Analysis of the performance of Icelandic pension funds

Competing with the pension funds

Master's thesis

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Abstract

Pension funds are large institutional investors that play a big role in many economies. One of those economies is Iceland where the total assets of pension funds amount to over 160% of the GDP. The main purpose of these pension funds is investing the contributions they receive from their members and to pay these fund members their money back when they retire. The biggest concern is that the pension funds are not achieving adequate returns in order to make sure that the money does not lose its value due to inflation or other factors.

This research focuses on two parts. First of which is analysing the investments of five of the largest pension funds in Iceland over the years 2010 until 2019 and how the pension funds have been allocating their investment assets. The second purpose of the research is to examine whether a knowledgeable individual could achieve higher returns than the pension funds. Given the assumptions that the investor would be allowed to invest its own money instead of paying the premiums to a pension fund.

The research finds that the pension funds have been investing efficiently and achieving good returns over the entire decade. Furthermore, the research shows that although the hypothetical investor is able to achieve decent returns, he is not able to beat the returns of the pension funds.

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1 Introduction

The cornerstone of a system that enables individuals to live a carefree retirement is a good and efficient pension system. In some countries, individuals are legally required to contribute a portion of their salary into a pension scheme. One of those countries is Iceland, where individuals are required by law to pay at least 12% of their monthly salary to a relevant pension fund; usually 4% directly from the salaries of the employee and the remaining 8% from the employer (Icelandic pension funds association, 2018). The main purpose of these pension funds is to safeguard the contributions from the pension fund members, invest the money and pay the members their money back when they reach retirement age. The secondary purpose of the pension funds is providing guarantees in case of individuals suffering disability or passing away.

The pension system in Iceland has been a big debate throughout the years due to the relative size of the pension market in Iceland. The total assets of all the pension funds in Iceland amounts to over 160% of GDP in the year 2019 which makes it one of the largest pension systems in the world (OECD, 2019). In recent years, investment opportunities available to the public have been increasing. Mutual funds and equity investments are more and more open to the public. Which begs the question whether a knowledgeable individual could achieve higher returns than the pension funds if that individual was allowed to invest its own money instead of paying premiums to a pension scheme every month.

1.1 Objective and purpose

The objective of this research is twofold. Firstly, I will analyse the investment performance of five large pension funds in Iceland over the years 2010 to 2019. I will inspect how they allocate their assets between different asset classes and how good, or bad, the returns have been over the decade. These years were chosen as they span an entire decade and should be enough to make fairly accurate assumptions. Another factor that comes into play is that the effects of the financial crisis of 2008 have substantially subsided at the start of the research period. Secondly, I will create a hypothetical investor who wants to investigate whether or not he could beat the returns of the pension funds

by following a simple portfolio approach like the mean-variance approach that Markowitz introduced in the year 1952.

1.2 Research question

Currently, pension savers in Iceland are forced into pension schemes that invest the money of the pension fund members. These individuals are often concerned if the pension funds are investing these contributions wisely and securing the financial future of the individuals as they retire. The following research questions will be answered in the research:

- How are the pension funds allocating their investment funds and how have they adjusted their portfolios over the last decade?
- Could an investor achieve higher returns than the pension funds by following a simple investment model?

The first question will be answered by analysing the annual reports and balance sheets of the pension funds and categorising their assets into a few categories. These figures are then compared between the different pension funds and how the returns have been over the last decade. The second part of that question will be answered the same way, the changes to the asset distribution of the pension funds will be explored and explained in some way, for example how the asset composition changes as the currency restrictions following the financial crisis were lifted. The second, and perhaps the biggest question of this research, is whether an investor could beat the returns of the pension funds. He would do so by instead of paying a premium to a pension fund, invest the same amount in different asset classes based on a relatively simple approach, as the mean-variance model by Markowitz.

1.3 Thesis structure

Chapter 2 starts with an explanation of the role and purpose of pension funds, followed by information about the Icelandic pension sector. Facts and figures about the sector are presented along with explanations about the legal framework and capital markets in Iceland. Chapter 3 is dedicated to the theoretical background of the research presented

in this paper. Portfolio selection by Markowitz is introduced, along with the capital asset pricing model and the efficient frontier. All of which form the basis for this research.

In chapter 4, previous research on similar topics is presented such as a paper by Fischer Black on capital market equilibrium with restricted borrowing, research on the effects of pension funds on capital markets and finally a paper about the Icelandic pension sector. Chapter 5 presents the methodology used in the research which shows the calculation methods behind creating the portfolio that the hypothetical investor creates. Chapter 6 covers both data used in the research and the delimitations. It starts off by introducing the five pension funds that are analysed and gives a brief overview of all of them. Next, the chapter shows how the assets of the five pension funds are classified into four broad categories for an easy comparison. Eight indices are introduced as investable assets for the hypothetical investor. The chapter ends by explaining the delimitations to the research.

In chapter 7 the investments of the pension funds over the last decade are analysed. The returns of the pension funds are looked at and they are compared against the indices introduced as investable assets for the hypothetical investor to invest in. Chapter 8 covers the portfolio creation of the hypothetical investor. Several portfolios are created and tested how they would perform against the returns of the pension funds. Chapter 9 is a conclusion chapter where the main results of the research will be covered, and the research questions will be answered.

2 Pension Funds and Iceland

In the following chapter the various aspects of pension funds will be covered. It starts by discussing the pension funds in general and what their main purpose and goal is. The pension system in Iceland and its history will be introduced. Followed by a short section on statistics and figures about the pension system in Iceland. The last two sections are dedicated to the legal framework around the Icelandic pension funds and the capital markets that they operate on.

2.1 Role of pension funds

A pension fund is a special type of fund designed to receive payments from workers with the promise of paying the individuals their money back when they retire at later stages in their life. The main purpose of the pension fund is to invest the money for the individual to make sure that it does not lose value due to inflation or other factors. Pension funds work within legal frameworks set forth by the government (Ambachtsheer, 2016).

Pension funds operate a variety of schemes that can most often be classified as either defined contribution plans or defined benefit plans. The defined contribution plan is characterised by the worker paying a predetermined part of his salary into the pension scheme which sets up an individual account for that particular pension saver. The money is then invested on his behalf and he receives the amount in his retirement. The defined benefit plan is set up as a plan or a formula that determines the benefits the individual receives in his retirement. An example of a defined benefit plan is a case where a worker will receive his average salary multiplied by years worked multiplied by 1.4%. So, an employee with an average salary of $100,000 and a 40-year work experience would receive $100,000 * 40 * 1.4% = $56.000 per year in pension payments in his retirement. The key difference between the two approaches is who bears the investment risk. In the defined benefit plan, the pension fund or the employer bears all of the risk whilst in the defined contribution plan the investment risk is solely borne by the employee (Hull, 2018). In recent years the trend has been moving towards new types of plans that are hybrids between defined contribution and defined benefit. Those have been given names such as “defined ambition” or “target benefit” and have in common that they increase the risk sharing between the two parties (Ambachtsheer, 2016). The biggest incentive for individuals to participate in pension funds is the tax incentive that employees receive, the

pension payments to the pension funds are not income taxed as regular salaries. Taxes are only payable when the pension is paid out to the individuals as pension payments (Hull, 2018). In some cases, the pension fund of an individual that passes away are transferable to a spouse or a child. This is especially true for the pillar three voluntary savings which are often fully transferable to a family member if the pension saver passes away (Ambachtsheer, 2016).

Another role of the pension fund is acting as insurance or a safety net if its members have an accident, get ill or for some other reason are unable to keep on working. In many countries, pension funds also allow the family members of a deceased pension fund member to receive pension payments from the fund (Hull, 2018).

2.2 The Icelandic Pension System and History

The Icelandic pension system is built on three pillars. First of which is a tax-financed public pension with the purpose of guaranteeing individuals with a predetermined minimum amount in their retirement. The second pillar is based on mandatory occupational pension schemes which legally requires 12% of individual's salaries to be paid into a pension scheme. Even though the minimum required by law is only 12%, most professions have a collective agreement to contribute 15.5% where the individual is deducted 4% of his salaries and the employer pays the remaining 11.5% (The Pension Fund of Commerce, n.d.-a). The third and final pillar is a voluntary pension saving with tax savings incentives for the saver where the employee is allowed to pay between 2% and 4% of his salary and the employer will pay 2% on top of that (Gudmundsson, 2001).

There is a long tradition of Icelandic pension funds being collectively run by the trade- and labour unions and many of the board of directors in these funds are elected by these unions (Gudmundsson, 2001). For example, in the Pension fund of commerce the board of directors has eight board members. Four of which are elected by the Store and Office Workers union and four are elected by the appropriate trade unions (The Pension Fund of Commerce, n.d.-b). There are currently 21 pension funds operating in Iceland, some of which are open to all employees, others are limited to certain industries. The number of funds has gone down from over 50 funds that were operating at the end of last century. Many of them have been merged to increase cost efficiency and reduce overhead costs (Gudmundsson, 2001; Icelandic pension funds association, n.d.-a).

The system cannot be strictly categorized as either defined benefits or defined contribution but is a combination of both. It has some characteristics of defined contribution in the sense that every worker is required by law to pay a certain percentage of his salary into a pension scheme but individuals do not have their own accounts in the pension scheme and the investment risk is collectively borne by all the pension scheme members (Gudmundsson, 2001). However, the pension funds are required by law to provide pensioners with 56% of their average monthly salaries on the condition that they have paid into the pension scheme for 40 years (Herbertsson, 2006). Furthermore, all pension funds in Iceland are legally required to provide members with disability pension, survivors pension and children pension which will be further detailed in chapter 2.3.

2.3 Legal Environment and Restrictions

The Icelandic pension funds are privately managed but operate under a law called the Act no. 129/1997 on mandatory pensions insurance and the operations of pension funds, henceforth referred to as the Icelandic pension law (Lög um skyldutryggingu lífeyrisréttinda og starfsemi lífeyrissjóða No. 129/1997). The Icelandic pension law states that the minimum contributions to pension funds is 12% of the salary of the pension member. However, as of July 1st, 2018 a collective agreement was finalized between most of the labour parties and the contribution to the pension funds was increased up to 15.5% for most of the working people. It is divided up between the employee and the employer. The former paying 4% of his own salary and the latter paying 11.5% as an employer contribution (Icelandic pension funds association, 2018). The Icelandic pension law also places various restrictions on the operations of pension funds and its main goal is to limit the exposure pension funds have towards financial losses. Among the restrictions are rules that state what assets pension funds are allowed to invest in. The act classifies the assets as in table 1:

Table 1: *Classifications of investment assets*

Asset class	Financial instruments within the class
A	Government bonds and housing bonds
B	Municipality bonds, deposits and covered bonds
C	Bonds issued by loan and insurance companies and shares in UCITS
D	Bonds issued by companies and other bonds
E	Shares in listed companies and real estate
F	Derivatives to hedge currency risk and other financial instruments

Source: The Icelandic pension law no. 129/1997

And the restrictions set forth in regard to investing in these asset classes are listed in table 2. Further restrictions include that the pension funds are only allowed to invest in financial instruments issued in OECD countries or countries that are participants to the EEA agreement from 1992 (No. 129/1997).

Table 2: *Investment restrictions*

Asset class	Restriction
C + D + E + F	Should be less than 80% of total assets
D + E + F	Should be less than 60% of total assets
F	Should be less than 10% of total assets
Assets in ISK	Should be at least 50% of total assets

Source: The Icelandic pension law no. 129/1997

The Icelandic pension law also stipulates that individuals who pay contributions to a pension scheme for at least 40 years are guaranteed a minimum of 56% of their average salary as pension payments when they retire, which is the equivalent of 1.4% for each year. Active members in a pension fund are also entitled to insurances in the case of becoming permanently disabled or passing away. In the case of disability, individuals are entitled to disability pensions depending on their calculated disability level. When active members in a pension fund pass away and have family members, the family members are entitled to receive a part of the pension benefits of the deceased individual. A spouse is entitled to receive the pension benefit for at least two years after the death of the

pension member, if children are in the household, the spouse is entitled to the pension benefit until the child is 18 years old. The child in the household should also receive the pension benefit until it reaches 18 years of age. The disability pension, spouse pension, and child pension amounts should be forecasted based on the salary of the pension member before the event occurred (No. 129/1997).

2.4 Numbers and statistics about Icelandic Pensions

According to the FSA, total assets of the Icelandic pension system in the end of 2019 was in the excess of 5,100 billion ISK. Even though that is not a great sum in an international comparison, the amount is over 160% of the GDP in Iceland which is the 3rd highest in the world, surpassed only by the Netherlands at 173% and Denmark at 199% (OECD, 2019).

An important indicator of the efficiency of a pension system is the replacement rate which is the percentage of the average working salary workers receive from the pension system in their retirement. A larger number indicates that individuals are receiving amounts that are closer to their average working salary during their working life. The OECD average replacement rate is 58.6 while the average replacement rate in Iceland is 69.8 (OECD, 2020).

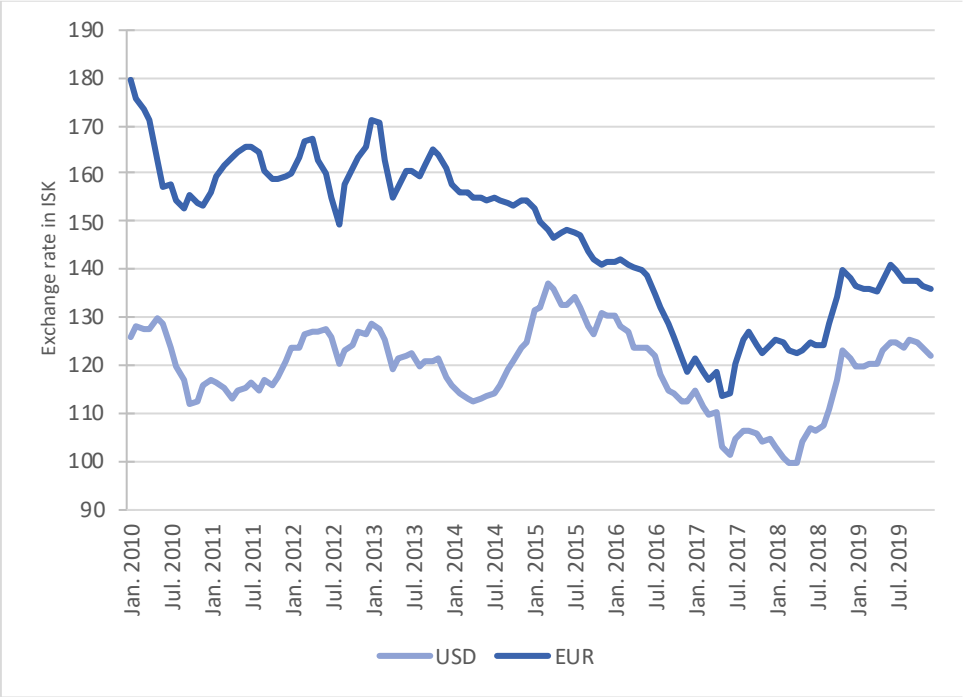
2.5 Capital Market Environment

A wide variety of financial instruments are traded in Iceland. Nasdaq, the largest stock exchange in the world, operates in Iceland and has been doing so since the year 1989 under a different name. It started trading equities in the year 1991. Before that time, it was mostly trading bonds and other financial instruments (Nasdaq OMX, n.d.).

