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Equity Allocation in the Government Pension Fund Global

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Abstract

The equity allocation in the Government Pension Fund Global has a major impact on the fund's overall long-term risk and return. The purpose of this study is to examine the optimal equity allocation in the GPFG by analyzing the different components that affect the decision. Our study complements prior assessments of the equity share. The evidence from this study suggests that the peer institutions take higher risk than the GPFG. We find that the GPFG has a competitive advantage due to specific fund characteristics and can therefore have a higher allocation to equities than the global market portfolio. We also find that the national wealth has similar characteristics to a corporate bond. However, the overall risk has increased since the previous equity assessment, as equity-like assets account for a higher share of the total national wealth. The results show that with the current fiscal rule, the fund is unlikely to maintain its real value in the future.

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1. Introduction

Since the Norwegian parliament voted to create the Government Pension Fund Global (GPFG) in 1990 to save the revenues of resource extraction for future generations, the equity allocation has been up for debate on several occasions. For the first few years, the fund exclusively invested in government bonds. After 1997, the fund was no longer restricted to government bonds, and the allowance for equity investments were set at 40 percent. A decade later, in 2007, the Norwegian Ministry of Finance increased the equity allocation to 60 percent (NBIM, 2017a). Further, the Mork Commission recommended in the fall of 2016 to increase the equity share of the fund from 60 to 70 percent (NOU 2016:20, 2016). At the same time, Norges Bank (the central bank of Norway) made their own recommendation to the Ministry of Finance to increase the equity allocation in the benchmark to 75 percent. Following these recommendations, the allocation to equities was increased to 70 percent (NBIM, 2016a).

In our thesis we will explore the question: *"What is the optimal equity allocation in the Government Pension Fund Global?"*

The first part of our master thesis focuses on the GPFG. We concentrate on discussing the equity arguments behind previous equity share changes. In the subsequent part, we provide the reader with theory about portfolio selection.

Next, we introduce relevant peers; the Canada Pension Plan Investment Board, the Australian Future Fund and the California Public Employees' Retirement System. We compare fund characteristics and asset allocations of the funds to the GPFG.

In the fourth part, we estimate the global investable market portfolio and analyze whether the GPFG is moving closer or further away from this portfolio. We also discuss whether the global market portfolio is optimal for the GPFG.

The thesis continues with an analysis of the government balance sheet, the fund's liabilities and Norway's national wealth. We concentrate on how these assets and liabilities play an important role for the equity allocation decision in the fund. Human capital, which is the largest revenue component in the national wealth is

further investigated through correlations with other variables, such as equity returns.

In the following part, we study the underlying capital market assumptions; how they have evolved historically and what to expect in the future. We provide reasonable long-term real return and volatility estimates for equity and fixed income, as well as correlation between the assets.

We use capital market assumptions in the Monte Carlo simulations. The purpose of the simulations is to show the scope of different outcomes for the real value of the fund over a 40-year period. We report three different scenarios that display how changes in the input variables affect the long-term sustainability of the fund. Subsequently, we discuss the fiscal rule and the GPFG's role in fiscal policy.

In the conclusion, we repeat the main arguments affecting the equity allocation decision for the GPFG and provide our own recommendation on how much equity the GPFG should have in its portfolio.

2. The GPFG and historical equity allocation

2.1 The Government Pension Fund Global

Oil and gas revenues have made Norway one of the wealthiest nations in the world over the past decades. Following the state budget surplus, the Norwegian government founded the GPFG in 1990, and decided that the surplus was to be reinvested in financial assets abroad. In this fashion, the wealth from non-renewable resources could be shared across generations, and the well-known resource curse avoided (Dutch disease). The strategy of the fund is to take advantage of its long investment horizon and size, to generate sufficient returns and shield the wealth for future generations.

As of December 31st, 2017, the total market value of the GPFG was NOK 8488 billion (NBIM, 2017b). The fund has an infinite investment horizon, where only the expected annual long-term real return of the fund is supposed to be spent to cover the oil-corrected budget deficit in the state budget. GPFG's goal is to have a well-diversified portfolio that generates the highest possible returns with a moderate risk profile. Norges Bank states that the fund is likely to take short-term losses. With 75 percent allocation to equity, losses of 11 percent are expected once every three years, and losses twice this size every twentieth year. The fund's ability to recover from losses has been proved effective during the financial crisis and the technology crash. Due to rebalancing, the fund was one of the largest buyers of stocks during these crashes and made it through the turbulent markets better than most institutional investors (Chambers, Dimson & Ilmanen, 2012). The main risk factors that the fund is exposed to are the allocation to equities, stock price movements, currency and interest rate risk in addition to credit risk (NBIM, 2016b).

At the end of 2017, the fund's asset allocation consisted of 66.6 percent equity, 30.8 percent fixed income and 2.6 percent unlisted real estate (NBIM, 2017b). In 2017, the Norwegian government made a strategic change to increase the allocation to equity to 70 percent, and therefore allowing for higher risk. GPFG has limited liquidity needs, due to natural liquidity from dividends and coupons. However, the fund prefers investing in liquid assets. The investment universe for the fund is under continuous development, but for now the fund invests in public equity, fixed income and real estate. The fixed income investments include government bonds,

corporate bonds and securitized debt. The third investment category is unlisted real estate, with investments in high-quality office or retail properties in selected cities around the world. A distinctive feature of the fund is that all capital is invested abroad. This is partly because the domestic market is far too small compared to the size of the fund. Also, investing abroad helps to avoid overheating the Norwegian economy and to protect it from the effects of oil price fluctuations (NBIM, 2017c).

The 'modern' investment theory is a special case of the general Keynesian investment framework. In this case, all investors possess the same information and have the same expectations about future returns. The Norway model was originally built around the idea that no investor can make excess returns (Ambachtsheer, 2015). However, the fund has some degree of active management, hence they believe it is possible to outperform the market. The current strategy has been developed over time with input from experts, in-depth analysis and practical experience (NBIM, 2017d).

The fund utilizes both internal and external managers. At the end of 2017, the fund used a number of external institutions to manage both equity and fixed income investments. A total of NOK 451 billion was managed by external managers with "specialist expertise in clearly defined investment areas" (NBIM, 2017e). The purpose of the external managers is to make excess returns by beating the market. The external and internal managers manage about 20 percent of the equity in active management. In a cost benchmarking analysis created by McKinsey on behalf of the Norwegian Ministry of Finance, it was documented that the total asset management costs of GPFG were 3.7 bps in 2016. These were largely driven by costly external managers (McKinsey & Company, 2017).

GPFG's governance model has been laid down by the Norwegian Parliament. The model is based on clear delegation of responsibilities and systems for control and supervision. Furthermore, the general responsibility for the fund's management is assigned to the Ministry of Finance, whereas Norges Bank is responsible for the day-to-day management of the fund (NBIM, 2017c).

2.2 Equity share changes in 1997 & 2007

In 1997, the assumptions for managing the GPFG had changed from the first deposit in 1996. Projections at the time revealed that it would take years before it was necessary to make withdrawals from the fund. Therefore, a long investment horizon was assumed for the management of the fund. As a result, investments in equity were included in the portfolio for the first time. The Norwegian national wealth is strongly dependent on oil and gas prices. Equity has historically been negatively correlated with oil prices, and therefore investing in equity, in addition to fixed income investments, would be beneficial in reducing the volatility in the Norwegian national wealth (Ministry of Finance, 1996).

