments could be increased. Based on most of the optimisations the current level of roughly 11% in real estate could be increased up to around 20%. In the short and medium run the cash holdings should be kept at the minimum, and in the long run the level should at least be lower than the current level.

To bear in mind, the optimisations imply similar optimal changes for the allocations regarding alternatives, real estate and cash, under both sets of regulations. Therefore, it cannot be concluded that these would be impacted due to the regulation changes, but rather due to the market expectations regarding risk and return among these asset classes. Nevertheless, the optimisations do suggest higher allocations on equity under the new regulations. Therefore, it can be concluded that the overall changes in the 2017 regulations regarding the solvency capital and technical provision calculations might impact the allocations strategies to some extent. Under the new regulations, adding more weight on equity while reducing weight from fixed income, would provide higher returns while keeping the relevant risks regarding solvency at their current levels.

8 Conclusions

This research has focused on studying the new 2017 pension reform and its impacts on the Finnish pension insurance companies' asset allocations, due to the changes in the solvency capital requirements. One of the 2017 pension reform's aims has been to implement a more risk-based capital requirement for all pension providers. This can be seen in effect from the new solvency limit calculations. The purpose of the changes regarding the equity linked buffer fund, on the other hand, has been the intentional desire to add weight on equity investments among the insurers, and to ultimately enhance investment returns in the long run. Even though, equity investments are more volatile and, therefore, also considered riskier investments than, for example, fixed income, the solvency capital requirements should ensure that the riskiness of the insurers' investment portfolios should not significantly increase.

Based on the findings concluded from this study, the overall fund development will slightly differ under the new regulations. The required solvency capital euro amount will increase, due to the changes on the limit calculations. Regarding the limit as a percentage, the fact that the lower bound for the solvency capital limit is eliminated in the new calculation, results in circumstances with low solvency capital limits, which intuitively reduces the probability of falling below the limit.

The yield requirement seems likely to be higher, due to added weight of the equity linked factor, meaning that the yield requirement will be more affected by the equity market returns. The equity linked buffer will experience a decline, as it seems that the new minimum limit of the buffer fund will be utilised. The hypotheses regarding the first research objective seem to be supported by the research conducted. By contrast, the initial assumptions on the solvency capital requirements being lower under the new regulations, should be rejected. As the new solvency capital requirement is calculated based on the invested assets, the requirement is in monetary terms actually higher after the pension reform.

The portfolio optimisations provide findings regarding, how the new regulations might impact the allocation strategies, thereby answering the second research objective. The optimal portfolios under both regulations differ from the allocation mix prevailing among the pension insurers at the end of 2015. However, the equity weight could be added even more under the new regulations, while keeping the probabilities of insolvency at the same or even lower levels, than they would be under the current regulations. This implies that the hypotheses described in subsection 1.2 cannot be fully rejected. Firstly, the optimisations suggest higher allocation in equity and a lower allocation for fixed income. However, as the solvency limit calculations will become more impacted by the investment assets, the change into riskier assets should not be very drastic. In addition, the allocation among the rest of the asset classes could experience some changes as well, though these changes cannot be explained by the regulation changes, but rather by market expectations on volatility and return optimisations.

Despite the fact that the study was done merely by using a static mix investment strategy, which in real life of course would not be the case, the implications regarding the impacts of the regulation change can be considered valid. However, to receive even more precise portfolio optimisations, a more dynamic approach could be used for the analysis. Pension insurance companies have different allocation strategies, and most often the solvency ratio is taken into consideration and implemented as a part of the allocation strategy, which could possibly be more close to the *portfolio insurance strategy* described by Koivu et al. (2005). One important risk also influencing strategic decision making in Finnish pension insurance companies is the competition among the insurers. Therefore, an additional risk measure to take into consideration under the analysis, could have been maximising the fund return, while minimising the risk of falling behind competitors.

Further research and analysis on the topic should be conducted especially after the pension reform has been implemented. As this is quite a concrete study, the realized impacts on asset allocation strategies could actually be observed. The Finnish earnings-related pension scheme continues to face criticism, partly due to its lack of transparency and partly due to the complexity of the entire framework. To extend the research even further, the validity of mathematical constants, such as the correlation matrix and expected loss and return regarding the different risk classes, could be examined more closely. Under the new regulations, these continue to be constant and pre-determined by the government (447/2015).