2.5.1 Currency

The currency used in Iceland is the Icelandic krona, abbreviated as ISK. Iceland has been using its own currency since late 19th century when the country stopped using the currency of Denmark. ISK is one of the smallest free-floating currencies in the world and has over the years seen some high volatility (Kallestrup, 2008). Figure 1 shows the exchange rate between ISK and two other major currencies, USD and EUR, in the years 2010 until end of year 2019.

Figure 1: *Development of the exchange rate between USD/ISK and EUR/ISK*



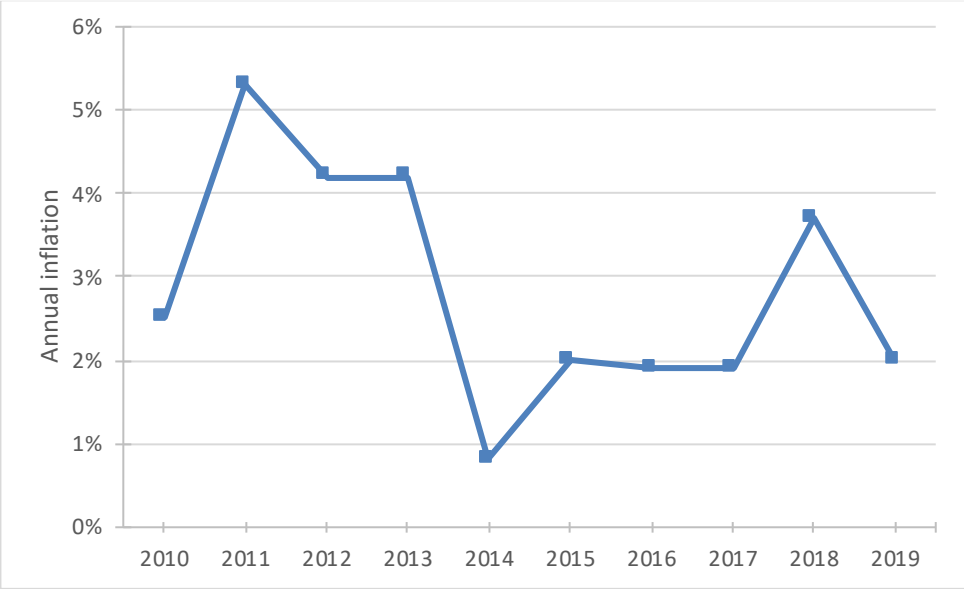
Source: Own contribution built on data from the Central bank of Iceland

As seen in figure 1, fluctuations in exchange rate between ISK and EUR in the period being examined are large. Ranging from EUR/ISK 179.78 in the beginning of the period down to 113.74 in 2017. The same is true for the exchange rate between ISK and USD where values range from USD/ISK 136.82 in 2015 to 99.59 in 2018. In the case of pension funds, where all or most of the liabilities are nominated in ISK, depreciation in the ISK towards foreign currencies can have positive effects on the returns on foreign investments. The opposite holds for when ISK is appreciating, returns on foreign investments become less valuable to the pension fund. Uncertainty is however something that investors do not want, and currency fluctuations are not desirable when evaluating an investment opportunity (Munk, 2018).

2.5.2 Inflation

Inflation is measured as the changes in the consumer price index (CPI). An increase in the CPI means that the relative purchasing power of each unit of currency drops by the same percentage as the change in the CPI (Central Bank of Iceland, n.d.-a). Figure 2 shows the inflation in Iceland between the years 2010 and 2019 using end of month figures for December every year.

Figure 2: *Annual inflation between the years 2010 and 2019*



Source: Statistics Iceland

At the beginning of the decade the inflation was above the target inflation rate of the Central Bank which is set at 2.5% (Central bank of Iceland, n.d.-a). During the middle of the decade there were four consecutive years where the inflation was below the target rate, followed by a sharp increase during the year 2018 and a subsequent drop a year later.

2.5.3 Equities and bonds

There are currently 20 companies listed at the stock exchange of Nasdaq in Iceland. Two companies are listed as large cap meaning market value above one billion Euros, 13 companies are mid cap meaning market value between 150 million and one billion Euros and five companies are small cap which means that the market value is below 150 million Euros (Nasdaq OMX, 2012). A wide variety of fixed income products are also traded at the Nasdaq Iceland exchange. These include government bonds, mortgage bonds, corporate bonds and more.

2.6 Currency restrictions following the 2008 crisis

This chapter is not complete without a short discussion about the currency restrictions imposed after the economic collapse of 2008. Following the downfall of the Icelandic banks, several restrictions were imposed on financial institutions and pension funds in Iceland. What affected the pension funds most was their inability to invest abroad for several years. However, they were allowed to use dividends, earned interests and the selling price of other foreign assets to buy new foreign assets. They were also allowed to continue with their financial commitments that were started before the restrictions. In the year 2016, the pension funds got an exemption from the currency restrictions and were allowed to invest abroad for 85b ISK. A year later the currency restrictions were fully abolished and foreign investments were allowed without limitations (Baldvinsson, Árnadóttir and Guðmundsson, 2018).

2.7 Chapter summary

The chapter starts off by explaining the purpose and role of pension funds in general, followed by an explanation of the Icelandic pension system. The chapter goes on to explain the legal environment around the pension funds and presents some statistical facts about it. Capital markets are explored, and the chapter ends with a short section on the currency restrictions that followed the economic crisis of 2008.

3 Theoretical Background

The following chapter contains the theoretical background of this research. Starting with the Modern Portfolio Theory by Markowitz, followed by the closely related Efficient Frontier and the Capital Asset Pricing Model. Finally, there is a short section on the Home Bias phenomenon.

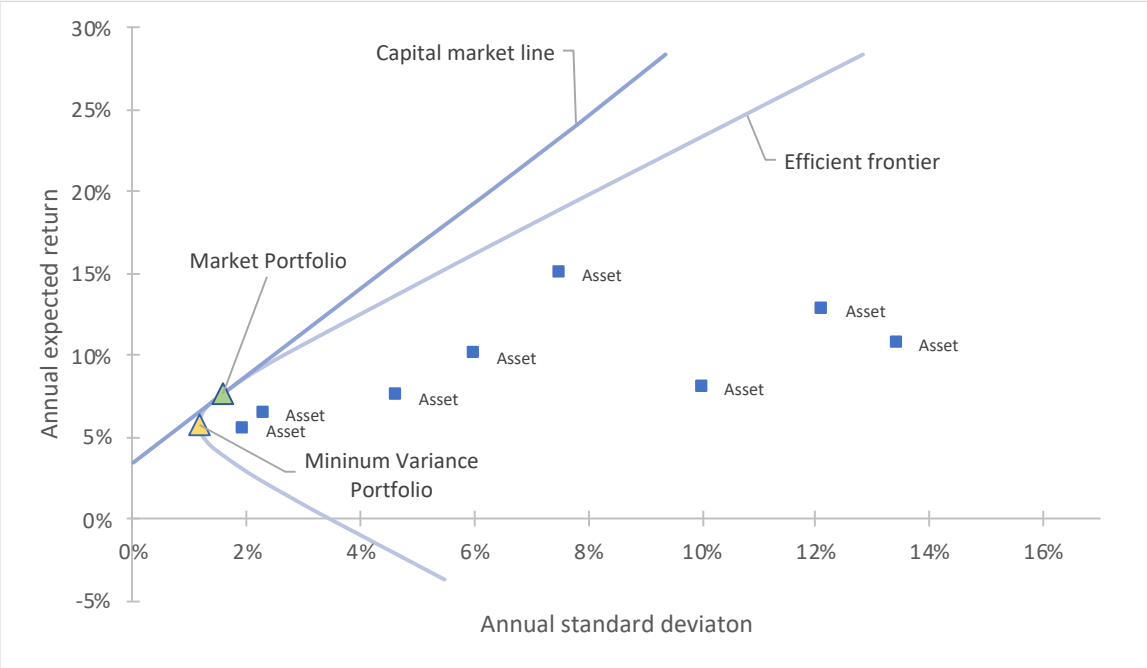
3.1 Portfolio Selection

The Modern Portfolio Theory is based on the work of the economist Harry Markowitz back in 1952 in his ground-breaking paper called Portfolio Selection (Markowitz, 1952). Markowitz starts off by discrediting the widely accepted rule concerning choice of portfolio which stated that investors should choose a portfolio that had the highest discounted future return. Markowitz pointed out that in some cases no diversification would take place if the only goal were to maximize discounted expected return, an individual would simply choose a single stock that fit that criteria. He goes on to discredit multiple theories and finally introduces a rule which he calls the E-V principle, which we now know as mean-variance theory. The principle considers the expected returns of stocks and the standard deviation of that expected return. One important message of Markowitz's paper is that investors should consider how securities move in relation to each other and how changes in one security affects others. By using that method, an investor could in theory create a portfolio with equal expected return but lower standard deviation and therefore less risk (Elton & Gruber, 1997).

3.2 Efficient Frontier

An important part of the Modern portfolio theory is the efficient frontier. It is most often used as a visual representation of the attainable portfolio with a given set of investable assets. As Markowitz (1952) explained, the portfolio construction mostly depends on the expected return and risk of the assets. Therefore, displaying the efficient frontier is relatively easy in a two-dimensional risk and return spectrum as shown in figure 3.

Figure 3: *The efficient frontier and capital market line*



Source: Own contribution

The x-axis represents the annual standard deviation, which is the risk of the asset on an annual basis. The y-axis represents the annual expected return. The global minimum variance portfolio is the asset distribution that yields the lowest possible risk. Any point on the efficient frontier above the minimum variance point is considered an efficient portfolio. The figure clearly shows how diversification allows investors to achieve lower risk in their portfolio and also reach expected returns that are above that which individual assets are expected to yield (Markowitz, 1952).

When there is a risk-free asset available to investors, the capital market line (CML) is often drawn from the risk-free point on the y-axis and runs upwards as also shown in figure 3. The market portfolio is at the tangency point of the CML and the efficient frontier (Bodie, Kane and Marcus, 2018).

3.3 Capital Asset Pricing Model

Even though the Capital Asset Pricing Model (CAPM) was introduced over 50 years ago it is still relevant today. It is a framework that allows investors to predict how to measure risk and the relation between expected return and risk. CAPM is built on the work of Markowitz which assumes that investors should choose assets that minimize the variance

of the portfolio and maximize expected returns with the given variance goal. The CAPM turns it into a testable prediction about the relation between expected return and risk (Fama and French, 2004). According to CAPM, the expected return of a portfolio can be expressed in the following way:

$$R_p = R_F + \beta_i(R_M - R_F) \quad (1)$$

Where R_p is the return of the portfolio, R_F is the risk-free rate, $R_M$is the expected market return and β_i is the sensitivity to changes in the market (Sharpe, 1964).

3.4 Home Bias

The Home bias puzzle is the phenomenon that investors tend to hold disproportionally high equity in their own home country. Cooper, Sercu and Vanpée (2012) reviewed the literature and came to the conclusion that a number of reasons have been theorised to try to explain why this happens. One of those reasons is that investors tend to have more faith in their local market due to the closeness to it and thinking that they know how to beat other investors on that same market. Other reasons include explicit costs or barriers for foreign investments, information asymmetries and currency risk. Finally, some behavioural factors could be used to explain the phenomenon, such as overoptimism, overconfidence and patriotism.

3.5 Chapter summary

This chapter covered the theoretical background of the research. The basis for the research is the work by Markowitz which laid ground to the Modern Portfolio Theory that we know today. The Capital Asset Pricing Model is explained, and Home Bias is briefly introduced.

4 Literature review

The literature behind this research is the topic of this chapter. The chapter starts by covering Fischer Black's paper on capital market equilibrium. Next we have a short section on papers related to pension funds in general. The chapter concludes on a section dedicated to the Icelandic pension sector and covers a report requested by the Icelandic government in 2017.

4.1 Research on capital markets

In his 1972 paper, Fischer Black explained how capital market equilibrium was achieved with restricted borrowing. He started off by explaining how the Capital Asset Pricing Model requires four assumptions to be made. One of which is the assumption that investors are allowed to take a long or short position in any asset, no matter how large or small the position is. Investors are also allowed to borrow or lend any amount of money at the riskless rate. Black rationalises why this does not hold in reality and explores alternative restrictions such as a scenario without a riskless asset, where there is no riskless lending or borrowing. He then goes on to show analytically how when there is no riskless asset, all efficient portfolios may be written as a weighted combination of the market portfolio and the minimum variance portfolios (Black, 1972).

4.2 Research on pension funds

Meng and Pfau (2010) researched the effect that pension funds have on capital market developments. They found that countries that have a developed financial market benefit significantly from having either large or growing pension funds. These pension funds are active participants on capital markets. They increase the availability of long-term funds, encourage financial innovation, improve corporate governance with active ownership and enhance market competition. They go on to explain how pension funds must be adequately regulated by policymakers to make sure that they have the legal framework and tools to support a healthy financial market

In recent years, responsible investments have been a big topic in the pension sector. Sievänen, Rita and Scholtens (2013) explored the drivers of responsible investments among pension funds. They explain how pension funds are indirectly owned by the people in the country and therefore the pension funds have an obligation, or should have,

to invest ethically. Their results indicate that the pension funds that often have responsible investments are the large ones and the small ones. They explain this with the fact that large ones attract the most attention and therefore public pressure to invest ethically. The small pension funds usually have a close relation with their stakeholders which directs them towards more responsible investments.