The trade-off between long-term return and short-term risk was the main motivation of changing the equity share in 2007. Because the portfolio had a long-term horizon, short-term fluctuations in the stock market were not as important (Norges Bank, 2006). Most arguments for deciding upon an equity share are similar in 2007 compared to 2017 and are presented in chapter 2.3.

In 2006, NBIM recommended that real estate and infrastructure should be included in the portfolio. For the real estate investment, NBIM found that equity instruments give the preferred exposure to the real estate markets compared to the alternative investments in debt instruments (Norges Bank, 2006). An advantage with real estate is that it is not perfectly correlated with fixed income and equities. In addition, real estate investments provide steady long-term real returns and hence may serve as inflation protection. The Ministry of Finance approved investing in real estate in 2008 and gave mandate to invest a maximum of 5 percent of the total portfolio in 2010. The first investment in real estate occurred in 2011 (NBIM, 2012). The Ministry of Finance never approved investments in infrastructure.

Private equity was recommended as an equity class for up to 5 percent of the total portfolio, by Norges Bank back in 2006. As a transition to be a private equity investor, it was suggested that the fund would invest in private equity firms which were expected to be listed on stock exchange during the next 12 to 24 months (Norges Bank, 2006). Nevertheless, private equity has not yet been included in the investment universe.

2.3 Equity share change in 2017 and current market conditions

In this section, we use arguments leading up to the 2017 equity share change, combined with current market conditions and fund characteristics, to outline arguments in favor of either an increase or a decrease in equity allocation for GPFG.

In 2016, NBIM argued that there has been a structural change in the relationship between equities and fixed income, and that the expectations about the future long-term correlation are lower than what has been the historical average. This change in expectations makes the fund more capable of bearing risk than it was back in 2007, and hence justifies for a higher equity share. NBIM also stated that the reduced return expectations on fixed income compared to 2006, favors a higher equity share in the GPFG (NBIM, 2016a).

Furthermore, the total risk in the Norwegian national wealth is an important factor when deciding upon an equity allocation. Norges Bank argued that the transformation from petroleum fortune in the ground, to financial fortune abroad, pulls in the direction that the fund can handle a higher equity share (NBIM, 2016a). The Mork Commission put emphasis on the fact that the transformation to financial fortune has made the petroleum fortune more diversified than it was back in 2007 when equity was increased to 60 percent, and therefore the fund is capable to bear more risk (NOU 2016:20, 2016). According to B. Gerard, transforming risky oil and gas resources into financial assets, the fund can increase the risk profile in the financial portfolio and still reduce the total risk in the Norwegian asset portfolio (B. Gerard, Discussion of Mork report, May 16, 2017).

Oil and gas are non-renewable resources and should therefore be managed in a sense that benefits future generations. In recent years, the value of the fund has increased substantially, and as a result the fiscal rule has been lowered from four to three percent. The rule states, that extractions from the fund should not exceed the expected long-term real return, which is now estimated at three percent. If payouts exceed the real return, the fund decreases in real value. This illustrates a threat to the main objective of the fund, which is to benefit future generations. The Mork Commission calculated in their analysis in 2016 an expected real return of 2.3

percent in the next 30 years with 60 percent equity. With an equity share of 70 percent, the expected real return for the next three decades would increase to 2.6 percent (NOU 2016:20, 2016). According to these returns, the fund is not sustainable with the current fiscal policy in the long-term.

In 2017, the Federal Reserve (FED) announced that it would gradually reduce its USD 4.5 trillion balance sheet, to unwind quantitative easing (Board of Governors of the Federal Reserve System, 2017). Quantitative easing is an unconventional monetary policy of purchasing copious quantities of long-term securities, with the objective to lower interest rates, and hence stimulate the economy. There exists significant evidence that QE has the desired effect on long-term interest rates (Krishnamurthy & Vissing-Jorgensen, 2011). As central banks around the world reverse their QE programs, interest rates are likely to increase, and bond prices drop. Hence, it may not be the best time to increase the allocation to fixed income, until after QE is fully reversed. This combined with the historically low interest rates, point towards a lower allocation to fixed income securities (B. Gerard, Discussion of Mork report, May 16, 2017).

With an aging population, the current fiscal rule is sustainable if the government implements for example pension reforms instead of draining the fund. Furthermore, one could increase the equity share to raise the expected return of the fund. The equity share is a trade-off between high expected return and low risk. The majority of the Mork Commission concluded that higher risk was acceptable. A minority (Mork) voted to lower the equity share to 50 percent and based this recommendation on the need to avoid large fluctuations in the fund value and emphasized the importance of providing fiscal policy with steady access to capital (NOU 2016:20, 2016). This can also be addressed by modifying the Tobin rule to better reflect the real return of the fund**.** The oil-corrected state budget deficit for 2018 is 18.4 percent, which is financed through transfers from the GPFG. This high dependency on capital transfers, means that large fluctuations in the fund value can be troubling for the fiscal policy (Ministry of Finance, 2018). This alone speaks for a lower risk tolerance in the GPFG.

3. Theory

3.1 Modern Portfolio Theory

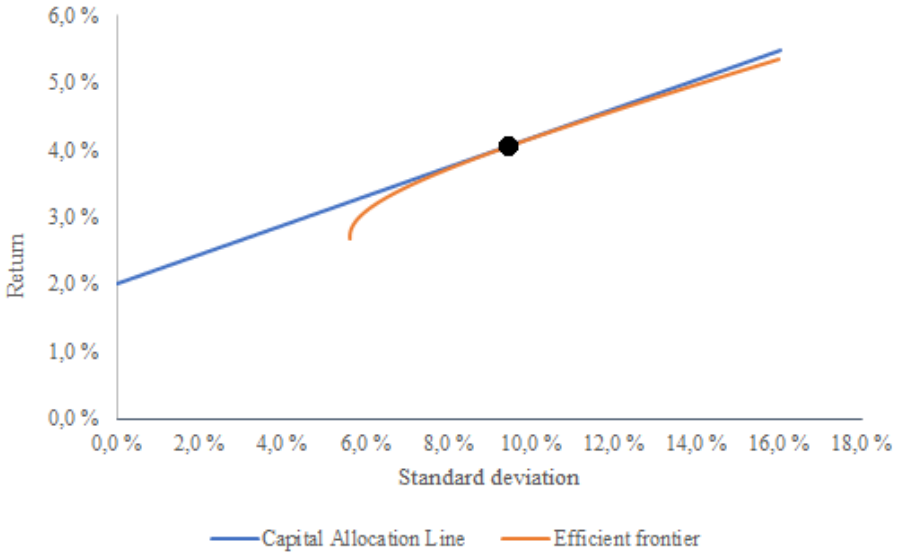
Modern Portfolio Theory was pioneered by the Nobel Prize winning economist Harry Markowitz in his article "Portfolio Selection" from 1952 (Markowitz, 1952). The theory builds on a framework called mean-variance portfolio optimization, which maximizes expected returns with a given level of risk. This groundbreaking theory proved that for a given expected return there is an optimal portfolio of assets at the efficient frontier that offer the minimum variance. The investor should not solely consider characteristics of a single security, but instead how the security behaves together with other securities (Elton & Gruber, 1997).