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Appendeces

Appendix 1. Asset allocation of stylised fund at the end of year 2015

Asset allocation	
Total	**100,0%**
Equity	**32,8%**
Euro area	5,7%
Emerging Markets	8,6%
Finland	9,8%
Developed Markets	8,6%
DM Japan	2,9%
DM UK	2,9%
DM WRLD	2,9%
Fixed income	**35,4%**
Government Bonds	12,1%
Bonds Non-Euro	5,4%
Bonds US	1,6%
Bonds Australia	1,1%
Bonds Emerging Markets	2,7%
Bonds Euro	6,7%
Bonds Germany	6,0%
Bonds Finland	0,7%
Credit	23,3%
HY Euro	5,8%
IG Euro	5,8%
HY US	5,8%
IG US	5,8%
Alternatives	**15,7%**
Private Equity	5,9%
Private Equity Venture Capital	3,0%
Private Equity BO	3,0%
Hedge Funds	9,8%
Equity Hedge	2,8%
Event Driven	2,4%
Macro	1,9%
Relative Value	2,6%
Real Estate	**11,2%**
Housing	5,6%
Office	5,6%
Cash	**4,9%**
MM investments	4,9%

Appendix 2. Restrictions on portfolio optimisation used in simulations

Equity
The minimum and maximum allocation of Equity is 20.00 % resp. 65.00 % of the total asset value.
The relative distribution of the portfolios under Equity is assumed to be constant.
The relative distribution of the portfolios under Equity DM is assumed to be constant.
Fixed Income
The minimum and maximum allocation of GovBonds + Credit is 20.00 % resp. 100.00 % of Total.
The relative distribution of the portfolios under Bonds Non-Euro is assumed to be constant.
The minimum and maximum allocation of Bonds Non-Euro is 0.00 % resp. 30.00 % of Fixed income.
The relative distribution of the portfolios under Bonds Euro is assumed to be constant.
The minimum and maximum allocation of Bonds Euro is 20.00 % resp. 50.00 % of Fixed income.
The relative distribution of the portfolios under Credit is assumed to be constant.
The minimum and maximum allocation of HY Euro is 0.00 % resp. 30.00 % of Fixed income.
The minimum and maximum allocation of HY US is 0.00 % resp. 30.00 % of Fixed income.
Alternatives
The minimum and maximum allocation of Real Estate + Alternatives is 0.00 % resp. 30.00 % of Total.
The minimum and maximum allocation of Private Equity is 0.00 % resp. 20.00 % of the total asset value.
The relative distribution of the portfolios under Private Equity is assumed to be constant.
The relative distribution of the portfolios under Hedge Funds is assumed to be constant.
The minimum and maximum allocation of Hedge Funds is 0.00 % resp. 20.00 % of the total asset value.
Real Estate
The relative distribution of the portfolios under Real Estate is assumed to be constant.
The minimum and maximum allocation of Real Estate is 5.00 % resp. 20.00 % of the total asset value.
Cash
The minimum and maximum allocation of Cash is 1.00 % resp. 10.00 % of the total asset value.

Appendix 3. Portfolio optimisations for years one, five and ten

Optimised Allocations Year 1	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Equity	20.0%	20.0%	22.5%	28.9%	35.3%	41.7%	48.1%	54.4%	59.5%	65.0%
Equity Euro	3.5%	3.5%	3.9%	5.0%	6.1%	7.3%	8.4%	9.5%	10.3%	11.3%
Equity EM	5.3%	5.3%	5.9%	7.6%	9.3%	11.0%	12.7%	14.3%	15.6%	17.1%
Equity FIN	6.0%	6.0%	6.7%	8.7%	10.6%	12.5%	14.4%	16.3%	17.8%	19.5%
Equity DM	5.3%	5.3%	5.9%	7.6%	9.3%	11.0%	12.7%	14.3%	15.6%	17.1%
Fixed income	65.0%	51.7%	46.5%	40.1%	33.7%	27.3%	20.9%	20.0%	20.0%	20.0%
GovBonds	52.0%	41.3%	37.2%	32.1%	27.0%	21.8%	16.7%	15.5%	10.0%	4.1%
Credit	13.0%	10.3%	9.3%	8.0%	6.7%	5.5%	4.2%	4.5%	10.0%	15.9%
Alternatives	0.0%	3.2%	10.0%	10.0%	10.0%	10.0%	10.0%	4.6%	6.5%	9.0%
Private Equity	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	4.6%	6.5%	9.0%
Hedge Funds	0.0%	3.2%	10.0%	10.0%	10.0%	10.0%	10.0%	0.0%	0.0%	0.0%
Real Estate	5.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	13.1%	5.0%
PropertyHousing	2.5%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	6.5%	2.5%
PropertyOffice	2.5%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	6.5%	2.5%
Cash	10.0%	5.1%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%
MM investments	10.0%	5.1%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%	1.0%