4.3 Literature on Icelandic pension funds

In 2017, the government of Iceland ordered a report on the pension sector and their foreign investments. The report started off by describing the simple fact that the Icelandic pension funds are somewhat too large for the Icelandic capital market. According to the report, the total assets of the pension sector in 2017 were 3,514 billion ISK, while the total amount of marketed financial instruments in Iceland were only 3,437 billion ISK. The authors go on to explain how the pension funds are big influencers on the pricing of most assets; they are price makers and not price takers on the financial market in Iceland. The equity ownership in Icelandic companies may also lead to horizontal ownership, where pension funds are stakeholders in companies that are direct competitors on the same market. A small market such as Iceland is highly susceptible to such problems. The report concludes that the pension sector will have to increase their foreign investments in the coming years, the capital market of Iceland is simply not large enough. The authors further point out that the biggest downside of foreign investments, currency risk, is something that should be prevented. They do not have a concrete answer as to how that should be done, although they suggest a few preliminary suggestions. Such as limiting all investments to the domestic market, linking a part of the liabilities to other currencies and finally hedging the currency. All of these have some serious shortcomings which will not be detailed here (Magnússon, Sigurgeirsson, Þórðardóttir, Sigurðsson and Agnarsdóttir, 2017).

4.4 Chapter summary

This chapter on literature review covered a few papers and reports that are relevant to this research. Black starts by demonstrating how a model that allows for any position in any asset, no matter how large or small, does not hold in reality and offers an alternative model that introduces an alternative scenario where there is no risk-free asset. Meng and Pfau show how capital markets gain from having large or growing pension funds followed

by a section on the responsible investments of pension funds. Pension funds must be aware that they are working for the fund members and must not only concentrate on pure profit every year. Finally, the chapter ends on a report requested by the Icelandic government on the Icelandic pension sector and the foreign investments of the pension funds. The report discusses how the pension funds are very large players on the capital market. The authors claim that the pension funds must increase their foreign investments in the coming years.

5 Methodology

The methodology behind the analysis will be covered in this chapter which explains the calculations behind how the efficient portfolio is created. There are various steps to creating a portfolio from multiple assets. First, monthly index figures are used to calculate the average monthly return figures for each, along with the average standard deviation of the returns of each asset. The next step is calculating how these assets move in relation to each other. Finally, matrix calculations are used to calculate various portfolios depending on the purpose and goal of the portfolio.

5.1 Risk and return

When calculating the monthly return of an asset the following equation is used:

$$Monthly\ return = \ln\left(\frac{P_{t-1}}{P_t}\right) = \ln(P_t) - \ln(P_{t-1}) \quad (2)$$

Where P_t is the price or index value at time t and P_{t-1} is the price or index value the month before. To calculate the expected monthly returns of the indices, average value is calculated from all the return figures.

The standard measurement of risk is variance (σ^2) and standard deviation (σ). These two values measure the dispersion of possible outcomes around the expected value (Bodie, Kane and Marcus, 2018). Sample variance is calculated with the following equation:

$$Variance: \sigma^2 = \frac{\sum_{i=1}^{n}(r_i - E(r))^2}{n-1} \quad (3)$$

Where r_i is the observed return in month i, $E(r)$ is the average or expected return over the period and n is the number of observations. Standard deviation is calculated with the following equation:

$$Standard\ deviation: \sigma = \sqrt{\sigma^2} \quad (4)$$

When evaluating the expected return and the variance of portfolios the following two formulas are used (Bodie, Kane and Marcus, 2018):

$$Expected\ portfolio\ return: E(r_p) = \sum_{i=1}^{n} w_i E(r_i) \quad (5)$$

$$Variance\ of\ portfolio\ returns: \sigma_p^2 = \sum_{j=1}^{n} \sum_{i=1}^{n} w_j w_i Cov(r_i, r_j) \quad (6)$$

Where w_i and w_j are allocations to assets i and j, $Cov(r_i, r_j)$ is the covariance between the returns of asset i and j.

5.2 Covariance and correlation

When portfolios are created, investors should not only look at the risk and return figures of individual assets. Investors must look at the correlations and covariances between the different asset classes and see how they move in relation to each other. The covariance between two assets is calculated with the following formula (Munk, 2018):

$$Cov(r_i, r_j) = \frac{1}{n-1} \sum_{n=1}^{N} (r_{it} - \overline{r_i})(r_{jt} \overline{r_j}) \quad (7)$$

Where $\overline{r_i}$ is the average value of r_i in the period being researched. Correlation coefficient between two assets is calculated as follows (Munk, 2018):

$$Corr(r_i, r_j) = \frac{Cov(r_i, r_j)}{\sigma_i \sigma_j} \quad (8)$$

The correlation coefficient can take any value between 1 and -1. A value of 1 means a perfectly positive relationship between the two returns, a value of -1 means that there is a perfect negative relationship between the two. A value of 0 means that there is no correlation between the returns.

5.3 Sharpe ratio

A well-known way to quantify the trade-off between risk and return is the Sharpe Ratio. The ratio measures the relationship between the expected excess return of an asset or a portfolio and the standard deviation. The ratio is measured with the following formula (Bodie, Kane and Marcus, 2018):

$$Sharpe\ Ratio = \frac{R_P - R_F}{\sigma_P} \tag{9}$$

Where R_P is the return of the portfolio, R_F is the risk-free rate and σ_P is the standard deviation of the returns of the portfolio.

5.4 Portfolio calculations

Matrix calculations are used when calculating the optimal portfolios. When writing the distribution of assets in a portfolio the following the following vector is used:

$$\pi = \begin{pmatrix} \pi_1 \\ \pi_2 \\ \vdots \\ \pi_n \end{pmatrix} \tag{10}$$

Where the total sum of all π's equals 1. When we invest in a portfolio of n assets, we write the rates of return of individual assets as the following vector:

$$r = \begin{pmatrix} r_1 \\ r_2 \\ \vdots \\ r_n \end{pmatrix} \tag{11}$$

Next step is writing the variance-covariance matrix ($\underline{\underline{\sum}}$) as an n x n matrix in the following way:

$$\underline{\underline{\sum}} = \begin{pmatrix} Var[r_1] & Cov[r_1 r_2] & \dots & Cov[r_1 r_n] \\ Cov[r_2 r_1] & Var[r_2] & \dots & Cov[r_2 r_n] \\ \vdots & \vdots & \ddots & \vdots \\ Cov[r_n r_1] & Cov[r_n r_2] & \dots & Var[r_n] \end{pmatrix} \tag{12}$$

The variance of the returns of the entire portfolio is calculated with the following formula:

$$Var[r(\pi)] = \pi^T \underline{\underline{\sum}} \pi = \pi \cdot (\underline{\underline{\sum}} \pi) \tag{13}$$

And finally, the return of the portfolio is calculated with the following formula:

$$Portfolio\ return = \pi^T \cdot r \tag{14}$$

5.5 Chapter summary

This chapter covered the methodology behind the calculations done in this research. It starts off with simple explanations on how the risk and return of the different assets are calculated, followed by sections on covariance and correlation. The Sharpe ratio is explained and finally, the chapter ends on how matrices are used to calculate the portfolio variance and return.

6 Data and Limitations

The following chapter will describe in detail the criteria used for choosing the pension funds used in this research and how the gathering of data was done. There is also a section on how the assets available to the hypothetical investor were chosen. The chapter concludes with a part about the delimitations of the research.

6.1 Choosing the pension funds

Five large pension funds in Iceland were chosen for this research. They collectively hold investment assets worth over 3,100 billion ISK which is around 60% of the total assets of the pension system in Iceland (FSA, n.d.). These pension funds were chosen on the basis of them holding the largest mandatory (pillar 2) capital and are easily comparable to each other. Some of the pension funds are marketed towards specific industries as will be further detailed in the sub-chapters to come while others are open to all individuals. The five pension funds have in common that they mostly use their own internal fund managers for domestic investments. They use managers of large foreign funds to invest in foreign equities such as Vanguard, BlackRock and similar funds.

6.1.1 The pension fund for state employees

The pension fund for state employees or simply LSR (Lífeyrissjóður starfsmanna ríkisins) is the largest pension fund in Iceland. In the year 2019 it celebrated 100 years of operations which makes it the oldest pension fund in Iceland. The fund is currently divided into division A and B. Division A is a typical defined contribution scheme, very similar to the schemes in the other pension funds. Division B was closed for new members in 1997 and will close down in the years to come. It is a reminiscence of older times where defined benefits were the norm. Division B has been dealing with an actuarial deficit over the years and is directly sponsored by the government who are required by law to guarantee the pension fund and its liabilities. The main goal of the fund now is to make sure that it does not run out of assets before all liabilities are settled (LSR, n.d.).

6.1.2 The pension fund of commerce

The pension fund of commerce (Live) is the 2nd largest pension fund in Iceland. Its membership base mostly comes from the Store and Office Workers' Union (VR) which is

the largest labour union in the country, but members in other unions are also allowed to join the fund (Icelandic pension funds association, n.d.-b.).

6.1.3 Gildi pension fund

Gildi is the 3rd largest pension fund in Iceland. It is open to everyone although its biggest membership base comes from the 10 labour unions that are obligated to contribute to the pension fund. Biggest of which is Efling, the 2nd largest labour union in Iceland. The fund has been operating since the 2005 with the merger of two pension funds (Gildi, n.d.).

6.1.4 Birta pension fund

Birta is the youngest pension fund selected for this research. It has been operating since the year 2016 after a merger of two pension funds and currently it is classified as the 4th largest pension fund in Iceland. Birta is open to all individuals that do not have a compulsory membership in other pension funds (Icelandic pension funds association, 2016). Due to the fact that Birta started operating in its current form in the middle of the period being examined some adjustments had to be made. Financial statements of the two pension funds that merged were combined to represent what the financial statement of Birta pre-merger would have looked like. However, financial statements for the years 2010 and 2011 for one of the pre-merger funds were not accessible and therefore these two years are excluded for Birta pension fund. This should not have a significant effect on the results of this research.

6.1.5 Stapi pension fund

Stapi has been operating since the year 2007 after a merger of two established pension funds. The membership base mostly comes from the northern and eastern part of Iceland, and employees from all industries are allowed to join (Stapi, n.d.). Stapi is the smallest of the five pension funds selected for this research and is currently classified as the 7th largest pension fund in Iceland.

6.1.6 Comparing the pension funds

The pension funds vary in size as mentioned in the previous chapters. Various statistics about the five pension funds are presented in table 3.

Table 3: *Comparison between the five pension funds*

	LSR	Live	Gildi	Birta	Stapi
Total investments in 2019 (ISK in billions)	980.99	855.15	639.25	421.33	250.32
Total investments in 2018 (ISK in billions)	839.37	704.16	546.64	365.52	216.35
Total fund members	111,065	171,158	234,968	96,412	89,433
Active fund members	31,703	36,788	34,216	16,284	15,086
Contributions paid to fund (ISK in billions)	33.40	32.36	29.90	16.40	11.31
Individuals receiving pension, total	27,735	17,630	23,397	14,282	9,620
Individuals receiving pension, old age only	20,461	11,772	14,459	9,447	N/A
Total pension payments (ISK in billions)	57.64	14.32	16.17	10.49	5.68
Average age of members paying contributions	45(A) & 60(B)	36	N/A	N/A	35

Source: Various annul reports

All of the figures in table 3, except the row with total investments in 2019, are figures from end of the year 2018. The reason for this is that some of the funds have not released their annual reports for the year 2019, only the financial statements.

The difference in size between the funds is quite significant, LSR is nearly four times the size of Stapi when looking at the total investments figure. Another thing that is interesting when comparing the pension funds is the difference between the contributions being paid to the fund and total pension payments. All of the funds, except for LSR, are receiving more contributions than they are paying out as pension payments. The reason for this is as mentioned in chapter 6.1.1, the division B of LSR has been closed for new members for over 20 years and the average age of contributing members is 60 years of age. That means that in a few years there will only be individuals receiving pension payments and no active members paying contributions. The 2018 annual report of the division B further shows that the number of active members is only 2,164, compared to 16,431 individuals receiving pension payments. When adding up the total fund members of the five pension funds yields a value of over 700,000 which is a surprisingly high number. Considering that the total inhabitants of Iceland at the end of year 2018 was only 356,991 (Statistics Iceland, 2019), some fund members must have pension rights within multiple pension funds. This might be caused by members changing

pension funds or simply starting a new job. That new job could belong to a different labour union which mandates that the members join a specific pension fund, even if they are already contributing to a different one.

All in all, the pension funds are quite similar in purpose and how they operate. They run occupational pension schemes that are a hybrid between defined contribution and defined benefit. Although some would classify them simply as defined contribution with a guaranteed replacement rate of 56% (When individuals have contributed for a minimum of 40 years).

6.2 Data from the Icelandic pension funds

Annual reports and financial statements of the five pension funds were analysed, and the investments listed on the balance sheets were divided into four categories as shown below.

- Domestic equity: This category contains all domestic assets with variable income, along with shares in mutual funds investing in domestic equities, both private and public.
- Foreign equity: This category contains all foreign assets with variable income. These include listed and unlisted equity shares, along with shares in mutual funds investing internationally in equities, real estate and more.
- Government bonds: This category contains all bonds that have government guarantees in Iceland. These bonds are issued by the government and the Housing Financing Fund.
- Bonds: This category contains fixed income securities issued by parties that do not have government guarantees. This includes bonds issued by banks, companies and others. The category also contains domestic and foreign bond funds, along with housing loans to fund members with the assets as collateral.

All of the annual reports and financial statements were retrieved from the websites of the pension funds which can be found in Appendix A.

6.3 Data for the portfolio creation

In order for our individual to create an efficient portfolio, assets must be chosen for him to invest in. The assets are listed in the following sub-chapters. There are eight assets

listed, five of which are indices and three are established funds in Iceland traded by well-established financial institutions.

6.3.1 Foreign equities

The class of foreign equities is represented by MSCI World index excluding Europe (MSCI World ex EU) index (USD) and the MSCI Europe index (USD). The two indices capture mid-cap and large-cap equities in 23 countries; 15 in Europe and 8 in other developed markets (MSCI, 2020a; MSCI, 2020b). Data was retrieved from the MSCI website for end-of-month gross figures from December 2009 until December 2019. The indices are denominated in USD. Considering our investor is mostly interested in returns in ISK and is not going to use any hedging strategies, each index value is multiplied by the exchange rate between USD and ISK. The currency exchange rates are gathered from the Central bank of Iceland and they are average monthly values ranging from USD/ISK 99.59 in April 2018 to 136.82 in March 2015 (See Appendix B). The average monthly returns of the MSCI World ex EU and MSCI Europe indices are 0.90% and 0.45% and the average standard deviations are 3.87% and 4.72%, respectively.