James Tobin (1958) further expanded this work with the Tobin Separation Theorem. By introducing a risk-free asset, the investor could lever or de-lever portfolios on the efficient frontier. The volatility could therefore be reduced or increased with different positions in the risk-free asset. Investors prefer to maximize excess return over volatility, hence all investors would hold the same portfolio of assets. This efficient portfolio is constructed on the capital allocation line, and except for the tangency portfolio, it offers a better risk-return trade-off than all portfolios on the efficient frontier. Furthermore, the Sharpe ratio is a frequently used tool to measure the excess return earned above the risk-free rate per unit of total risk (Sharpe, 1966). The formula is given below.

$$Sharpe\ ratio = \frac{Portfolio\ return - risk\ free\ rate}{Standard\ deviation}$$

All possible combinations of the risk-free asset and the optimal asset portfolio on the efficient frontier make up the capital allocation line (CAL). In figure 1, we see an example of the CAL and the efficient frontier, where CAL is given by the straight blue line.

Figure 1: Capital allocation line and efficient frontier



3.2 Capital Asset Pricing Model

The capital asset pricing model (CAPM) is a financial theory, which specifies that under certain conditions, the expected return on an equity investment is a function of the expected systematic risk (risk that can be rewarded). The model builds on Modern Portfolio Theory by Markowitz and was further developed by Jack Treynor, John Lintner, William F. Sharpe and Jan Mossin in the mid 1960's (Fama & French, 2004). CAPM is built on several key assumptions such as risk averse investors, homogeneous expectations about asset returns, all investors have the same information, and perfect capital markets. Below is the CAPM formula, where beta represents the systematic risk (Copeland, Weston & Shastri, 2014).

$$Cost\ of\ capital = Risk\ free\ rate + Beta\ \times Market\ risk\ premium$$

William Sharpe (1964) proved through the CAPM that Tobin's portfolio was the market weighted combination of all risky assets; the Global Market Portfolio. The model can be applied to all available assets; hence arbitrage will ensure that the model holds – in theory. Therefore, rational investors would want to hold the weighted portfolio of all risky assets available in the market.

4. Peer analysis

To assess the optimal equity allocation for the GPFG, it is instructive to document the allocation of the peer institutions. Peers are large institutional investors such as pension funds, endowments and sovereign reserve funds. This part compares the GPFG to three peer institutions, the Canada Pension Plan Investment Board, the Australian Future Fund and the California Public Employees' Retirement System.

4.1 The Canada Model

The Canada model is currently being used by the Canada Pension Plan Investment Board, the Ontario Teachers' Pension Plan, and a few other major Canadian pension funds. It is a relevant competitor to the Norway model because of its comparable asset pool size and its intellectual foundation. The Canada model descends its intellectual foundation from frameworks developed by John Maynard Keynes and Peter Drucker (Ambachtsheer, 2015).

Keynes' framework lays out the fundamental investment philosophy of the Canada model. The framework distinguishes between investing through 'beauty contest' and real investing. In 'beauty contest' investors try to identify and buy stocks that will shortly become popular, and then sell them for higher returns. In contrast, in real investing, uncertain cash-flows are calculated into future values and compared to a pre-established minimum rate of return (a 'turn saving into productive capital' investor). An investor can choose from three investment style alternatives; join the 'beauty contest' game, become a low-cost passive investor or become a 'turn savings into productive capital' investor by acquiring the essential skills. The Canada model prefers the last option, with a slight contribution from the low-cost passive investor option (Ambachtsheer, 2015).

Drucker's framework is based on five critical organizational aspects: mission clarity and organizational autonomy, good governance, sensible investment beliefs, right-scaled and right-peopled. The Canada model has a clear mission statement, and the business structure has harmony between organizational accountability and autonomy. In contrast to the Norway model, an experienced independent board oversees the fund with a support from an appointing committee. The organization's investment beliefs are based on the investment frameworks by Keynes. In addition,

with support from investment strategies built to suitable scale, competent internal teams invest in global private markets through active management (Ambachtsheer, 2015).

4.1.1 The Canada Pension Plan Investment Board

The Canada Pension Plan Investment Board (CPPIB), which was established in 1997, oversees and invests the funds of the Canada Pension Plan (CPP) on behalf of its 20 million Canadian contributors and beneficiaries. As of September 30th, 2017, CPP had a value of NOK 2103 billion[1] (CAD 328.2 billion), which is equivalent to one quarter of the size of the GPFG (CPPIB, 2017c). CPPIB has a long-term horizon as it aims to pay pensions and meet its current and future financing needs by raising the value of its assets. Its goal is to maximize returns without taking excessive risk. To reach this, CPPIB is prepared for occasional up-and-downturns in the market and forecasts losses of 12 percent or more every ten years (CPPIB, 2017a).

Long-term risks that could decrease CPP contributions or increase CPP benefits are the base for setting the fund's risk level. The major risks CPP faces are longevity, an aging population, and Canadian economic growth and employment. In addition, real wage growth, birth rates, demographics and immigration affect the fund. CPPIB finds climate change both as a risk as well as an opportunity (CPPIB, 2017a).

CPPIB believes that a portfolio consisting of 40 percent global public equities and 60 percent Canadian government bonds offers the lowest level of risk to achieve the net real return required to maintain the real value of CPP. However, higher justifiable risk level will result in better returns. As of March 31st, 2017, CPPIB invested 55.4 percent in public and private equities, 21.5 percent in fixed income, and 23.1 percent in real assets. Compared to the GPFG, CPP has a higher allocation to equity and equity-like assets (CPPIB, 2017a).

[1] Calculated from the NOK/CAD exchange rate as of September 29th 2017 (Norges Bank).

CPPIB's investment portfolio has changed significantly since March 2000, when 95 percent was invested in fixed income and only five percent in equities. In 2014, CPPIB decided gradually to increase the risk level up to 85 percent in global equities and 15 percent in Canadian government bonds in the coming years. The increasing maturity, scale and best forecasts for long-term economic and capital market factors are considered when the risk level is re-evaluated every third year. CPPIB has experienced a similar development as GPFG with a gradual increase in allocation to equity over the past 20 years (CPPIB, 2017a).

Currently, CPP benefits are paid entirely with CPP contributions. However, the Chief Actuary of Canada has estimated that in 2021, CPP will need to start using a portion of investment income in addition to CPP contributions. CPPIB forecasts that 65 to 70 percent of contributions and 30 to 35 percent of investment returns will finance future benefits. As a result, the fund will grow at a slower pace (CPPIB, 2017a).

Like the GPFG, CPPIB engages in both passive and active management. Instead of only investing in an index-based portfolio, CPPIB buys and sells individual securities that it believes are temporarily mispriced. The external and internal managers manage about 23 percent of the assets in active management. To justify active management, CPPIB compares its returns against a reference portfolio that holds public market indexes to ensure superior returns are delivered. Through active management, CPPIB takes advantage of large-scale transactions, private market deals as well as structural changes and trends. CPPIB also engages in strategic tilting, which temporarily moves asset allocations and factor exposures to other direction from the portfolio's long-term objective. This strategy provides extra flexibility for the active managers, in contrast to the GPFG (CPPIB, 2017a).