Optimised Allocations 5 Years	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Equity	20.0%	20.0%	23.7%	29.8%	35.9%	41.1%	46.1%	49.0%	49.0%	54.0%
Equity Euro	3.5%	3.5%	4.1%	5.2%	6.2%	7.2%	8.0%	8.5%	8.5%	9.4%
Equity EM	5.3%	5.3%	6.2%	7.8%	9.4%	10.8%	12.1%	12.9%	12.9%	14.2%
Equity FIN	6.0%	6.0%	7.1%	8.9%	10.8%	12.3%	13.8%	14.7%	14.7%	16.2%
Equity DM	5.3%	5.3%	6.2%	7.8%	9.4%	10.8%	12.1%	12.9%	12.9%	14.2%
Fixed income	53.4%	43.7%	36.3%	30.2%	24.1%	20.0%	20.0%	20.0%	20.0%	20.0%
GovBonds	42.7%	35.0%	29.1%	24.2%	19.3%	14.6%	12.9%	10.0%	4.0%	4.0%
Credit	10.7%	8.7%	7.3%	6.0%	4.8%	5.4%	7.1%	10.0%	16.0%	16.0%
Alternatives	0.0%	6.3%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	12.9%	20.0%
Private Equity	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	3.3%	12.9%	20.0%
Hedge Funds	0.0%	6.3%	10.0%	10.0%	10.0%	9.8%	10.0%	6.7%	0.0%	0.0%
Real Estate	16.6%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	17.1%	5.0%
PropertyHousing	8.3%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	8.6%	2.5%
PropertyOffice	8.3%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	8.6%	2.5%
Cash	10.0%	10.0%	10.0%	10.0%	10.0%	8.9%	3.9%	1.0%	1.0%	1.0%
MM investments	10.0%	10.0%	10.0%	10.0%	10.0%	8.9%	3.9%	1.0%	1.0%	1.0%

Optimised Allocations 10 Years	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Equity	20.0%	20.0%	20.0%	24.2%	27.1%	32.7%	40.9%	46.3%	49.0%	54.0%
Equity Euro	3.5%	3.5%	3.5%	4.2%	4.7%	5.7%	7.1%	8.1%	8.5%	9.4%
Equity EM	5.3%	5.3%	5.3%	6.4%	7.1%	8.6%	10.8%	12.2%	12.9%	14.2%
Equity FIN	6.0%	6.0%	6.0%	7.3%	8.1%	9.8%	12.3%	13.9%	14.7%	16.2%
Equity DM	5.3%	5.3%	5.3%	6.4%	7.1%	8.6%	10.8%	12.2%	12.9%	14.2%
Fixed income	65.0%	50.3%	40.0%	35.8%	32.9%	27.3%	20.0%	20.0%	20.0%	20.0%
GovBonds	52.0%	40.2%	32.0%	28.7%	21.1%	13.7%	9.2%	6.1%	4.0%	4.0%
Credit	13.0%	10.1%	8.0%	7.2%	11.9%	13.7%	10.8%	13.9%	16.0%	16.0%
Alternatives	0.0%	0.0%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	14.2%	20.0%
Private Equity	0.0%	0.0%	1.6%	5.9%	8.6%	9.1%	8.8%	9.6%	14.2%	20.0%
Hedge Funds	0.0%	0.0%	8.4%	4.1%	1.4%	0.9%	1.2%	0.4%	0.0%	0.0%
Real Estate	5.0%	19.7%	20.0%	20.0%	20.0%	20.0%	20.0%	20.0%	15.8%	5.0%
PropertyHousing	2.5%	9.9%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	7.9%	2.5%
PropertyOffice	2.5%	9.9%	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	7.9%	2.5%
Cash	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	9.1%	3.7%	1.0%	1.0%
MM investments	10.0%	10.0%	10.0%	10.0%	10.0%	10.0%	9.1%	3.7%	1.0%	1.0%