6.3.2 Domestic equities

The domestic equities asset class is represented by the OMX Iceland All-Share Index (OMXIGI) created by Nasdaq. It includes all of the 20 equities listed at the Icelandic stock exchange as described in chapter 2.4.2. The index is available both as a price index (PI) and a gross index (GI). The PI means that cash dividends are not reinvested in the index itself while the GI means that the cash dividends are reinvested in the index (Nasdaq OMX, 2012). In this research the GI index is chosen due to the circumstances our investor is in; he is a long-term investor trying to maximize his wealth in his retirement. Therefore, all proceeds from the investments should be reinvested in order to maximize future profits. The average monthly return over the period is 1.07% with an average monthly standard deviation of 3.50%.

6.3.3 Domestic government bonds

Two indices from Nasdaq and one fund from the Icelandic asset management company Stefnir were used to represent bonds with government guarantees. The two indices constructed by Nasdaq have the names NOMXIREAL and NOMXINOM. The former is an

index-linked inflation bond index containing only government guaranteed bonds issued by the government or the Housing financing fund which is an independent government institution (Housing Financing Fund, n.d.). The latter contains the same assets but is not index-linked (Nasdaq OMX, 2013). The average monthly return over the period being examined for NOMXIREAL is 0.62% and NOMXINOM is 0.64%. The average monthly standard deviations are 1.34% for NOMIXLREAL and 1.40% for NOMXINOM. The third asset is a government bond fund set up by Stefnir which is an asset management company. The fund invests in long-duration government bonds, some of which are index linked and others are not, the fund was launched in 1999 (Stefnir, n.d.). I will refer to this fund as the Long government fund (Long Gov.). The average monthly return of the fund over the period is 0.59% and the average monthly standard deviation is 1.35%.

6.3.4 Domestic bonds

As there are no official indices for bonds issued by Nasdaq in Iceland other than government guaranteed ones, proxies were chosen to represent domestic bonds. Two bond funds were selected with the criteria that they had to be open to individual investors. The first one is a covered bond fund investing dominantly in bonds issued by the three largest banks in Iceland, the fund is controlled by an asset management company called Jupiter. This fund will henceforth be called the Covered bond fund (or Cov. Bond). It started trading in February 2015 and therefore has only 59 months of data. However, the average monthly return of the fund over the period is 0.54% and an average monthly standard deviation of 0.66% (Jupiter, n.d.). The second fund used as a proxy is a fund controlled by a company called Icelandic Securities. The fund invests in bonds traded at the Nasdaq exchange and holds bonds issued by municipalities, financial institutions and various other companies. This fund will henceforth be called the Corporate bond fund (or Corp. Bond). It was launched in April 2014 and therefore has only 69 monthly data points to use. The average monthly return of the fund is 0.45% and the average monthly standard deviation is 0.56%, making it the asset with both the lowest return and standard deviation (Icelandic Securities, n.d.).

6.3.5 Risk-free asset

In order to calculate various statistics such as the Sharpe ratio, a risk-free rate must be chosen. Risk-free rate is a rate that represents the interest rate an investor is able to

receive with no variance in returns. The risk-free rate chosen for this research is the 3-month Reykjavík interbank offered rate (REIBOR). The REIBOR data is collected by the Central bank of Iceland and is published daily on their website (Central bank of Iceland, n.d.-b). Over the last decade, the 3M REIBOR has seen some changes. In the beginning of 2010, the rate was 8.40% which is the highest it was over the entire decade. That could be explained by how close the date is to the financial crisis of 2008 where the 3M REIBOR rose to over 18%. The lowest rate over the period 2010 to 2019 was 3.70% in the end of 2019. A simple average of the rate over the period is calculated and the results are displayed in table 4.

Table 4: The risk-free rate

	Average annual rate	Average monthly rate
Risk-free rate	5.524%	0.46%

Source: The Central bank of Iceland and own contribution

As table 4 shows, the average annual rate of the 3M REIBOR is 5.524%, which translates to a monthly rate of 0.46%. This will be the official risk-free rate for this research.

6.4 Delimitations

In order for me to answer the research questions, some assumptions will have to be made, along with some implications that I will look past. These delimitations are explained and rationalised in the following sub-chapters

6.4.1 Number of pension funds

In this analysis I have chosen five pension funds to concentrate on. Even though that is only a quarter of the amount of pension funds, they collectively hold assets worth over half of the total worth of assets of the entire pension sector in Iceland. I therefore conclude that I should be able to draw conclusions about them collectively from the figures of only five funds.

6.4.2 Asset classification

The assets of the pension funds are divided into four categories as mentioned earlier. These classes are however rather broad and can have a wide variety of assets in them. This was decided due to the fact that not all of the five pension funds classify their investment assets as detailed as others. Some annual reports and financial statements have very detailed categories, such as foreign hedge funds, real estate funds and more. Others simply categorise all these assets under foreign investments in funds, without a detailed explanation of what these funds invest in. However, this asset classifications allows for a fair comparison to the investment possibilities chosen for the hypothetical investor.

6.4.3 Investable assets

Eight classes were chosen to represent the investments available to the hypothetical investor. In reality there are many more investment options, such as hedge funds, private equity, real estate and many more. However, the asset classes chosen are all easily investable by individuals, as there are various funds open to the public allowing for easy access to these investments as well as an accessible equity market in Iceland. Including more indices to the investable assets would complicate the analysis further and also somewhat violate the assumptions that these assets are relatively easy to invest in. Many specialized investment funds, such as hedge funds, are only open to sophisticated investors that fully understand the risk, which I am assuming that the hypothetical investor is not.

6.4.4 Transaction costs

When evaluating the portfolios and investments of the hypothetical investor, all transaction costs are ignored. This is done mostly for simplicity; funds have a very different cost structure, and the costs associated with buying equity can vary. This should be taken into consideration when comparing the returns of the hypothetical investor and the pension funds.

6.5 Chapter summary

The chapter starts by explaining how the five pension funds were chosen, followed by a short description of all of them and a comparison of various statistics about the funds.

The annual reports of these five funds were analysed, investment assets were divided into four different categories based on various criteria.

The chapter also has a detailed section about the eight assets that the hypothetical investor will be allowed to invest in. The assets are chosen to represent the possible assets an individual could invest in if he had the will to do so. There are various public funds open to individual investors that track or benchmark against the MSCI indices (BlackRock, n.d.). Individuals are allowed to invest as they want on the Icelandic Nasdaq stock exchange which is represented by the OMXIGI. All investors are allowed to purchase government bonds in Iceland and the Long government fund, the Covered bond fund and the Corporate bond fund are all open to the public. The final section of the chapter is dedicated to the delimitations of the research, all of which can have some effect on the results.

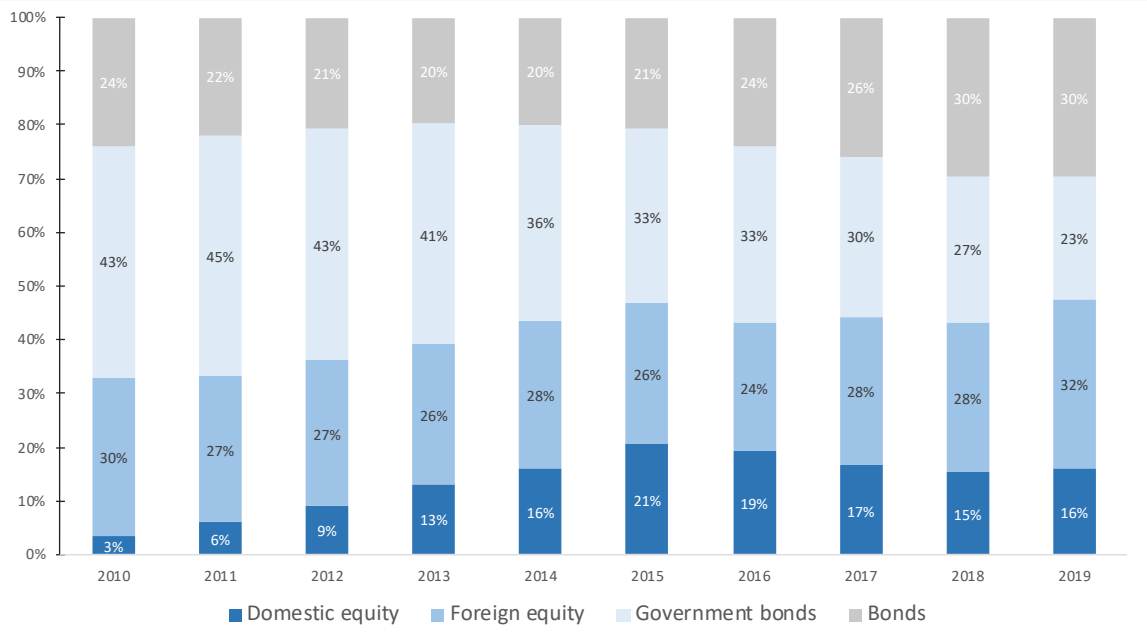
7 Analysing the pension funds

In the following chapter the performance of the five pension funds that were selected will be analysed. The first part covers how the development of the asset distribution of the pension funds has been over the entire decade. The second part examines the annual returns of the pension funds and compares the returns to the indices chosen as investable assets for the hypothetical investor. The section also compares the pension funds and examines if there is a noticeable difference in investment decisions that could explain the difference in returns. The chapter concludes on a comparison between the best and the worst performing pension fund.

7.1 The development of the asset distribution

When looking at the asset distribution of the five pension funds over the analysis period, a clear trend is noticeable as can be seen in figure 4.

Figure 4: *Average asset distribution of the five pension funds*

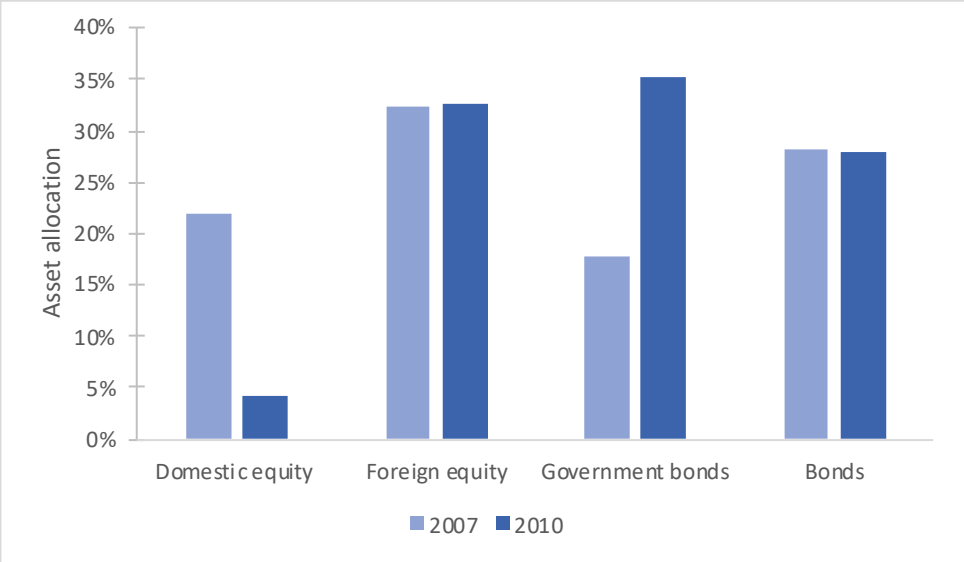


Source: Various annual reports and own contribution

At the start of the decade, the five pension funds were allocating their funds to bond categories quite dominantly. Government bonds accounted for 43.16% and bonds accounted for 23.85%. Adding up to a total of roughly 67% asset distribution to fixed

income classes. The most interesting figure however is the very low amount invested in domestic equity, only an average of 3.32% in the year 2010. This relatively low allocation is a direct effect of the financial crisis in 2008 where equities dropped significantly in value. Figure 5 compares the asset allocation of one of the pension funds, Live, in the years 2007 and 2010

Figure 5: *Asset distribution of Live in the years 2007 and 2010*



Source: Annual reports of Live and own contribution

When looking at figure 5, most noticeable is the change in domestic equity and government bonds. In the year 2007, Live had a significantly higher asset allocation to domestic equity than they did in the year 2010. Following the financial crisis, the fund lost a majority of their domestic equity assets, although they also reported a net sale of domestic assets of 6 billion ISK in the year 2008, indicating that they were already lowering their equity stake in Icelandic companies before the financial crisis.

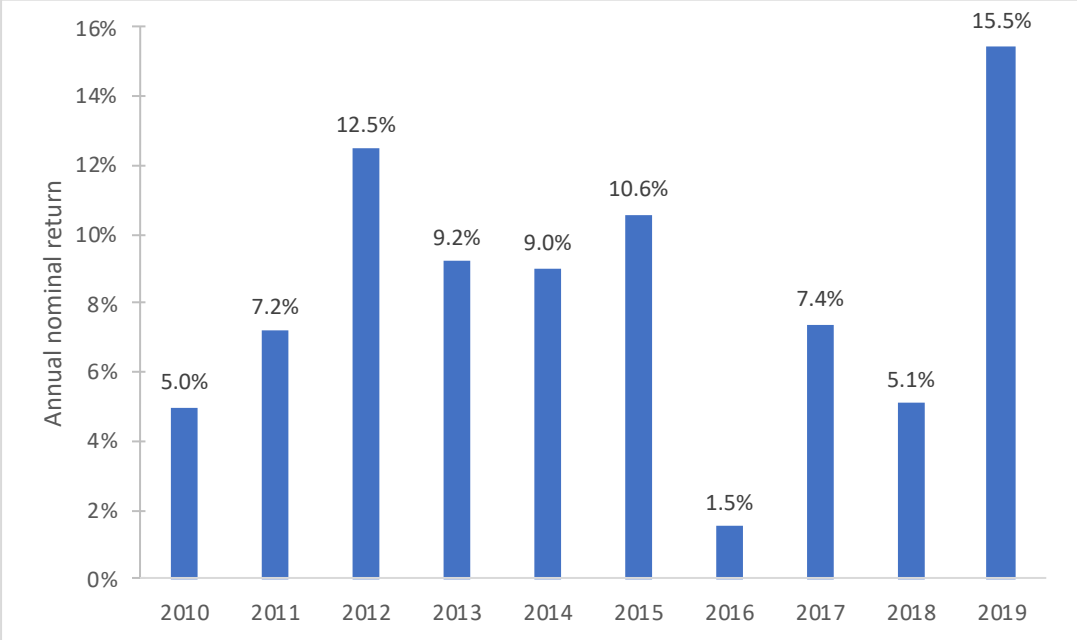
In the years following 2010, pension funds slowly increased their allocation to domestic equities and lowered government bonds which the pension funds were heavily invested in as they sought to keep their funds in relatively safe investments, as government bonds usually are. From the years 2010 until 2016 domestic equity was on the rise until the year 2017 when the investment restrictions were lifted, and the pension funds were again allowed to invest abroad. In 2017, the total asset distribution to

domestic equities and government bonds starts to decrease. Government bonds and domestic equities are being substituted for other bonds and foreign equities.