CPPIB invests in more than 40 countries, and therefore the fund is exposed to currency risk. The Canadian economy is likely to be more stable, when the Canadian dollar appreciates against other currencies due to higher commodity prices. This is reflected in higher real salaries for CPP contributors. With higher salaries, the contributions to CPP increase as well. This way CPP is naturally hedged, and its explicit requirements for currency hedging are reduced. Moreover,

hedging increases inherent risk, because of Canadian dollar's status as a commodity currency. The dollar behaves in a procyclical way; it appreciates when global equity markets are rising and depreciates when the markets are falling. However, there might not be excess return to compensate for taking this risk and therefore inherent risk increases. Hedging is also costly, and currency risks can be reduced through diversification (CPPIB, 2017a).

CPPIB's governance model is globally recognized as an outstanding example for national pension plans. CPPIB operates independently from the CPP and from the federal and provincial governments, whereas the GPFG is under government control. Their main responsibilities are approving investment policies, deciding strategic direction and making key operational decisions. An independent Board of Directors provides overall direction to CPPIB (CPPIB, 2017b).

4.2 The Australian Future Fund

The Australian Future Fund (AFF) had a value of NOK 891 billion[2] (AUD 139 billion), at the end of 2017, which is about one tenth of the size of the GPFG (Australian Government Future Fund, 2018). AFF's purpose is to enhance the long-term financial status of the Australian Government by covering the cost of unfunded public sector retirement liabilities. Capital inflows to the fund come from contributions from budget surpluses, and sale and transfer of government-held shares. However, since 2007, there has not been additional contributions to the fund, in contrary to the intentions at the time of establishment in 2006 (Australian Government Future Fund, 2017a).

The governing legislation rules the size of capital transfers from the fund to cover the Commonwealth's unfunded pension liabilities. To avoid draining the fund, it was determined that withdrawals to pay superannuation benefits should not occur until the superannuation liability is fully offset. The superannuation liability was about AUD 46 billion higher than the AFF market value at 30th of June 2016 (Parliament of Australia, 2017). The government has decided not to make any withdrawals for at least the next 10 years, as they want to improve the long-term

[2] Calculated from the NOK/AUD exchange rate as of December 29th, 2017 (Norges Bank).

financial situation. In case withdrawals that equal to the full amount of annual liabilities, were to start in 2020, the fund would be drained and AUD 275 billion of superannuation liability would remain in 2046 (Australian Government Future Fund, 2017a).

Similarly to the Norway model, AFF has clear missions and objectives as well as detailed investment philosophies. The fund's investment mandate is governed by the Australian Government and its goal is to "achieve an average annual return of at least the Consumer Price Index plus four to five percentage points per annum over the long term, with an acceptable but not excessive level of risk" (Australian Government Future Fund, 2017b). Until the end of June 2017, the mandate's goal was 0.5 percentage points higher but was decreased due to a shift in global market circumstances and expectations. The lower average annual return outlines the current belief between risk and return. Investment risk contains of macro, market, liquidity, inflexibility, specific, investment manager and counterparty risks. All foreign investments are hedged to offset the currency risk (Australian Government Future Fund, 2017a).

As of December 31st, 2017, AFF invested 45 percent in equity, 26 percent in fixed income and 29 percent in real assets. AFF has moderately higher allocation to equity and equity-like assets than the GPFG. The portfolio weights are flexible since AFF does not follow a fixed strategic asset allocation, and therefore does not have a reference portfolio. Instead, the fund measures performance using a fixed allocation that represents the average level of risk over time (Australian Government Future Fund, 2018).

AFF's investment portfolio has experienced major changes, as 75 percent was invested in fixed income and 25 percent in equities at the beginning of 2008 (Australian Government Future Fund, 2008). The change to a higher equity share has mainly been due to two desired characteristics in portfolio construction; diversification and flexibility to bear and take advantage of market dislocations (Australian Government Future Fund, 2018). AFF and GPFG have experienced a similar development in their allocation to equities. However, AFF's development has occurred over a shorter timeframe.

Compared to the GPFG, AFF is made as autonomous as possible. It is governed by 'the Board of Guardians', which consists of experienced independent members. The Future Fund Management Agency, an Australian Government agency, gives consultation and advice to the 'Board of Guardian'. 'The Future Fund Act 2006' legislates the governance of the fund (Australian Government Future Fund, 2017c). In contrast to the GPFG, the investments strategies are carried out exclusively through external managers (Australian Government Future Fund, 2017c).

4.3 The California Public Employees' Retirement System

The California Public Employees' Retirement System (CalPERS) has managed pension benefits for its members since 1932, and currently has 1.26 million active and 0.67 million inactive members. With a total market value of NOK 2734 billion[3] (USD 326 billion), equivalent to one-third of GPFG's assets, it is the largest peer fund discussed in this paper. At the end of June 2017, it was the largest defined benefit public pension fund in the United States. CalPERS invests for decades thereby securing the long-term sustainability of the fund.

Capital inflows to the fund come from investment returns, which accounts for the largest part, as well as from employee and employer contributions. The current contributions do not alone cover for the yearly pension benefits that need to be paid out (CalPERS, 2017a).

The investment decisions in CalPERS are governed with applicable law, and the CalPERS Board of Administration invests and manages the fund's assets. The goal of the fund is to obtain complete funding of the liabilities at an acceptable level of risk (CalPERS, 2017a). Risks that affect CalPERS are changing demographics, a growing number of retirees, longevity, as well as governance and regulatory challenges (Eason, 2017). The fund was fully funded before the financial crisis, but has only been funded by 68 percent during the two previous fiscal years. To decrease the shortfall, the CalPERS Board reduced the funding discount rate from 7.5 to 7.0 percent resulting in higher unfunded liabilities and costs to employers. If investment returns exceed the discount rate by at least two percentage points, the

[3] Calculated from the NOK/USD exchange rate as of June 30th 2017 (Norges Bank).

current asset allocation will be revised in order to further reduce the investment risk (CalPeRS, 2017a).

As of 30th June 2017, CalPERS invested 56 percent in public and private equity, 28 percent in fixed income and 16 percent in real assets. CalPERS has a slightly higher allocation to equity and equity-like assets compared to the GPFG. At the end of 2017, the asset allocation was revised and decided to be kept similar with a maximum of one to two percentage point deviations to the previous allocation during the next four years. The new allocation supports the expected rate of return of seven percent and protects CalPERS from unnecessary risk (CalPERS, 2017a).

CalPERS' investment portfolio is exceptional, as its asset allocation has not changed during the period 2000-2017. CalPERS believes "the portfolio represents their best option for success while protecting their investments from unnecessary risk" (CalPERS, 2017b). Although, the current asset allocation for CalPERS and the GPFG do not deviate significantly from each other, this has not always been the case.

Similarly to the GPFG, CalPERS engages both in active and passive investing. Investment strategies are carried out by internal and external managers. During the fiscal year 2016-2017, CalPERS moved assets from external managers to internal managers to cut total investment costs (CalPERS, 2017a). Currently, external managers manage about 20 percent of public equities and 10 percent of the fixed income investments (CalPERS, 2018).