Appendix 4. Optimisations pre- and post- 2017 regulations – Year 1

Score	BaseNew	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	6.0%	3.3%	3.9%	4.5%	5.1%	5.7%	6.3%	6.9%	7.5%	8.1%	8.7%
Yield Requirement	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
Investment return < 0% Prob	23.2%	21.7%	19.4%	20.2%	20.8%	22.3%	22.9%	23.1%	24.4%	24.8%	25.5%
Investment return > 5% Prob	55.6%	35.6%	41.0%	47.5%	51.7%	55.4%	57.3%	58.9%	60.3%	61.2%	61.6%
Total return < Yield Requirement Prob	48.8%	97.0%	87.3%	72.3%	60.5%	52.4%	46.5%	42.9%	41.3%	39.8%	39.0%
Solvency ratio	26.7%	19.1%	19.5%	19.9%	20.3%	20.7%	21.1%	21.4%	21.7%	22.0%	22.2%
Solvency limit	13.2%	7.5%	7.5%	8.1%	9.4%	11.2%	13.4%	15.8%	18.2%	21.2%	25.0%
Solvency capital	24,211	21,324	21,964	22,606	23,248	23,890	24,532	25,174	25,816	26,458	27,100
Assets	114,444	111,557	112,197	112,839	113,481	114,123	114,765	115,407	116,049	116,691	117,333
Liabilities	90,233	90,233	90,233	90,233	90,233	90,233	90,233	90,233	90,233	90,233	90,233
Clearing Reserve	11,277	11,277	11,277	11,277	11,277	11,277	11,277	11,277	11,277	11,277	11,277
Equalisation Reserve	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426
Equity Linked Buffer	652	652	652	652	652	652	652	652	652	652	652
Solvency capital < Solvency limit*	1.8%	0.0%	0.0%	0.0%	0.1%	0.3%	2.3%	6.9%	17.9%	36.4%	68.7%
Solvency capital < 10% *	1.3%	0.0%	0.0%	0.1%	0.1%	0.3%	1.1%	2.2%	3.1%	4.8%	6.3%
Solvency capital < 5% *	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.7%	1.8%	2.7%
Solvency capital < Solvency limit	1.8%	0.0%	0.0%	0.0%	0.1%	0.3%	2.3%	6.9%	17.9%	36.4%	68.7%
Solvency capital < 10%	1.3%	0.0%	0.0%	0.1%	0.1%	0.3%	1.1%	2.2%	3.1%	4.8%	6.3%
Solvency capital < 5%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.2%	0.7%	1.8%	2.7%