7.2 Annual returns of the pension funds

Over the last decade the pension funds in Iceland have had irregular returns on their investments. In 2016 the pension funds had their lowest annual return of only 1.5%. However, the best result was in the year 2019 where the average nominal return was 15.5% and one of the pension funds, Live, had nominal returns of 18.7%. The lowest return that year was 12.9% which was achieved by Stapi pension fund. These results of 2019 are in line with the development of the MSCI World ex EU, MSCI Europe and OMXIGI indices where the annual returns were 24.2%, 18.8% and 24.5%, respectively (see Appendix C). The average nominal returns of the pension funds included in this research are shown in figure 6.

Figure 6: *Average nominal return of the five pension funds*



Source: Various annual reports and own contribution

The pension fund with the overall best performance of the period being examined was Live pension fund which had an average of 9.16% nominal return per year. The pension fund with the lowest average nominal return was Stapi pension fund with a return of 7.37%. This can be partially explained by looking at the average asset

distribution of these two pension funds. Stapi pension fund had on average 44.5% of their total investments in government bonds while Live pension fund only had 27.7% of their total investments in that asset class. However, Live pension fund had a much higher asset allocation to equity, both foreign and domestic. The percentages were 46.2 for Live and 37.4 for Stapi.

In their annual reports, the five pension funds tend to discuss a few indices that they compare themselves with. Most often the pension funds use the MSCI World index as a benchmark for foreign equity, although some of them use indices such as MSCI Emerging Markets (MSCI EM), MSCI All Country World Index (MSCI ACWI), S&P500 and the FTSE. All of the pension funds, except for Stapi, use the OMXIGI index as a benchmark for domestic assets. Stapi uses a similar index created by an asset management company (Stapi, 2018). Generally, the pension funds do not disclose their benchmark for domestic bonds or other assets. Table 5 shows how the annual nominal return of the five pension funds compares against the indices used for this study.

Table 5: *Comparison between average returns of the pension funds and indices*

Year	Pension funds	MSCI W ex EU	MSCI Europe	OMXIGI	Avg. of bonds
2010	5.30%	7.02%	-3.40%	13.67%	13.02%
2011	7.18%	1.57%	-6.67%	2.42%	10.63%
2012	12.46%	18.66%	22.60%	16.48%	5.71%
2013	9.21%	17.20%	15.67%	25.51%	3.03%
2014	9.01%	15.57%	0.41%	11.68%	4.58%
2015	10.56%	4.35%	1.63%	35.25%	7.17%
2016	1.55%	-4.27%	-14.25%	-4.84%	6.10%
2017	7.38%	12.86%	16.17%	6.05%	7.28%
2018	5.11%	8.11%	-0.81%	-2.86%	5.32%
2019	15.47%	26.39%	22.56%	24.51%	8.35%

Source: Own contribution

The pension funds column is the average nominal returns of the five pension funds for each year and the other four columns to the right are indices. The average of bonds column to the far right is the average nominal return of the five fixed income bonds.

When comparing the return figures between the pension funds and the indices it is very noticeable how the returns of the pension funds fluctuate with the markets. To demonstrate, all of the non-bond assets had negative returns in the year 2016. The average return of the five bond assets is however positive and therefore keeps the average return of the pension funds at 1.55%. That year, the average asset allocation to bonds and government bonds was 56.76%. That year the positive effects of diversification are clear. The exact opposite is apparent in the year 2019 where all of the non-bond assets have annual returns of over 20%, but the annual return of the five pension funds is only 15.47% on average. The five bond classes however have a much lower return and therefore lower the return of the pension funds. The average asset allocation to bonds and government bonds that year was 52.51%. These two examples, albeit extreme, demonstrate how diversification is beneficial in some years and detrimental in others. Table 6 compares the nominal annual returns of all of the pension funds included in this research.

Table 6: *Nominal returns of the five pension funds*

Year	LSR	Live	Gildi	Birta	Stapi
2010	4.9%	6.1%	4.0%	3.8%	6.2%
2011	7.2%	8.2%	8.1%	7.3%	5.2%
2012	14.2%	13.4%	12.2%	12.4%	10.1%
2013	10.5%	10.2%	9.1%	9.5%	6.8%
2014	10.1%	9.8%	9.9%	7.9%	7.3%
2015	8.7%	12.4%	9.9%	10.4%	11.4%
2016	3.0%	0.9%	1.2%	0.6%	2.0%
2017	7.6%	7.6%	7.7%	7.0%	7.0%
2018	5.6%	4.3%	5.8%	5.0%	4.8%
2019	16.6%	18.7%	15.1%	14.0%	12.9%
Average	8.8%	9.2%	8.3%	7.8%	7.4%

Source: Own contribution

Table 6 shows how the annual returns of the pension funds fluctuate between the years. Live, for example, only achieves a 0.9% return in the year 2016. Three years later it has a return of 18.7% which is a difference of 17.8%.

7.3 Comparing the best performer and the worst performer

When comparing the nominal returns of the pension funds, it is noticeable that the pension funds are not achieving the same returns. Live is the pension fund that has, on average, the highest nominal return over the period while Stapi is the pension fund that achieves the worst returns. Live has an average annual return of 9.2% and Stapi has an average annual return of 7.4%. The difference may seem like not much but over a long investment horizon, such as many decades as is the case with pension savings, the difference in returns becomes very large over time. Table 7 and 8 show the asset composition of these two funds in the years 2019 and 2013. The difference in returns between the two pension funds was greatest during these two years, 5.8% in 2019 and 3.4% in 2013 in favour of Live.

Table 7: *Comparison between asset compositions in 2013*

2013	Domestic equity	Foreign equity	Gov. bonds	Bonds	Annual return
Live	17.12%	27.57%	32.07%	23.24%	10.20%
Stapi	10.61%	22.62%	52.55%	14.22%	6.80%

Source: Own contribution

Table 8: *Comparison between asset compositions in 2019*

2019	Domestic equity	Foreign equity	Gov. bonds	Bonds	Annual return
Live	16.30%	38.79%	17.92%	26.99%	18.70%
Stapi	16.49%	26.35%	28.68%	28.49%	12.90%

Source: Own contribution

When comparing the two funds it is noticeable how the two pension funds allocate their assets differently. The difference starts to show in the year 2013 where Live allocates 6.51% more of its assets to domestic equities than Stapi does. Live also invests more in foreign equities than Stapi does, the difference is 4.95%. Stapi invests most of its

portfolio, or 52.55%, in the government insured bond class. This could be interpreted as Stapi being more risk averse and chooses to invest in more secure assets. Live has nearly a 3rd of its assets in the government bond class and the remaining 23.24% are allocated to other bonds. In the year 2019 the asset allocations of the two pension funds are much more similar. However, Live allocates 12.44% more of its assets to foreign equities and seems to take bigger advantage of the fact that currency restrictions were lifted in 2017 and the pension funds were again allowed to invest in foreign equity markets. Stapi has however substantially decreased its allocation to government insured bonds and increased its distribution to other bonds.

The difference in returns between these two pension funds in these years can however mostly be explained by the difference in foreign equity investments. The two foreign indices used for this research, the MSCI World ex EU and the MSCI Europe, had returns of 26.39% and 22.56% in 2019. In 2013 the returns were 17.2% and 15.67%, respectively. As shown in figure 6 in chapter 7.2, Stapi does achieve higher returns than Live twice in the years that are being examined. Those years are 2010 and 2016. Those years, the two MSCI indices had very poor returns which affected Live more than Stapi, due to them having a higher asset allocation to foreign equities.

7.4 Chapter summary

The chapter starts off by showing the average asset distribution of the five pension funds over the decade and how the distribution changed every year. Effects of the financial crisis were apparent in the beginning of the decade, but they start subsiding in the following years and in the year 2017 the currency restrictions imposed on foreign investments were lifted. The next section covers the annual returns of the pension funds and shows how the fluctuations between the years. It also shows the comparison between the returns of the pension funds and the indices used in this research. Finally, the last section analyses the difference between the returns of two of the pension funds, Live and Stapi. Live is the best performing pension fund of decade and Stapi is the worst performer. The difference in return can explained for the most part by Live investing more in foreign equities that yield a higher return but are more volatile than the government bonds that Stapi allocates more funds to.

8 Evaluating the portfolios

In the following chapter, I will be creating portfolios for the hypothetical investor based on the Markowitz approach. The method uses realised returns to estimate the expected return in the future. The chapter starts off by validating the indices presented in chapter 6.3 which act as assets that the investor is allowed to invest in. The next section presents three distinct portfolios that are created using various methods and restrictions. Followed by a section on how one of the portfolios created earlier would have done in the years 2011 to 2019.

8.1 Validating the indices

In order to validate the indices and proxies used to represent the assets our hypothetical investor is allowed to invest in, analysis and statistical tests were done on the data. Finally, the asset allocations by the pension funds presented in chapter 7 will be used and invested in the indices used for the hypothetical investor to examine if the indices are a fair representation of real investment options. The tests and their results are presented in the following sub-chapters.

8.1.1 Risk and return profiles of the indices

Using the monthly index values for the eight asset classes, average monthly return and standard deviations were calculated as explained in chapter 5.1. The results are presented in table 9.

Table 9: *Monthly return and standard deviation of the eight asset classes*

Asset class	Average monthly return	Monthly standard deviation
MSCI World ex EU	0.90%	3.87%
MSCI Europe	0.45%	4.72%
OMXIGI	1.07%	3.50%
NOMXIREAL	0.62%	1.34%
NOMXINOM	0.64%	1.40%
Long Gov.	0.59%	1.35%
Cov. Bonds	0.54%	0.66%
Corp. Bonds	0.45%	0.56%

Source: Own contribution based on various indices

As can be seen in table 9 the average monthly return and standard deviation of the eight asset classes varies by quite a lot. The MSCI Europe index is the index with the highest monthly standard deviation of 4.72% and also the lowest average monthly return of 0.45%, making it the least desirable asset when only looking at them individually. The MSCI World ex EU index has a substantially higher average monthly return of 0.90% and a lower monthly standard deviation of 3.87% making it a more desirable asset when investing abroad. The asset with the highest average monthly return is the OMXIGI index with a return of 1.07% and a monthly standard deviation of 3.50%. The five indices representing various types of bonds all have similar risk and return profiles. Especially the three classes that contain government bonds. The other two bond classes, Corporate bonds and Covered bonds, are the two classes that carry the least amount of risk.

When creating a portfolio and comparing different asset classes, simply looking at the average returns and standard deviations is not enough. Investors must consider how the assets move in relation to each other. Table 10 shows the correlation matrix between the different asset classes.

Table 10: *Correlation between the asset classes*

Index name	MSCI W ex EU	MSCI Europe	OMXIGI	NOMXI REAL	NOMXI NOM	Long Gov.	Cov. Bonds	Corp. Bonds
MSCI W ex EU	1							
MSCI Europe	0.8574	1						
OMXIGI	0.3146	0.3258	1					
NOMXIREAL	-0.0385	0.0174	0.1006	1				
NOMXINOM	-0.2001	-0.2131	0.0991	0.3768	1			
Long Gov.	-0.0937	-0.0381	0.1239	0.9720	0.5569	1		
Cov. Bonds	-0.1357	0.0210	0.2455	0.7936	0.6153	0.8450	1	
Corp. Bonds	-0.1363	-0.0083	0.1915	0.6743	0.7408	0.7888	0.8946	1

Source: Own contribution

As can be seen in the correlation matrix, some of the assets are highly correlated. The two MSCI indices have a correlation coefficient of 0.8574 which is a very high correlation. Considering the risk and average return profile of these two indices, the very high correlation coefficient gives early evidence that the index with less favourable characteristics will not be selected in the efficient portfolio as they are so highly correlated. Furthermore, the MSCI World ex EU index is also negatively correlated with all of the bond classes, which is a desirable feature when diversifying away risk.

The Long Government asset class is also highly correlated with NOMXIREAL which indicates the same as above; that it will not be included in the efficient portfolio considering its sub-par average return. The bond classes are all somewhat correlated as well, but not as highly as the classes mentioned earlier.

8.1.2 Statistical test on the data

A statistical test was applied to the return values of the eight indices chosen for the research. The Shapiro-Wilk test was used to test for normality within the data. There is a wide variety of tests of normality available, Razali and Wah (2011) show that Shapiro-Wilk is the most powerful normality test and even works well when the sample size is small, as with the Covered bonds class (n = 58) and Corporate bonds class (n = 68). Normality is important when determining if the calculated average return and standard deviation is an accurate representation of expected values in the future. The symmetrical shape of the normal distribution is a key factor in the standard deviation being an accurate risk measurement (Bodie, Kane and Marcus, 2018). The XLSTAT add-in for Microsoft Excel was used to calculate the test statistics and the results are listed in table 11.