4.4 Peer allocation comparison

Table 1: Market weights of the GPFG and the peer institutions

	GPFG		CPP		AFF		CalPERS	
	Eq.	FI	Eq.	FI	Eq.	FI	Eq.	FI
2017	69,2 %	30,8 %	82,6 %	17,4 %	74,0 %	26,0 %	72,0 %	28,0 %
2008	49,6 %	50,4 %	75,0 %	25,0 %	36,5 %	63,5 %	74,0 %	26,0 %
2000	40,4 %	59,6 %	14,0 %	86,0 %	-	-	72,0 %	28,0 %

Sources: NBIM, CPPIB, AFF and CalPERS

We categorize GPFG's and its peers' asset allocations to fixed income and equity and equity-like assets. What stands out in table 1 is that the allocation to equity and equity-like assets is moderately lower in the GPFG compared to the peer institutions. The allocation to equity and equity-like assets varies between 72 to 83 percent for the peers. This indicates that the GPFG takes lower risk compared to the peers. However, it is worth mentioning that the GPFG and the peers have different asset classes within the category of equity and equity-like assets. For example, all peers invest a significant amount in private equity and real assets.

CPP, AFF and GPFG have gone through a similar transformation, where equities have developed to become the most popular asset class in their respective financial portfolios. In contrast, CalPERS has had the same allocation to equity and equity-like assets for the last 17 years.

The peer institutions share two distinctive fund characteristics; their size is significantly smaller than the GPFG and they invest both in domestic and foreign assets, whereas the GPFG only invests abroad. The GPFG's size provides them an advantage with low management costs relative to the peers. Although, the GPFG is required to only invest abroad, it does not bring a significant disadvantage to the GPFG due to the size of the market.

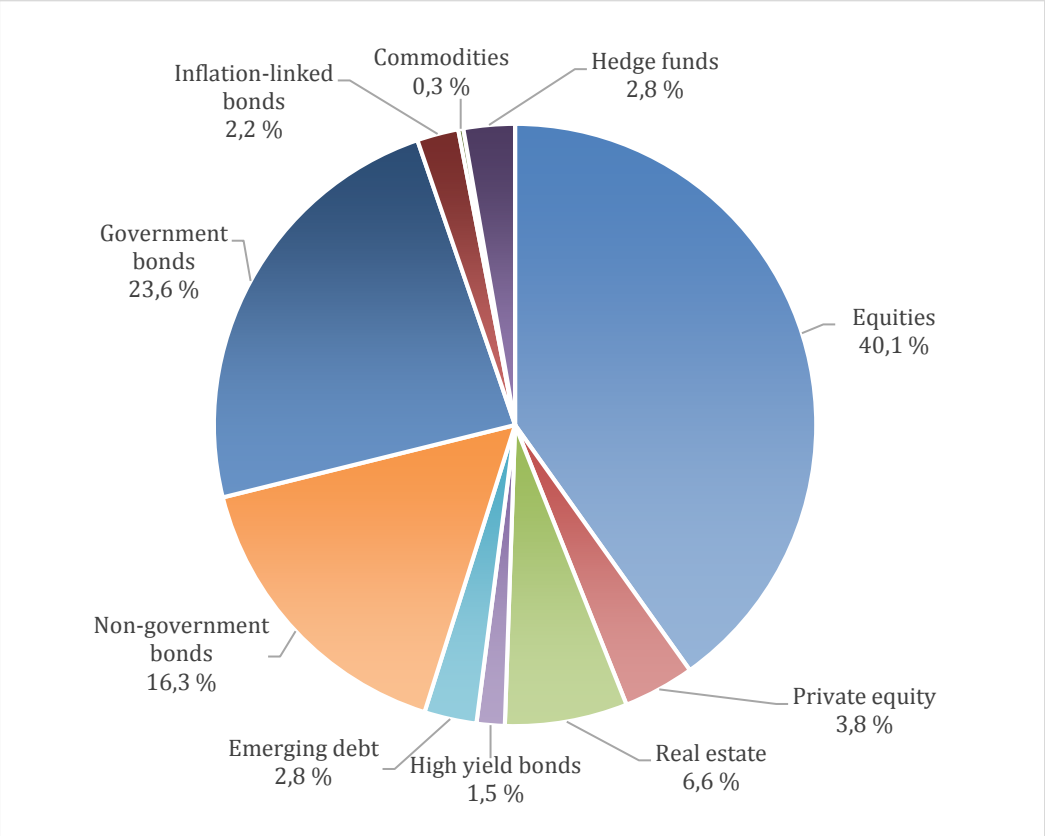
5. The Global Market Portfolio

5.1 The invested multi-asset market portfolio

Theory tells us that if markets are efficient, globally integrated, and all investors are risk averse with similar risk and return expectations, then the global market portfolio is the investors efficient portfolio. The market portfolio is the portfolio consisting of all securities available in the market. In figure 2, we estimate the global invested market portfolio for 2017, based on the approach by Doeswijk, Lam and Swinkels (2014). In 2017, our estimates are equivalent to Doeswijk et al's, except for a small deviation in the market value for real estate since we employ a different real estate index to backfill the period 1996-2003 and to fill the period 2005-2017. Furthermore, Doeswijk et al. do not include market values for commodities and hedge funds in their 2017 estimate, which makes our projected

weights for the remaining asset classes deviate slightly from theirs. For commodities and hedge funds, we use data for assets under management (AUM) provided by BarclayHedge. Long and short positions in commodities cancel each other out, hence the net value of this market is low. Since a full timeseries on the commodity market capitalization from Barclays Capital is not publicly available, the commonly used alternative for the "CTA industry - Assets Under Management" was chosen. Further, including hedge funds leads to double counting, and it can also be discussed whether it is more of a set of strategies than an asset class, but the small size results in only a minor bias in our invested market portfolio in 2017. The invested market portfolio is a subset of the investable market portfolio. Hence, assets in the investable market portfolio that are unavailable for investors to invest in, are excluded. This includes human capital, durable consumption goods and government stakes in enterprises. (Doeswijk et al., 2014)

Figure 2: Global invested market portfolio 2017



Sources: Thomson Reuters, MSCI, Preqin, BarclayHedge, Doeswijk et al., own calculations

At the end of 2017, the total market capitalization of our invested market portfolio sums up to USD 124.5 trillion. The largest asset class is equities accounting for 40.1