Score	BaseOld	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	6.0%	3.3%	3.9%	4.4%	5.0%	5.5%	6.1%	6.6%	7.1%	7.6%	8.2%
Yield Requirement	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
Investment return < 0% Prob	23.2%	21.6%	20.0%	21.3%	21.5%	22.7%	23.3%	23.8%	24.2%	24.5%	25.1%
Investment return > 5% Prob	55.6%	35.6%	41.6%	47.3%	51.5%	54.2%	56.4%	58.2%	59.6%	60.2%	61.3%
Total return < Yield Requirement Prob	44.6%	76.4%	65.7%	58.2%	50.7%	46.4%	43.6%	41.3%	39.7%	39.0%	37.7%
Solvency ratio	27.6%	24.5%	25.2%	25.8%	26.4%	27.1%	27.7%	28.3%	28.9%	29.5%	30.1%
Solvency limit	14.9%	7.9%	8.4%	10.1%	11.8%	13.9%	16.2%	18.6%	21.2%	24.1%	27.3%
Solvency capital	24,861	21,974	22,615	23,184	23,773	24,336	24,898	25,461	26,024	26,578	27,169
Assets	114,444	111,558	112,198	112,768	113,356	113,919	114,482	115,045	115,608	116,162	116,752
Liabilities	89,583	89,583	89,583	89,583	89,583	89,583	89,583	89,583	89,583	89,583	89,583
Clearing Reserve	11,253	11,253	11,253	11,253	11,253	11,253	11,253	11,253	11,253	11,253	11,253
Equalisation Reserve	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426	2,426
Equity Linked Buffer	3,418	3,418	3,418	3,418	3,418	3,418	3,418	3,418	3,418	3,418	3,418
Solvency capital < Solvency limit*	11.4%	0.0%	0.1%	1.0%	2.6%	7.2%	14.0%	23.3%	31.2%	40.8%	50.6%
Solvency capital < 10% *	2.2%	0.0%	0.0%	0.2%	0.5%	1.2%	1.8%	2.5%	3.2%	4.4%	5.5%
Solvency capital < 5% *	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.8%	1.4%	1.9%	2.6%
Solvency capital < Solvency limit	11.4%	0.0%	0.1%	1.0%	2.6%	7.2%	14.0%	23.3%	31.2%	40.8%	50.6%
Solvency capital < 10%	2.2%	0.0%	0.0%	0.2%	0.5%	1.2%	1.8%	2.5%	3.2%	4.4%	5.5%
Solvency capital < 5%	0.6%	0.0%	0.0%	0.0%	0.0%	0.2%	0.4%	0.8%	1.4%	1.9%	2.6%

Appendix 5. Risk measures pre- and post- 2017 regulations – 5 Years

Score	BaseNew	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	5.2%	3.0%	3.5%	3.9%	4.4%	4.8%	5.3%	5.8%	6.2%	6.7%	7.1%
Yield Requirement	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%	5.3%
Investment return < 0% Prob	28.9%	26.8%	25.7%	26.2%	27.0%	27.9%	28.3%	28.5%	29.0%	30.3%	32.3%
Investment return > 5% Prob	51.7%	35.5%	39.7%	44.0%	47.6%	49.9%	52.0%	53.5%	54.7%	55.2%	55.1%
Total return < Yield Requirement Prob	49.9%	82.7%	75.5%	66.5%	58.9%	53.1%	49.3%	46.6%	44.2%	44.3%	44.3%
Solvency ratio	24.3%	14.6%	15.6%	16.7%	17.7%	18.6%	19.5%	20.3%	21.1%	21.5%	21.5%
Solvency limit	12.8%	7.0%	7.0%	7.7%	9.0%	10.9%	13.0%	15.1%	17.2%	20.4%	25.1%
Solvency capital	25,064	17,111	18,642	20,340	22,149	23,989	25,821	27,688	29,541	31,403	33,530
Assets	125,988	118,034	119,565	121,264	123,073	124,912	126,744	128,611	130,465	132,327	134,453
Liabilities	100,923	100,923	100,923	100,923	100,923	100,923	100,923	100,923	100,923	100,923	100,923
Clearing Reserve	14,874	14,874	14,874	14,874	14,874	14,874	14,874	14,874	14,874	14,874	14,874
Equalisation Reserve	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178	2,178
Equity Linked Buffer	-537	-537	-537	-537	-537	-537	-537	-537	-537	-537	-537
Solvency capital < Solvency limit*	26.9%	20.7%	10.6%	7.5%	11.3%	19.3%	29.1%	39.3%	49.1%	67.1%	87.7%
Solvency capital < 10% *	22.8%	53.3%	33.1%	22.2%	20.1%	21.6%	23.4%	24.9%	26.8%	31.7%	38.6%
Solvency capital < 5% *	10.3%	8.5%	3.5%	2.9%	4.4%	7.2%	9.8%	12.5%	14.3%	20.2%	27.5%
Solvency capital < Solvency limit	8.7%	4.9%	2.4%	1.7%	3.0%	6.3%	10.9%	16.4%	22.7%	36.9%	59.8%
Solvency capital < 10%	7.2%	14.9%	8.8%	6.1%	6.3%	7.3%	8.4%	9.3%	10.3%	13.4%	17.5%
Solvency capital < 5%	2.8%	1.8%	0.8%	0.7%	1.1%	2.0%	3.1%	4.0%	5.0%	7.4%	11.5%