Table 11: *Shapiro-Wilk test results*

Index	W	p-value	Result
MSCI World ex EU	0.979	0.064	Normal
MSCI Europe	0.985	0.205	Normal
OMXIGI	0.979	0.052	Normal
NOMXIREAL	0.984	0.169	Normal
NOMXINOM	0.990	0.580	Normal
Long Gov.	0.967	0.005	Non-normal
Cov. Bonds	0.987	0.806	Normal
Corp. Bonds	0.967	0.068	Normal

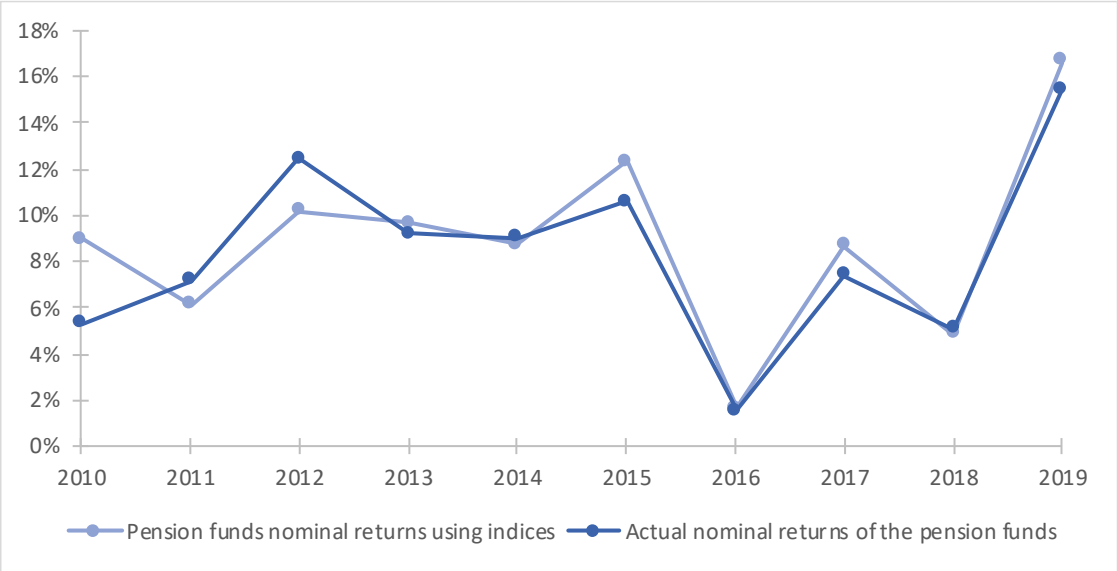
Source: XLSTAT add-in for Microsoft Excel and own contribution

The test was done at a 95% confidence level. The value of W can be anywhere between zero and one. A value of one means that the data is perfectly normalized, the opposite holds for a W value of zero. The underlying hypothesis of the test is that the return data follows a normal distribution. The only p-value that is below the significance level ($\alpha = 0.05$) are the return figures of the Long government bonds asset class, therefore I reject the null hypothesis that the Long government bond returns are normally distributed. Most of the other indices show strong signs of normality. I can therefore assume that our data fulfils for the most part the requirement of normality to be able to accurately calculate the mean-variance portfolio.

8.1.3 Comparing the indices to actual returns

In order to further validate that the indices were appropriate investment opportunities, the average asset allocations of the pension funds were used and invested in the indices for every year of the decade. To simplify, the average asset allocation of the five pension funds, as shown in figure 4 in chapter 7.1, was used as an asset allocation and invested in the indices chosen. The results can be seen in figure 7.

Figure 7: *Comparison between actual nominal returns and returns using the indices*



Own contribution and various annual reports

When comparing the actual nominal returns of the pension funds with the figures that resulted from using the annual returns of the indices, it can be seen from figure 7 that the return figures are very similar. The only year that deviates substantially from the actual average nominal returns of the pension funds is the year 2010. That year, the average nominal return was 5.30%. If the pension funds had invested in the indices chosen for this research, the average nominal return would have been 8.98% for that year.

When looking at the whole period, the average annual nominal returns of the pension funds is 8.32%. The same asset allocation invested in the indices would have led to an average annual nominal return of 8.79%, which is a difference of only 0.46%. Judging from that, and the visual similarities of figure 7, I conclude that the indices chosen for this research accurately represent the investment opportunities that the pension funds are investing in.

8.2 Creating the efficient portfolio

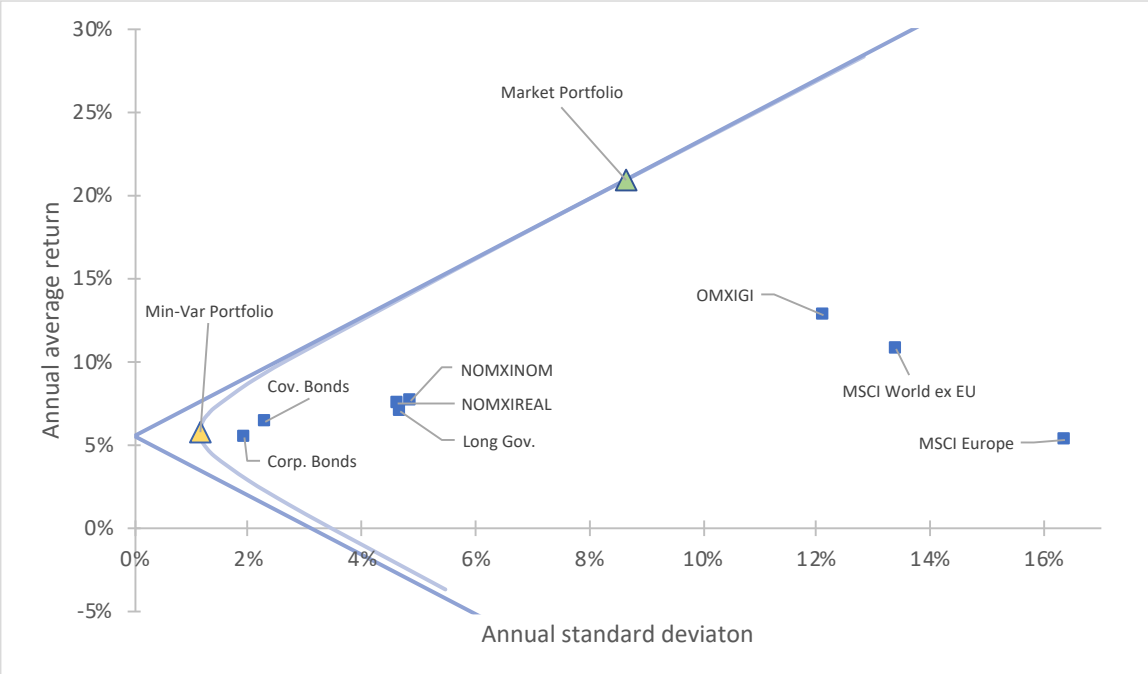
When creating the efficient portfolio constructed by our hypothetical investor the methods and theories first introduced by Markowitz were used. In general, different investors have different investment goals. Some want to maximize their returns by any means necessary, even if it means taking on substantial risk. Others like to minimize their

risk but still keep the expected return somewhat attractive. This section will describe three different portfolios, how they are constructed and who they are intended for. All of the portfolios are constructed under the assumption that our investor does not invest in the risk-free asset. No other restriction is applied to the first portfolio, only portfolios two and three.

8.2.1 Portfolio 1 – Mean variance portfolio with no restrictions

The mean-variance portfolio framework introduced by Markowitz in 1952 is a very popular method to analyse the portfolio choices an investor has. However, the model itself does not explicitly model how an investor should allocate his funds. Rather it displays the optimal portfolio that the investor hypothetically could create, considering his preference for risk and return. I will follow the method explained in the Financial Asset Pricing Theory written by Munk (2013). He explains how using a mean-variance utility function the optimal portfolio can be derived. His method utilizes Lagrange multipliers and auxiliary constants to derive an efficient frontier of assets, both using only risky assets and a combination of risky and risk-free assets. Using his methods, I have calculated the efficient frontier as visually shown in figure 8 with no investment restrictions applied.

Figure 8: The efficient frontier with no restrictions



Source: Own contribution

Figure 8 displays the efficient frontier and the capital market line. The eight squares are the eight indices used to represent the various assets our hypothetical investor is allowed to invest in. The minimum variance portfolio is the portfolio to the far left, marked with a yellow triangle. The average annual return at that point is 5.80% and the annual standard deviation is 1.16% which is the lowest standard deviation that is within the reach of the investor when investing only in risky assets. The market portfolio marked with a green triangle is the tangency point between the efficient frontier and the capital market line. The average annual return at that point is 20.96%, which is substantially higher than that of the minimum variance portfolio, which also comes at a higher risk with an annual standard deviation of 8.66%. In order to achieve either the minimum variance portfolio or the market portfolio, the asset allocation is shown in table 12.

Table 12: *Asset composition of the minimum variance and market portfolio*

Asset class	Minimum variance portfolio	Market portfolio
MSCI World ex EU	5.87%	41.52%
MSCI Europe	-5.27%	-34.05%
OMXIGI	-0.16%	24.87%
NOMXIREAL	116.96%	849.66%
NOMXINOM	5.83%	266.02%
Long Gov.	-150.04%	-923.26%
Cov. Bonds	-7.47%	276.20%
Corp. Bonds	134.27%	-400.95%
Total	100.00%	100.00%

Source: Own contribution

As can be seen in the table 12, both of these portfolios require that the investor takes a short position in multiple asset classes. In the minimum variance portfolio, a small short position is taken in the MSCI Europe, OMXIGI and the Covered bond assets, along with a large short in the Long government asset. The market portfolio has similar ratios but with even larger positions taken in various assets, a -923.26% position in the Long government asset and 849.66% allocated to NOMXIREAL.

A common problem with the mean variance model is the extreme values it tends to yield when restrictions are not applied. These numbers are a very clear representation of that problem where very large positions is taken in multiple assets and counteracting short position in other assets. To further emphasize this point of extreme values I will continue with applying the mean variance utility function without introducing any restrictions. The utility function is expressed as:

$$Utility = E[r] - \frac{1}{2}\gamma Var[r] \tag{15}$$

Where γ is a positive constant representing the risk aversion an investor has. A higher value of γ increases the second term and therefore decreases utility. This maximization problem is solved in Excel using Solver to maximize the utility formula with a set of various risk aversion levels. The results are presented in table 13.

Table 13: *Risk and return of three different risk aversion portfolios*

	1	5	20
Average annual return	317.90%	68.22%	21.41%
Annual standard deviation	176.67%	35.35%	8.91%
Utility	1.62	0.37	0.13
ω	552.26	111.59	28.96

Source: Own contribution

Each column represents different risk aversions with 1 being the most risk seeking investor. ω represents the combined absolute value of all of the asset weights with the formula:

$$\omega = |w_1| + |w_2| + \cdots + |w_8| \tag{16}$$

The three portfolios displayed in #figureabove# have three separate risk aversions. Risk aversion of 1 represents an investor that is willing to take all the risk he can to maximize his returns. The average annual return of that portfolio is 317.90% with an annual standard deviation of 176.67%, these numbers are very high and quite unrealistic. The high ω value represents the very large negative and positive positions the investor is

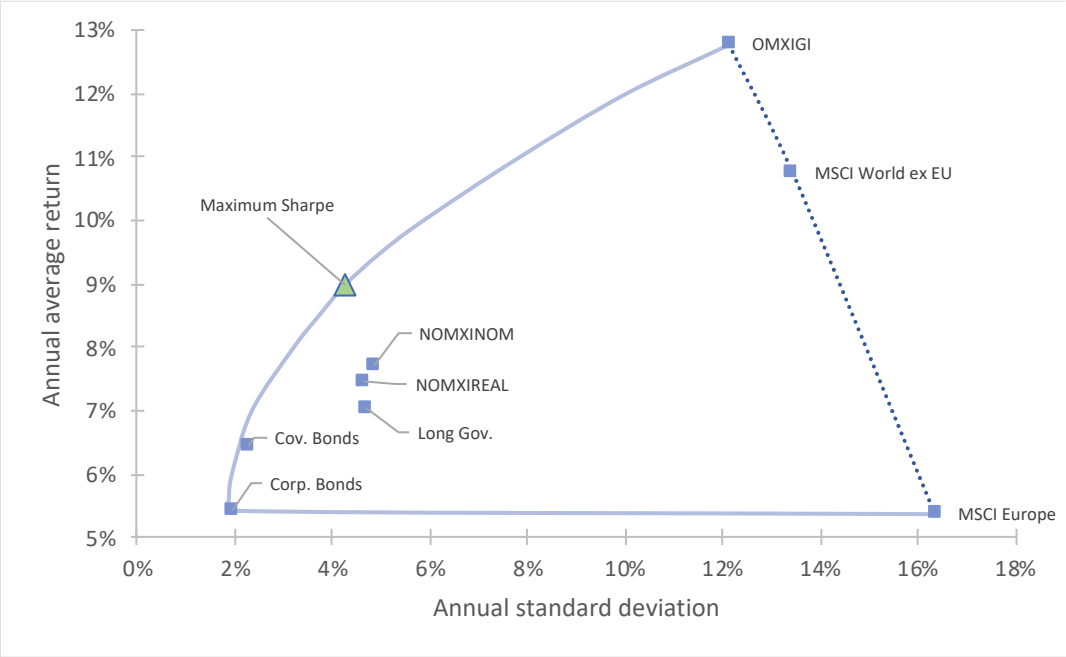
taking in the assets. For example, with a risk aversion of 1, an investor has a negative position of over 16,000% in the Long government asset. When looking at the portfolio composition at a risk aversion of 20 there are some high values, albeit not as extreme as with the risk aversion of 1. For a risk aversion of 20, the annual average return is 21.41% and the standard deviation is 8.91%.

The method of maximizing utility further demonstrates the implications of not applying restrictions to the investment options of the investments. The extreme results derived from creating the mean-variance portfolio with no restrictions shows that this method is not a viable way for an individual investor to follow, at least not when he is simply trying to secure his financial security in retirement.

8.2.2 Portfolio 2 – Maximum Sharpe ratio

The second attempt at portfolio creation is largely based on the methods explained in the chapter before, with some exceptions. First of which is implementing the restriction that the investor is not allowed to short sell any assets. The hypothetical investor is an individual mostly interested in securing his own financial future for retirement and therefore holding a highly leveraged portfolio should not be his goal. Furthermore, the only assets available to the investor are the eight risky assets. The goal of this portfolio will be to maximize the Sharpe ratio, which effectively allows the investor to find the portfolio that has the maximum amount of return in exchange for a minimum amount of risk for that return level as described in chapter 5.3. The efficient frontier and the investable assets are shown in figure 9.