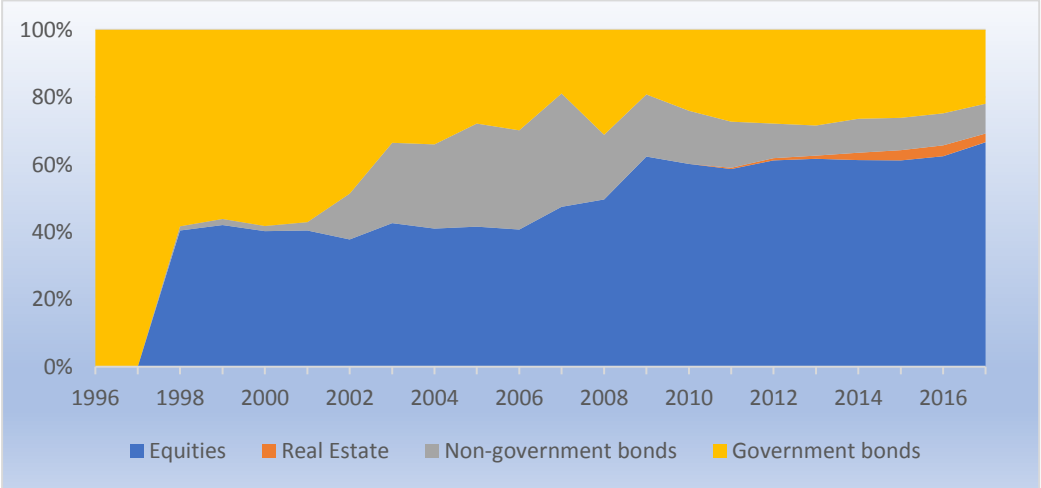
percent of the total market capitalization. Equities, along with government and non-government bonds, account for 80 percent of the market capitalization, leaving the remaining seven asset classes only with a total market capitalization of 20 percent. Equity and equity-like asset classes (public and private equity, real estate, hedge funds and commodities), account for approximately 54 percent.

5.2 The GPFG and the Global Market Portfolio

5.2.1 Asset allocation in the GPFG and in the Global Market Portfolio

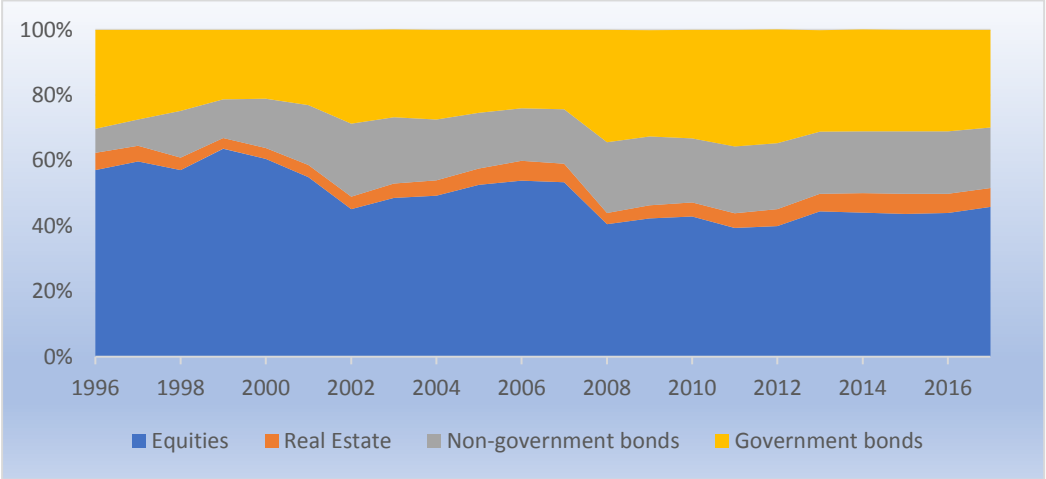
In this part, we compare the actual asset allocation of the GPFG, with our own calculations of the market capitalization of the invested market portfolio over the same time-period (see detailed global market portfolio in appendix 1). To do this, we group the market portfolio into four broader asset classes: equities (public and private), real estate, non-government bonds (includes high yield bonds) and government bonds (includes emerging debt and inflation-linked bonds). Commodities and hedge funds are excluded from the analysis. Theory tells us that the market portfolio is the most efficient portfolio, and it is therefore interesting to investigate whether GPFG is moving closer or further away from this optimal portfolio.

Figure 3: GPFG allocation over the period 1996-2017



Source: NBIM

Figure 4: Global market portfolio allocation over the period 1996-2017



Sources: Thomson Reuters, MSCI, Preqin, BarclayHedge, Doeswijk et al., own calculations

To compare GPFG with the market portfolio, we focus on the equity share of the fund. What can clearly be seen from figure 3 and 4, is that the equity allocation has increased steadily in the GPFG, while the market weight of equities in the global market portfolio has decreased over the same time-period. The market capitalization of equities (public and private) has ranged between 43 and 45 percent since 2012, hence GPFG's current allocation to equities is significantly higher than the market. The recent increase in the equity share makes the fund move further away from the global market portfolio than what has been the case for the period 2002-2016. It is important to note that the GPFG had not yet reached the allocation of 70 percent equities at the end of 2017, hence the fund will move further away from the global market portfolio than illustrated by the figures above.

Table 2: Percentage point difference in equity-like assets

The GPFG	1996	1998	2007	2017
Equity and equity-like	0 %	40 %	60 %	75 %
Fixed income	100 %	60 %	40 %	25 %
The Market Portfolio (MP)				
Equity and equity-like	62 %	61 %	59 %	52 %
Fixed income	38 %	39 %	41 %	48 %
Difference (GPFG-MP)				
Equity and equity-like	**-62 %**	**-21 %**	**1 %**	**23 %**

Sources: NBIM and own calculations

From table 2, we see the theoretical difference between equities in the strategic benchmark index in GPFG (real estate is given a weight of five percent and classified as part of the equity-like assets) and in the simplified market portfolio. The difference in allocation to equities has varied a lot over time. In 1996, GPFG was invested solely in government bonds, and therefore the difference to the market portfolio was significant. In 1998, GPFG was underweighted by 21 percentage points in equities. The allocation moved closer to the global market portfolio between 1999 and 2006, making GPFG's allocation equivalent to the simplified market portfolio in 2007. After the most recent equity change, the fund has a significant overweight in equity-like assets. The equity gap is 23 percentage points higher in the GPFG relative to the market portfolio.

5.2.2 Regional allocation in the GPFG and in the Global Market Portfolio

Next, we document the difference in the regional allocation weights in the GPFG compared to the market portfolio. We display the percentage point difference in equity weights for the three major regions accounting for more than 90 percent of the listed equity market. All regional weights are given in appendix 2-4.

Table 3: Percentage point difference in the regional equity weights for the GPFG compared to the market portfolio (calculated: GPFG – the market portfolio)

	1998	2007	2017
Europe	23,40 %	23,30 %	18,04 %
Asia	2,31 %	-14,88 %	-12,48 %
North America	-24,59 %	-4,78 %	-3,84 %

Sources: NBIM, World Federation of Exchanges database, Borsa Italiana, London Stock Exchange

From table 3, we see that European equities have been given a significant overweight in the GPFG compared to the market portfolio. At the end of 2017, the GPFG allocated almost twice as much to European equities (36.39%) than the actual regional market weights in the market portfolio (18.35%) imply. In contrast, the allocation to the Asian equity market has been underweighted in the fund during the last decade. The North American equity market is the region where the weights of the GPFG and the world equity market has developed to become more aligned.

Over the period, the aggregate percentage point difference has decreased, and hence the equity share of the fund is now invested closer to the regional market weights.

Table 4: Percentage point difference in the regional fixed income weights for the GPFG compared to the market portfolio

	2007	2016
Europe	38 %	9 %
Japan	-9 %	-6 %
United States	-23 %	-7 %

Sources: Bank of International Settlements (BIS), NBIM

For fixed income securities, we clearly see that all the regional weights in the fund have moved closer to actual regional market weights (table 4). However, despite moving closer, the fund does not track regional weights given by the market for either equities or fixed income. This means that the fund allows for the introduction of unsystematic risk in the portfolio.