Score	BaseOld	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	5.2%	3.0%	3.4%	3.9%	4.3%	4.8%	5.2%	5.7%	6.1%	6.5%	7.1%
Yield Requirement	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%
Investment return < 0% Prob	28.9%	27.2%	25.7%	26.2%	26.9%	27.7%	28.2%	28.5%	28.7%	30.3%	32.3%
Investment return > 5% Prob	51.7%	35.2%	39.3%	43.7%	47.2%	49.6%	51.8%	53.3%	54.8%	55.4%	55.1%
Total return < Yield Requirement Prob	49.3%	71.1%	65.8%	60.5%	55.8%	51.9%	49.2%	47.1%	45.2%	44.1%	44.7%
Solvency ratio	25.4%	18.0%	19.5%	21.0%	22.5%	24.2%	25.8%	27.4%	29.1%	30.9%	33.0%
Solvency limit	15.0%	7.8%	7.9%	9.7%	11.3%	13.3%	15.2%	17.2%	19.2%	24.6%	31.8%
Solvency capital	25,861	17,750	19,314	20,936	22,689	24,473	26,234	28,063	29,887	32,017	34,411
Assets	125,996	117,885	119,450	121,071	122,824	124,609	126,370	128,199	130,022	132,151	134,541
Liabilities	100,135	100,135	100,135	100,135	100,135	100,135	100,135	100,135	100,135	100,134	100,130
Clearing Reserve	14,362	14,362	14,362	14,362	14,362	14,362	14,362	14,361	14,361	14,360	14,357
Equalisation Reserve	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170	2,170
Equity Linked Buffer	3,230	3,230	3,230	3,230	3,230	3,230	3,230	3,230	3,230	3,230	3,230
Solvency capital < Solvency limit*	56.2%	43.7%	30.2%	35.1%	41.4%	47.3%	52.8%	57.8%	62.9%	75.0%	85.8%
Solvency capital < 10% *	29.8%	45.1%	30.3%	25.5%	24.6%	26.2%	27.3%	27.7%	28.2%	33.1%	38.9%
Solvency capital < 5% *	16.8%	13.6%	8.9%	9.3%	10.6%	13.4%	15.3%	17.1%	18.8%	24.7%	30.2%
Solvency capital < Solvency limit	23.8%	12.2%	8.3%	10.8%	14.5%	19.3%	23.6%	27.5%	31.3%	43.4%	56.5%
Solvency capital < 10%	10.4%	12.9%	8.5%	7.7%	8.0%	9.2%	10.0%	10.5%	10.9%	13.9%	17.4%
Solvency capital < 5%	5.1%	3.2%	2.1%	2.4%	3.0%	4.1%	4.9%	5.8%	6.5%	9.3%	12.8%

Appendix 6. Risk measures pre- and post- 2017 regulations – 10 Years

Score	BaseNew	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	5.7%	3.3%	3.8%	4.2%	4.7%	5.2%	5.7%	6.2%	6.7%	7.1%	7.6%
Yield Requirement	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%
Investment return < 0% Prob	28.1%	27.0%	23.6%	24.1%	26.0%	26.9%	27.8%	28.7%	29.3%	30.2%	31.8%
Investment return > 5% Prob	53.4%	38.6%	41.5%	45.5%	48.6%	51.0%	52.8%	54.1%	55.5%	56.0%	56.0%
Total return < Yield Requirement Prob	46.2%	74.0%	69.8%	61.9%	54.8%	50.2%	46.7%	44.7%	43.1%	42.5%	42.6%
Solvency ratio	23.1%	9.3%	12.6%	15.4%	17.9%	20.5%	23.4%	26.4%	29.3%	31.9%	34.2%
Solvency limit	12.7%	7.0%	6.8%	7.0%	8.1%	9.7%	12.0%	15.0%	17.9%	21.2%	25.7%
Solvency capital	27,190	9,243	13,145	16,765	20,274	23,789	27,684	31,997	36,050	39,809	43,524
Assets	140,586	122,639	126,541	130,160	133,668	137,180	141,079	145,392	149,445	153,204	156,917
Liabilities	113,396	113,396	113,396	113,396	113,394	113,392	113,395	113,396	113,396	113,396	113,394
Clearing Reserve	18,805	18,805	18,805	18,805	18,803	18,801	18,804	18,805	18,805	18,805	18,803
Equalisation Reserve	2,019	2,019	2,019	2,019	2,019	2,019	2,019	2,019	2,019	2,019	2,019
Equity Linked Buffer	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546	-1,546
Solvency capital < Solvency limit*	47.8%	96.1%	71.4%	49.5%	37.3%	39.6%	47.6%	58.4%	67.5%	78.0%	91.4%
Solvency capital < 10% *	43.2%	99.8%	91.4%	77.5%	60.4%	49.9%	45.1%	44.2%	44.5%	47.1%	53.0%
Solvency capital < 5% *	23.6%	91.2%	59.4%	34.0%	21.6%	21.3%	23.6%	27.1%	29.5%	34.2%	41.9%
Solvency capital < Solvency limit	13.8%	43.2%	24.7%	12.5%	8.9%	11.2%	15.7%	22.9%	29.6%	39.3%	55.9%
Solvency capital < 10%	12.1%	60.4%	43.8%	27.5%	18.4%	15.5%	14.9%	15.9%	16.3%	18.0%	21.7%
Solvency capital < 5%	5.6%	34.8%	17.2%	7.4%	4.8%	5.3%	6.4%	8.3%	9.4%	11.7%	15.7%