Figure 9: The efficient frontier with restrictions



Source: Own contribution

The area within the efficient frontier parabola and the dotted line represents all the possible risk and return profiles our investor is able to achieve by diversifying his portfolio with these assets. Any asset composition resulting in the portfolio being on the efficient frontier line means that the investor has an efficient portfolio with maximized returns for a given risk level. When solving for the maximum Sharpe ratio, the following asset composition is reached as shown in table 14.

Table 14: *Asset composition of the maximum Sharpe portfolio*

	Maximum Sharpe ratio
MSCI World ex EU	13.19%
OMXIGI	18.25%
NOMXIREAL	27.20%
NOMXINOM	41.37%
Expected annual return	8.98%
Annual standard deviation	4.23%
Sharpe ratio	0.8171

Source: Own contribution

As seen in the table 14, our investor only invests in four out of the eight asset classes available to him. This is due to the fact that many of the asset classes are so highly correlated as shown earlier in the correlation matrix in table 10. Long government bonds, covered bonds and corporate bonds are highly correlated with the two government bond classes in this portfolio, NOMXIREAL and NOMXINOM and are therefore excluded from the portfolio. The two government bond assets have a higher expected annual return which is more beneficial when trying to maximize the Sharpe ratio. It is also not a surprise that MSCI Europe is not included in the portfolio as it has the lowest expected annual return and the highest standard deviation. Furthermore, MSCI Europe is highly correlated with the more attractive MSCI World ex EU asset and the correlation with other assets is very similar to what MSCI World ex EU has.

As previously noted, this portfolio is designed for individuals who want to maximize their return in exchange for risk. The portfolio is therefore well suited for a wide range of investors. However, sometimes investors do not want to pursue a maximum Sharpe ratio. Instead, they want to pursue a specific return on their investment and minimizing the risk for that return. That is the purpose of the next portfolio.

8.2.3 Portfolio 3 – Return target

One factor that an individual has to consider when trying to secure his financial wealth in retirement is his age. A younger individual is more likely to be willing to accept higher risk for higher expected return as he has a long investment horizon. That individual could tolerate some short-term losses for long term gains. That is the purpose of the last portfolio; set a specific return goal and minimize the standard deviation.

The same rules apply here as in the portfolio before this one, where short selling is not allowed and there is no risk-free asset. Table 15 shows the asset composition of three portfolios that have specific return goals, which are 7%, 8.5% and 10%.

Table 15: *Asset compositions of the target return portfolios*

	7% target return	8.5% target return	10% target return
MSCI World ex EU	7.65%	11.93%	16.05%
OMXIGI	2.29%	13.53%	35.83%
NOMXIREAL	0.00%	22.06%	10.07%
NOMXINOM	6.79%	35.70%	38.05%
Cov. Bonds	83.28%	16.77%	0.00%
Annual standard dev.	2.33%	3.70%	5.84%
Sharpe ratio	0.6326	0.8039	0.7670

Source: Own contribution

As can be seen from table 15, the model only invests in five out of the eight asset classes. As mentioned in an earlier chapter, MSCI Europe and the Long government bond asset class are highly correlated to other assets that have a more attractive return profile. The last asset that is not included in any of the portfolios is corporate bonds, which does have the lowest annual standard deviation but simply does not have average returns that are high enough.

The three portfolios all have different standard deviations which increases as the return target is increased. The intervals between the return targets of the portfolios are 1.5%. When increasing the expected return from 7% to 8.5% the standard deviation increases by 1.33%. The next step in expected return, from 8.5% to 10%, increases the standard deviation by 2.14%, which is substantially higher than the first increase. Showing that standard deviation grows exponentially as target return increases. From the test of normality in chapter 8.1.2 where I concluded that the returns follow a normal distribution, I can calculate the confidence intervals using the standard normal distribution and its properties. Table 16 shows the upper and lower bounds for the return values using two different confidence intervals, 99% and 90%.

Table 16: *Upper and lower bounds using two different confidence levels*

Confidence level - Bounds	7% target return portfolio	8.5% target return portfolio	10% target return portfolio
99% - Lower bounds	1.00%	-1.03%	-5.04%
99% - Upper bounds	13.00%	18.03%	25.04%
90% - Lower bounds	3.17%	2.41%	0.39%
90% - Upper bounds	10.83%	14.59%	19.61%

Source: Own contribution

As seen in table 16, accurately predicting returns becomes much harder as the target return increases. For the 7% target return portfolio and using a 99% confidence interval, returns can be anywhere between 1% and 13% which is a span of 12%. The same figures for the 8.5% target return portfolio are -1.03% and 18.03% which is a span of 19%. The 10% target return portfolio has a span of 30% where values range between -5.04% and 25.04%. The spans when using a 90% confidence interval are relatively smaller, where the smallest span is 7.66% and the largest one is 19.22%.

It is important to mention that the target returns of the three portfolios are based on realised returns over the last 10 years, past returns are not always an accurate representation of what the future will look like.

8.3 Using the maximum Sharpe method

All of the portfolios introduced in the previous sections are portfolios based on historical returns of the indices. An investor is usually more interested in what happens in the future and not in the past. Although past returns are sometimes a good indicator of future returns, and sometimes the only data to rely on. In this chapter I will revisit the maximum Sharpe portfolio and create it again with the same principles and methods. However, this time I will begin by creating a portfolio in the beginning of 2011 and only base it on the historical returns for the year 2010. A year later I will add to the data set the return figures from 2011. The building blocks of the portfolio change as data is added to the data set. The building blocks are the expected annual return, the standard deviation, the correlation matrix and covariances between the different assets. Based on these new building blocks, I will rebalance the portfolio and examine how the portfolio would do

that year. I will do the same until 2019 and examine how the portfolio will do every year from 2011 until 2019. The annual returns of the maximum Sharpe portfolio of the hypothetical investor are displayed in table 17 (Asset distribution for every year is shown in Appendix D).

Table 17: *Comparison between the returns of the investor and the pension funds*

	Return of the investor	Avg. ret. of Pension Funds
2011	1.60%	7.21%
2012	6.34%	12.46%
2013	5.60%	9.21%
2014	6.53%	9.01%
2015	11.39%	10.56%
2016	-2.57%	1.55%
2017	6.10%	7.38%
2018	3.16%	5.11%
2019	13.87%	15.47%
Compounded return	64.42%	109.99%

Source: Own contribution

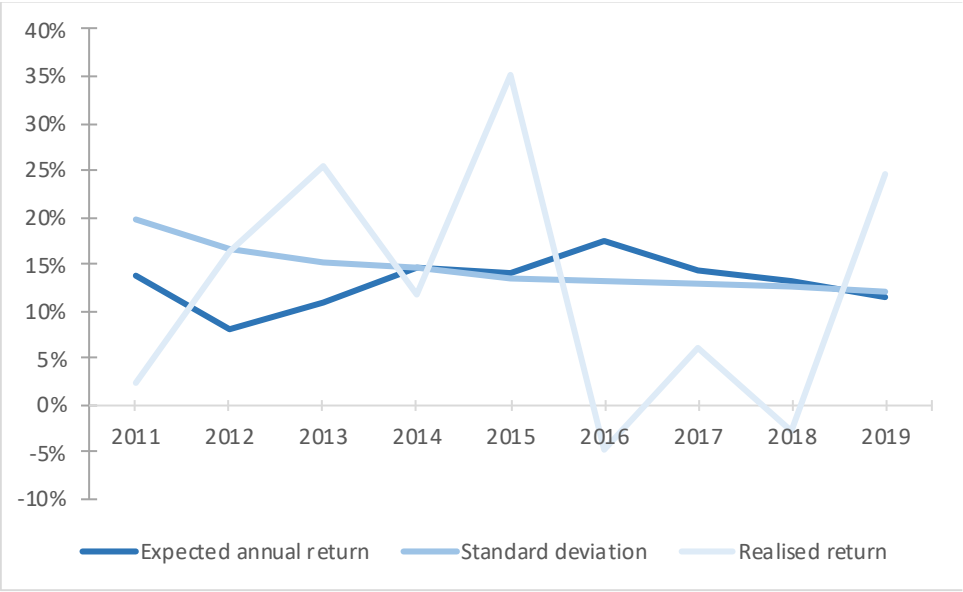
To estimate what the returns of the portfolio would have been every year the asset allocation is multiplied by the realized returns for each index. As can be seen in table 17 the five pension funds have a higher average return every year, except for the year 2015 where the return is 0.83% higher for the hypothetical investor. The flaw of the investment method is apparent in the first year where the return of the hypothetical investor is only 1.60%. This is mostly due to the fact that in the year 2010 the NOMXINOM asset had the highest return of all of the assets with a return of 16.40%. This causes the model to allocate 88.97% of the entire portfolio to the NOMXINOM asset. The remaining 11.03% is split between MSCI World ex EU and MSCI Europe which are negatively correlated with the NOMXINOM asset. However, in the year 2011 the NOMXINOM asset performs considerably worse than the year before and only yields a return of 1.92%. The MSCI World ex EU and MSCI Europe yield a return of 1.57% and -6.67%, respectively. This

causes the total return of the portfolio in the year 2011 to be 1.60% which is considerably lower than the average return of the five pension funds that year which is 7.21%.

Next we look at the 2012 performance of the portfolio as it has been rebalanced to reflect the returns of the assets in the year 2011. That year the total return of the portfolio is 6.34%. The poor performance of NOMXINOM in 2011 causes the asset distribution to NOMXINOM to be lowered down to 0%. The NOMXIREAL asset, which had a return of 11.09% in 2010 and 16.46% in 2011, becomes the dominant asset in the portfolio with an asset distribution of 92.99%. The remaining 7.01% is split between MSCI World ex EU and OMXIGI. The returns of the investor do however improve and become more in line with the returns of the pension funds in the following years when more years are included in the data set to create the portfolio. The investor however only beats the pension funds in the year 2015.

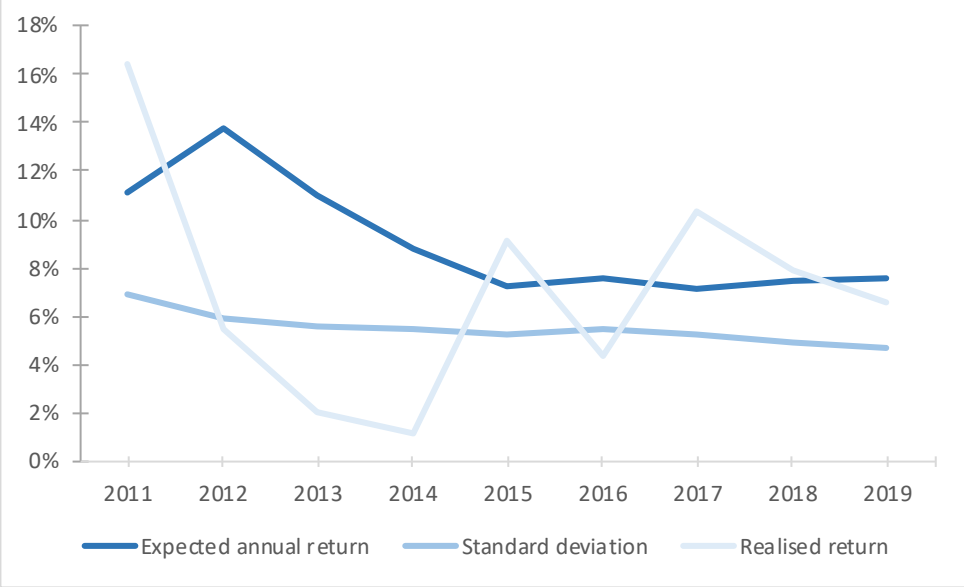
As noted earlier, the expected annual return and the standard deviations of each asset changes as additional data is added to the data set. Figure 10 and 11 show the expected annual return, standard deviation and the actual realised return that year for two of the assets, OMXIGI and NOMXIREAL.

Figure 10: Comparison between expected annual return, standard deviation and realised returns for OMXIGI



Source: Own contribution

Figure 11: Comparison between expected annual return, standard deviation and realised returns for NOMXIREAL



Source: Own contribution

Figure 10 and figure 11 show how the expected annual return and the standard deviation fluctuate in the first years but converges to the true mean as the years pass. The graphs also demonstrate how volatile the assets really are, especially the OMXIGI where realised returns fluctuate substantially between the years. In the year 2015 the realised return of OMXIGI is 35.25% and a year later the realised return drops down to a negative 4.84%. The standard deviation for OMXIGI ranges from 19.77% in the beginning of the period down to 12.21% at the end of the period. NOMXIREAL has a substantially lower volatility where the standard deviation ranges from 6.90% in the beginning of the period and drops down to 4.75% at the end of the period. However, realised annual returns fluctuate by a lot.

When the annual returns of the hypothetical investor using the Maximum Sharpe Method are compared to the average annual return of the pension funds there is a clear difference between the two. Table 18 shows the results from compounding the annual returns from the years 2011 to 2019.

Table 18: *Compounded return of the investor and the pension funds*

	Return of the investor	Avg. ret. of Pension Funds
Compounded return	64.42%	109.99%

Source: Own contribution

Overall, the compounded return over the period is 64.42% for the investor and 109.99% for average of the pension funds. Which is a 70% better return for the investor if he simply pays the premium to a pension fund instead of investing on his own. This compounded return is based on the fact that there is only a single investment done in the beginning of the period. However, with premium payments to pension funds, they are usually done every month. I will now examine how the returns differ when comparing the returns of the investor when he invests on his own and when he pays premium to a pension fund. I will do this by having him pay either 100,000 ISK to his own portfolio account at the beginning of every year or simply paying a premium of 100,000 ISK to his pension fund at the same time of the year. Although pension payments are usually done on monthly basis, this research will do it on a yearly basis for simplicity. The cash flow from the two options are shown in table 19.

Table 19: *Cash flow comparison*

Date - Start of year	Investor	Pension fund
2011	100,000	100,000
2012	201,602	207,206
2013	314,390	333,016
2014	431,983	463,686
2015	560,212	605,446
2016	724,035	769,382
2017	805,425	881,291
2018	954,592	1,046,330
2019	1,084,729	1,199,777
2020	1,335,210	1,485,334

Source: Own contribution

Each row shows the accumulated portfolio gain (or loss) over the previous year plus the annual contribution of 100,000. Row two for the pension fund is therefore (100,000 * (1 + 7.21%)) + 100,000 = 207,206 ISK. When comparing the cash flows of the two options it is very noticeable that the returns of the pension funds are significantly higher than the investor achieves. After deducting the annual investment cost, which is 100,000 ISK annually over a 10-year period, the total return in ISK is 485,334 for the pension fund and 335,210 for the hypothetical investor. Which means that the pension funds achieve a 44.79% better return than the investor does on his own. For an investor with a very long investment horizon, such as pension savers, every percentage matter as the returns get compounded over the years.