5.3 Is the Global Market Portfolio optimal for the GPFG?

In the previous chapter, we document that the GPFG has a significantly different allocation than the market capitalization of all risky assets at the end of 2017. The recent increase in the equity allocation is an active choice to move away from the global market portfolio weights. Financial theory states that a passive long-position in the market portfolio is the optimal portfolio. According to Doeswijk et al. (2014) holding the market portfolio is optimal for the average investor. Hence, a relevant question is whether GPFG is an average investor. In this respect, we discuss some of the fund characteristics and the fund management to see if they provide the fund with a competitive advantage. First, the long investment horizon combined with the inflows gives the fund the characteristics of a younger investor capable of bearing more risk than average in his portfolio. Secondly, the fund invests no capital in the Norwegian market, and therefore deviates from country market weights. This is an active choice due to the large exposure towards the Norwegian economy by supporting the state budget. Further, GPFG's size provides them a competitive advantage, in the sense that management costs are relatively less expensive compared to the peers and most other investors. Overall, GPFG's characteristics make the fund more suited to deviate from market weights than the average

investor. Therefore, we find it reasonable for the GPFG to have a higher allocation to equities than the market portfolio.

6. Government balance sheet and national wealth

Risk and return play an important role when choosing the equity share. However, the optimal allocation is highly dependent on the fund's assets and liabilities, as well as their ambiguity. Government revenues and expenditures significantly increase the level of uncertainty in the GPFG case, due to correlation between the different factors, such as revenues and asset returns. The risk-return trade-off can be undervalued, if the other factors are neglected. In GPFG, revenues and expenditures are large in size, vary considerably, and co-vary with asset returns, and thus need to be considered for the equity share decision (NBIM, 2016d).

6.1 Government revenues and expenditure

Revenues for the Norwegian government come from taxations of private sector economic activity, direct financial interests as well as from asset returns in the GPFG. The dominant revenue factor, taxation, is difficult to estimate as it is subject to changes. It is levied by the government, which bases the yearly tax rate on how big share of the economic activity need to be collected to cover the costs (NOU 2016:20, 2016). The petroleum industry plays a major role in the Norwegian economy and it affects revenues through taxation and direct financial interests. The petroleum wealth depends on the level of oil prices, which are known to fluctuate causing the wealth to significantly change. In 2016, the remaining offshore petroleum wealth was valued at approximately NOK 3500 billion (NBIM, 2016d). The government's total net cash flow from the petroleum industry is estimated to be NOK 224 billion, accounting for 17 percent of the national accounts in 2018. NOK 105 billion is expected to come from taxes and the remaining NOK 109 billion from direct ownership, fees and ownership dividend (Norwegian Petroleum Directorate & Ministry of Petroleum and Energy, 2018b).

Government expenditures consist of the public services offered to the citizens that are funded by the different revenue streams. Estimating the liabilities is challenging as the government's obligations are more political than contractual. In addition, the

government's infinite time horizon and changing preferences create an obstacle to the estimations (NOU 2016:20, 2016). When the government underestimates its commitments, it needs to pull additional income from the fund further decreasing the fund's value. In contrast, when the commitments are overestimated, the unused amount remains in the fund, thus protecting the fund's long-term horizon (NBIM, 2016d).

6.2 Fund's liabilities

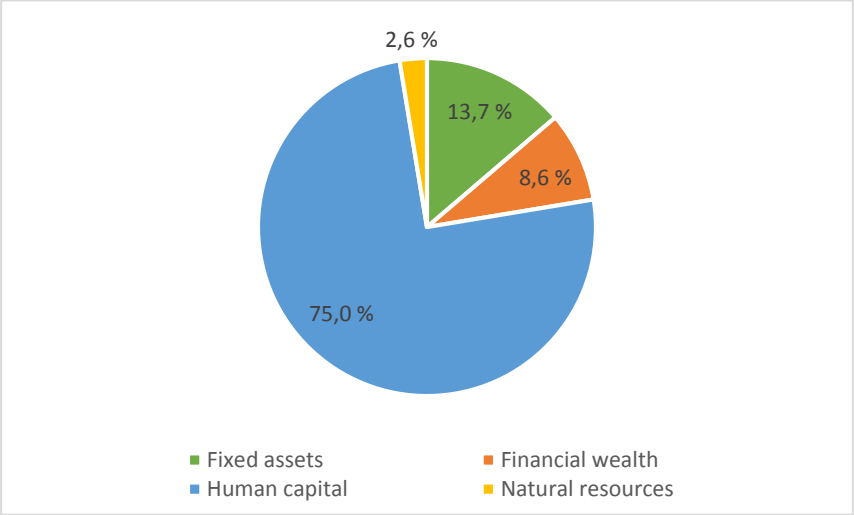
Defining the liabilities is one of the most important steps when running a fund. Currently, the fiscal rule is three percent of the fund's value. This amount covers a part of the government's expenditure, namely future consumption, real investments and public services. The liabilities help to cover the budget deficit, indicating that the fund's main commitment is to fiscal policy. However, the liabilities are not specific.

6.3 Norway's national wealth

Financial wealth should be allocated in a way that achieves the best trade-off between expected risk and return for the total national wealth. Norway's national wealth includes expected future revenues, and it provides a fair illustration as it takes into consideration the temporary revenues from the petroleum industry. However, the estimations of future revenues are highly uncertain, and the calculations depend on the elements included and the assumptions made (Ministry of Finance, 2017).

The Ministry of Finance (2017) estimates Norway's national wealth to be NOK 14 million per inhabitant, accounting for two and half times the nation's gross domestic product. The national wealth is categorized into four components; human capital, natural resources, fixed assets and financial wealth. They account for 75.0, 2.6, 13.7 and 8.6 percent, respectively, of the national wealth (figure 5). Human capital is the most important component in Norway's national wealth.

Figure 5: The national wealth of Norway



Source: Ministry of Finance (Perspektivmeldingen 2017)

The estimations from national accounts are used both for fixed assets and financial wealth whereas for human capital and natural resources the future income is calculated to present value (Ministry of Finance, 2017).

6.3.1 Calculation of natural resources

In natural resources, petroleum wealth is highlighted, and other resources are disregarded as their wealth is insignificant to the calculations of national wealth. To calculate the estimation of present value of petroleum wealth, the future economic rent earned from fixed assets and labor in the petroleum industry, is used as a discount rate. The Ministry of Finance (2017) uses the following formula to calculate natural resources:

$$P = \sum_{t=1}^{T} \left(\frac{R_t + I_t - iK_t + 0{,}5L_t}{(1+t)^t} - \frac{K^{T-1}}{(1+r)^{T-1}} \right) / N_0$$

P: discounted future resource rate per inhabitant
r: the future economic rent (3%)
R: cash flow in the sector (real value)
I: petroleum investment (real value)
K: capital in real value in the sector
i: normal return in the industry (6%)
L: labour income in fixed price in the sector
T: number of years of petroleum extraction
N_0: number of inhabitants at the beginning of the year

The estimation is uncertain and depends on several factors, like future oil price, the level of production and extraction costs (Ministry of Finance, 2017).