Score	BaseOld	OP1	OP2	OP3	OP4	OP5	OP6	OP7	OP8	OP9	OP10
Return Total	5.7%	3.3%	3.8%	4.3%	4.7%	5.2%	5.7%	6.2%	6.6%	7.1%	7.6%
Yield Requirement	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%	5.1%
Investment return < 0% Prob	28.1%	27.0%	24.5%	24.3%	25.7%	26.6%	27.4%	28.0%	28.9%	30.4%	31.8%
Investment return > 5% Prob	53.4%	38.6%	42.0%	46.0%	49.3%	51.8%	53.7%	55.1%	55.8%	56.0%	56.0%
Total return < Yield Requirement Prob	46.8%	66.1%	61.6%	56.5%	51.9%	48.5%	46.2%	44.4%	43.5%	43.8%	43.4%
Solvency ratio	23.9%	9.9%	13.2%	16.3%	19.0%	21.8%	24.6%	27.5%	30.5%	33.2%	35.9%
Solvency limit	15.0%	8.0%	7.6%	9.4%	11.1%	12.8%	14.7%	17.1%	20.8%	25.4%	31.8%
Solvency capital	27,889	9,949	13,944	17,856	21,427	24,995	28,660	32,537	36,720	40,467	44,311
Assets	140,598	122,659	126,655	130,567	134,138	137,705	141,370	145,240	149,388	153,047	156,802
Liabilities	112,709	112,711	112,711	112,711	112,711	112,711	112,710	112,703	112,668	112,580	112,490
Clearing Reserve	17,556	17,557	17,557	17,557	17,557	17,557	17,557	17,550	17,515	17,426	17,336
Equalisation Reserve	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998	1,998
Equity Linked Buffer	3,184	3,184	3,184	3,184	3,184	3,184	3,184	3,184	3,184	3,185	3,185
Solvency capital < Solvency limit*	76.9%	99.6%	90.9%	80.3%	75.5%	71.3%	71.5%	72.8%	77.8%	85.2%	90.6%
Solvency capital < 10% *	51.8%	99.7%	92.9%	73.8%	59.8%	50.8%	47.5%	45.9%	45.5%	49.7%	54.0%
Solvency capital < 5% *	34.3%	91.9%	67.0%	43.6%	33.3%	31.4%	30.9%	31.9%	34.8%	40.0%	45.0%
Solvency capital < Solvency limit	28.9%	51.9%	33.6%	26.8%	25.3%	25.0%	26.6%	29.5%	36.1%	44.2%	53.1%
Solvency capital < 10%	15.8%	52.8%	36.3%	23.2%	17.7%	15.3%	14.7%	14.6%	16.0%	18.6%	21.6%
Solvency capital < 5%	9.1%	32.4%	17.5%	10.1%	8.5%	8.2%	8.5%	9.1%	11.0%	13.7%	17.0%