8.4 Chapter summary

This chapter starts by validating the indices introduced in chapter 6 as investable assets to the hypothetical investor. That is done in three ways. First, the three indices are analysed and the average return and standard deviation over the research period are calculated. Along with a calculation of the correlation between the assets, which tests how the assets move in relation to each other. The second validation method is a statistical test on the return data of the indices. The Shapiro-Wilk test for normality is used to make sure that the data follows the standard normal distribution which is important when using past data to predict the future. The third validation is a visual test to check if the indices presented are a fair representation of the investment opportunities that the pension funds have had over the decade. These three factors all show that the indices used in this research are accurate representation of investment opportunities.

The second part of the chapter focuses on creating the portfolios for the hypothetical investor. The Markowitz method is used along with various criteria to create three portfolios. The first portfolio is a mean variance portfolio with no restrictions which yields a very high return but comes with substantial risk and involves taking huge long and short positions in some of the assets. The second portfolio follows the principle of maximising the Sharpe ratio and also implements the restriction that short selling assets is not allowed. That portfolio yields a lower return but is also a lot less risky. The third and final portfolio creation involves setting a return target and minimising the risk for that specific return goal.

The third and final part of the chapter examines what would happen to the portfolio of the hypothetical investor if he decided to use the maximum Sharpe method to invest his money from the years 2011 until 2019. In short, the results show that the investor would have greater returns if he would simply pay the premiums to the pension fund instead of trying to beat the returns on his own.

9 Conclusion

This chapter will summarize the findings from the research along with a discussion about them. The chapter will shed some light on the research questions which will be answered in this chapter.

The first few chapters of the research cover the purpose and motivation behind pension funds. The pension system in Iceland, which is one of the largest in the world in relation to the GDP of the country, is explained along with the capital markets it operates on. The pension funds are responsible for the financial futures of most individuals. It is only natural for individuals to wonder whether the pension funds are achieving adequate returns to support the retirement of those individuals. That brings me to the first research question which asks how the pension funds are allocating their investment funds and how have they adjusted their portfolios over the last decade. The annual reports and balance sheets of the five pension funds from the years 2010 until 2019 were broken down and their assets were categorised into four categories which allowed for a fair comparison. It quickly became obvious that the portfolio composition changes every year. At the start of the decade the pension funds were still recovering from the financial crisis of 2008 where domestic and foreign equities took a big hit and lost some of its value. During the first three years of the decade the average asset allocation to government insured bonds ranged from 45% to 43% which shows that the pension funds were looking for safe returns as the financial markets were still trying to recover from the recent crisis. Over the rest of the decade the asset allocation to government bonds decline and, in the end of 2019, only amounted to 23% of the total investment portfolios of the pension funds. As noted earlier, domestic equities took a big hit in the financial crisis and the asset allocation to domestic equities was only roughly 3% at the start of the decade. That percentage rose quickly and was up to 21% in the year 2015. The allocation to domestic equity started dropping at that point and at the end of the decade it was down to 16%. This is in part due to the fact that in the year 2017 the currency restrictions imposed on the pension funds was lifted and the pension funds were again allowed to invest abroad without restrictions. That change in restrictions caused the allocations to foreign equities to rise from 24% in 2016 to 32% at the end of the decade. The non-government bond class remained somewhat constant over the first half of the decade as the allocation was

at 20% to 24%. However, as the end of the decade drew near and the allocation to government started to drop the allocation to bonds increased up to 30%. Overall, the pension funds that had a higher asset allocation to more risky assets, which are the domestic and foreign equities, had a greater average annual return over the decade.

Pension funds are however not investors that should only look at their annual return measured in percentages. The pension funds operate with the interests of their fund members at heart and should look at more factors than just the simple returns. One of those factors are ethical investments. The pension funds should aim to support both a healthy financial market and economy and they should not invest in assets that are detrimental to the society in the long run. As explained by Sievänen, Rita and Scholtens (2013) pension funds face an increasing pressure from the media and the public to invest in responsible investments.

There does not seem to be indications of an equity home bias amongst the pension funds. The pension funds are allowed to invest half of their total assets in foreign currencies but as of the end of 2019 only a third of their assets are foreign investments. However, as explained earlier the pension funds should support their domestic capital market. The report from Magnússon et al. (2017) listed the downsides for the Icelandic pension funds investing in the domestic market. The total assets of the pension sector in 2017 exceeded the total amount of all financial instruments in Iceland, indicating that they could buy all of them. Another issue the pension funds are facing is the Icelandic currency which has fluctuated in value over the years. Currency risk is a substantial risk for the pension funds and hedging a small currency as the ISK can be very costly.

The second research question asks if an investor could achieve higher returns than the pension funds by following a simple investment model. This question is answered in the calculations done in chapter 8. Three portfolios are created using various methods and criteria. The investment model the investor chooses to utilise is the maximum Sharpe method which revolves around trying to maximise returns and minimise risk at the same time. From the year 2011, the investor creates a portfolio and bases its asset composition on the return data from the year before. He does the same a year later and the model adds a year of data to the data set. This is done every year until the end of the decade. The results clearly show that the portfolio of the investor yields lower returns than the

pension funds do every year, except for one of the years. According to these results, the investor is not able to beat the returns of the pension funds.

These results are in line with what one could expect. The pension funds employ multiple professionals that have a full-time job of analysing investment opportunities and adjust the portfolios accordingly. The portfolio created by the hypothetical investor; a static portfolio adjusted once-a-year did however yield an average return of 5.78%. Some investors would consider that a decent return, but the investor could not beat the returns of the pension funds. It must be mentioned that this research does not include any calculations of investment or transaction costs which would negatively affect the returns of the investor. Another factor in favour of the pension funds is the guarantees that the pension fund members receive when they pay the monthly premium. Such as a guaranteed minimum payment in the retirement and disability benefits. Nevertheless, there is an upside for the hypothetical investor. As detailed in chapter 2, the law states that a spouse is entitled to pension payments from the pension fund of the deceased individual for two years. If that deceased individual had decided to not pay the premiums to the pension fund and instead invest the money on his own, that money could be inherited in full by the surviving spouse.

It must be noted that while doing this research a global pandemic has hit the economies of many countries quite hard. It would therefore be interesting to do the same research a year from now to examine how the portfolios of the pension funds handled such turmoil on capital markets. As noted earlier, the pension funds that had more risky portfolios had higher average annual returns over the last decade. 2020 could possibly be a year where the more risk averse pension funds achieved greater returns. When contemplating further research topics some topics come to mind. One of those is to compare the returns of the Icelandic pension funds to foreign pension funds; How do the Icelandic pension funds compare to pension funds in other countries. A further addition to this research would be to include a longer period than just one decade. Even going back to the year 2000 and capturing multiple economic cycles. Doing that would add more return data to the data set of the hypothetical investor and perhaps change some of his investment decisions.

As a conclusion, this research has examined the pension funds in Iceland and analysed how they have been allocating their investment funds. Funds that the working people of Iceland own. The research is beneficial to individuals that are interested in the performance of the pension funds and how they invest the premiums paid every month. The research also shows the benefits to paying a premium to pension funds instead of investing the money. Investing is a form of placing a bet on assets, albeit often an educated bet. Positive returns on those investments are never guaranteed. The Icelandic pension funds have however been achieving good returns on their investments over the entire decade, returns that cannot be beat with a simple investment model.

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Appendix A - The pension funds and their annual reports

Lífeyrissjóður starfsmanna ríkisins

- English name: The pension fund for state employees
- Simple name: LSR
- Website: https://www.lsr.is
- Annual reports: https://www.lsr.is/um-lsr/utgafa/arsskyrslur/

Lífeyrissjóður verzlunarmanna

- English name: The pension fund of commerce
- Simple name: Live
- Website: https://www.live.is
- Annual reports: https://www.live.is/sjodurinn/utgefid-efni/

Gildi lífeyrissjóður

- English name: Gildi pension fund
- Simple name**:** Gildi
- Website**:** https://gildi.is
- Annual reports: https://gildi.is/um-gildi/

Birta lífeyrissjóður

- English name: Birta pension fund
- Simple name: Birta
- Website: https://www.birta.is
- Annual reports: https://birta.is/um-sjodinn/utgefid/

Stapi lífeyrissjóður

- English name: Stapi pension fund
- Simple name: Stapi
- Website: https://www.stapi.is
- Annual reports: https://www.stapi.is/is/um-sjodinn/arsskyrslur

Appendix B - USD/ISK exchange rates

Exchange rate between USD and ISK. All values are average monthly values.

Date	USD/ISK	Date	USD/ISK	Date	USD/ISK
Dec. 09	125.07	Apr. 13	118.84	Aug. 16	117.85
Jan. 10	125.87	May. 13	121.15	Sep. 16	114.82
Feb. 10	128.2	Jun. 13	121.82	Oct. 16	114.13
Mar. 10	127.54	Jul. 13	122.53	Nov. 16	112.29
Apr. 10	127.51	Aug. 13	119.65	Dec. 16	112.53
May. 10	129.62	Sep. 13	121.03	Jan. 17	114.39
Jun. 10	128.59	Oct. 13	120.78	Feb. 17	111.54
Jul. 10	123.45	Nov. 13	121.61	Mar. 17	109.59
Aug. 10	119.48	Dec. 13	117.38	Apr. 17	110.44
Sep. 10	116.79	Jan. 14	115.81	May. 17	102.98
Oct. 10	111.7	Feb. 14	114.1	Jun. 17	101.41
Nov. 10	112.45	Mar. 14	112.89	Jul. 17	104.59
Dec. 10	115.7	Apr. 14	112.34	Aug. 17	106.06
Jan. 11	116.8	May. 14	112.69	Sep. 17	106.29
Feb. 11	116.54	Jun. 14	113.71	Oct. 17	105.52
Mar. 11	115.21	Jul. 14	114.27	Nov. 17	104.27
Apr. 11	112.98	Aug. 14	116.01	Dec. 17	104.79
May. 11	114.5	Sep. 14	119.01	Jan. 18	102.8
Jun. 11	115.06	Oct. 14	120.82	Feb. 18	100.89
Jul. 11	116.07	Nov. 14	123.61	Mar. 18	99.63
Aug. 11	114.45	Dec. 14	124.96	Apr. 18	99.59
Sep. 11	116.72	Jan. 15	131.57	May. 18	103.98
Oct. 11	115.95	Feb. 15	132.03	Jun. 18	106.85
Nov. 11	117.24	Mar. 15	136.82	Jul. 18	106.48
Dec. 11	120.94	Apr. 15	136.15	Aug. 18	107.63
Jan. 12	123.65	May. 15	132.52	Sep. 18	110.54
Feb. 12	123.34	Jun. 15	132.28	Oct. 18	116.92
Mar. 12	126.32	Jul. 15	134.01	Nov. 18	122.98
Apr. 12	126.75	Aug. 15	131.79	Dec. 18	121.32
May. 12	127.06	Sep. 15	128.15	Jan. 19	119.68
Jun. 12	127.53	Oct. 15	126.39	Feb. 19	119.93
Jul. 12	125.87	Nov. 15	131.11	Mar. 19	119.95
Aug. 12	120.18	Dec. 15	130.06	Apr. 19	120.31
Sep. 12	122.84	Jan. 16	130.26	May. 19	123.04
Oct. 12	124.14	Feb. 16	128.27	Jun. 19	124.68
Nov. 12	127.21	Mar. 16	126.97	Jul. 19	124.68
Dec. 12	126.41	Apr. 16	123.83	Aug. 19	123.76
Jan. 13	128.66	May. 16	123.65	Sep. 19	125.02
Feb. 13	127.69	Jun. 16	123.33	Oct. 19	124.59
Mar. 13	125.28	Jul. 16	122.01	Nov. 19	123.6
				Dec. 19	122.02

Appendix C - Annual returns of the indices

Year	MSCI W ex EU	MSCI Europe	OMXIGI	NOMXI-REAL	NOMXI-NOM	Long Gov.	Cov. Bonds	Corp. Bonds
2010	7.02%	-3.40%	13.67%	11.09%	16.40%	11.58%	N/A	N/A
2011	1.57%	-6.67%	2.42%	16.46%	1.92%	13.52%	N/A	N/A
2012	18.66%	22.60%	16.48%	5.48%	6.23%	5.41%	N/A	N/A
2013	17.20%	15.67%	25.51%	2.11%	5.41%	1.58%	N/A	N/A
2014	15.57%	0.41%	11.68%	1.21%	9.85%	2.68%	N/A	N/A
2015	4.35%	1.63%	35.25%	9.07%	6.53%	8.06%	N/A	5.01%
2016	-4.27%	-14.25%	-4.84%	4.43%	9.70%	5.05%	5.26%	6.08%
2017	12.86%	16.17%	6.05%	10.33%	4.83%	8.72%	6.42%	6.11%
2018	8.11%	-0.81%	-2.86%	7.94%	2.63%	6.12%	5.66%	4.23%
2019	26.39%	22.56%	24.51%	6.55%	13.82%	7.49%	7.74%	6.16%

Appendix D - Asset distribution of the annually rebalanced portfolio

Year	MSCI W ex EU	MSCI Europe	OMXIGI	NOMXI REAL	NOMXI NOM	Expected return	Realised return	Avg. ret. of pension funds
2011	7.62%	3.41%	0%	0%	88.97%	15.01%	1.60%	7.21%
2012	4.17%	0%	2.84%	92.99%	0%	13.22%	6.34%	12.46%
2013	7.99%	0%	7.45%	68.21%	16.36%	10.38%	5.60%	9.21%
2014	6.94%	0%	18.91%	46.98%	27.16%	9.68%	6.53%	9.01%
2015	14.13%	0%	16.63%	15.46%	53.78%	9.42%	11.39%	10.56%
2016	8.51%	0%	75%	3.29%	13.19%	15.31%	-2.57%	1.55%
2017	4.12%	0%	32.32%	9.99%	53.57%	9.98%	6.10%	7.38%
2018	8.05%	0%	24.88%	27.36%	39.72%	9.12%	3.16%	5.11%
2019	9.23%	0%	19.62%	44.09%	27.06%	8.33%	13.87%	15.47%