6.3.2 Calculation of human capital

To calculate human capital, the three most common methods are indicators, cost-based measurement and income-based measurement. When measuring the overall knowledge of the population, such as how many years of school people have attended, the indicators approach is used. To determine how much education costs to the society, the cost-based approach applies. The income-based approach estimates the return on human capital, by calculating the net present value of future labor input. The value of human capital will be higher, if workers work more. Human capital is also dependent on productivity growth in the future. The value of human capital will be reduced, if long-term economic or productivity growth is lower (Ministry of Finance, 2017). The formula for the income-based approach used by the Ministry of Finance (2017) is the following:

$$W = \sum_{t=1}^{\infty} \left(\frac{1+p}{1+r}\right)^{t} w_0 h_0 = w_0 h_0 \frac{1+p}{r}$$

W: net present value of future labour income per inhabitant
w_0: wage level per hour at the beginning of the year
p: labour productivity (estimated at zero in the main option)
r: the future economic rent (3%)
h_0: number of hours worked per inhabitant at the beginning of the year

6.3.3 Uncertainty scenarios for national wealth

As previously mentioned, estimations of the national wealth are highly uncertain, and therefore the Ministry of Finance (2017) has projected several scenarios with different assumptions, which can be seen in table 5.

Table 5: National wealth scenarios

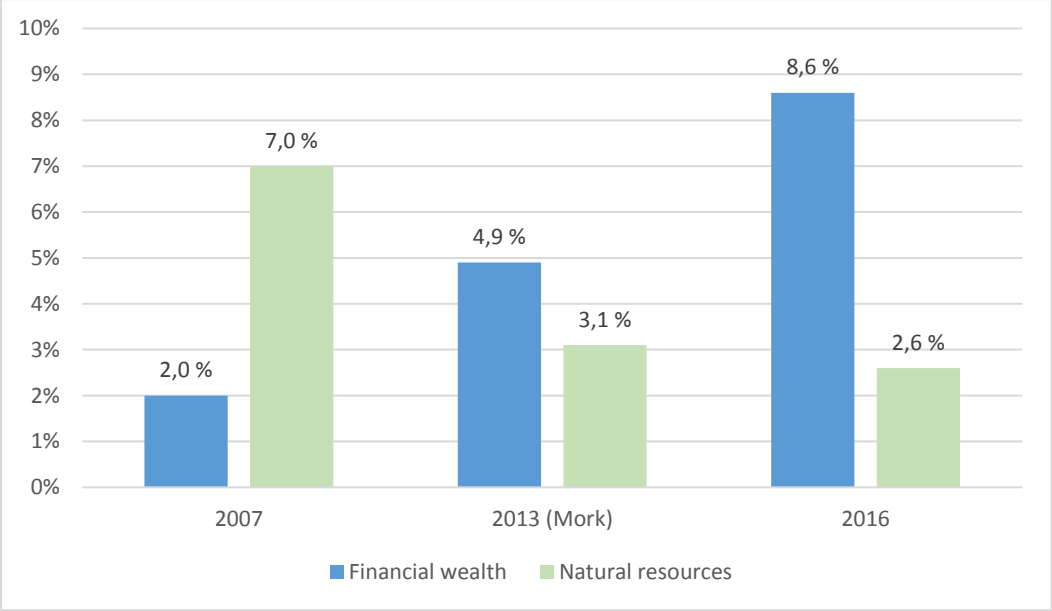
	Main	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5	Alt. 6	Alt. 7
Fixed assets	13,7 %	7,7 %	18,1 %	10,0 %	16,9 %	13,5 %	13,9 %	15,2 %
Fin. wealth	8,6 %	4,9 %	11,4 %	6,3 %	10,7 %	8,5 %	8,8 %	9,6 %
Human capital	75,0 %	85,9 %	67,2 %	81,9 %	69,4 %	74,0 %	76,1 %	72,3 %
Nat. resources	2,6 %	1,4 %	3,4 %	1,9 %	3,1 %	3,9 %	1,2 %	2,9 %
Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Source: Ministry of Finance (Perspektivmeldingen 2017)

6.4 Analyzing the national wealth

The values of financial wealth and natural resources have experienced a major shift since the time of equity share change in 2007, in respective weights relative to the overall national wealth (figure 6). In 2007, financial wealth accounted for two percent and natural resources for seven percent of the national wealth. In 2016, the weights were reversed, mostly due to high petroleum production, sharp increase in the value of GPFG and to some degree lower oil prices in recent years. According to Norges Bank and the Ministry of Finance, the increase in diversified financial wealth and the decrease in petroleum resources indicate that the fund's risk has diminished in isolation to the other components (Ministry of Finance, 2017).

Figure 6: Financial wealth and natural resources in 2007, 2013[4] and 2016

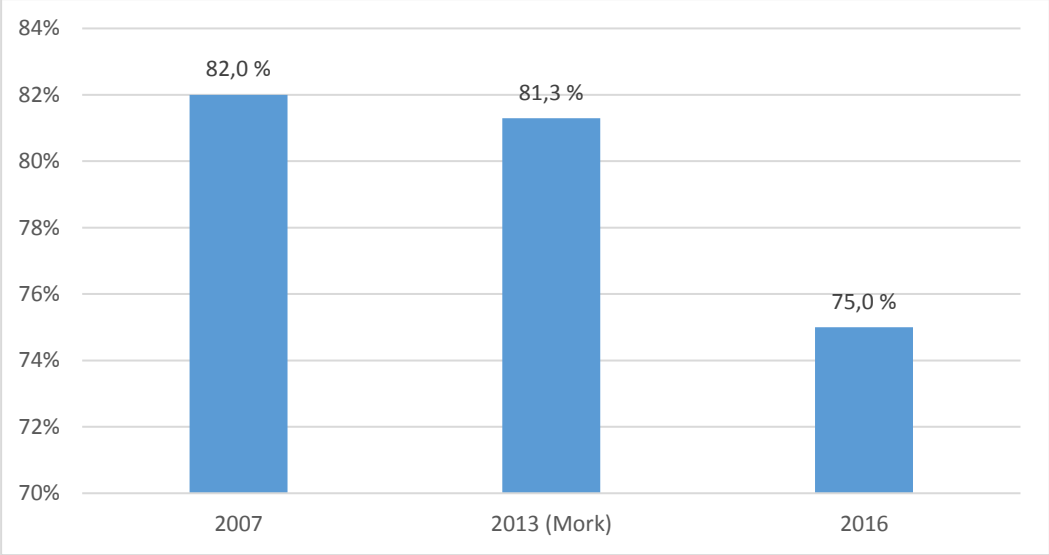


Source: Ministry of Finance (Perspektivmeldingen 2009 & 2017, Nasjonalbudsjettet 2015)

[4] National wealth in 2013 was presented by the Mork Commission in 2016.

Figure 7 shows that the value of human capital has decreased by over six percentage points from the last equity share assessment in 2017 (human capital from 2013 was used in equity assessment 2017). This is mainly due to relatively low economic growth during the past decade, which can be partially explained by the recent economic downturn, but also by structural factors (Ministry of Finance, 2017). When taken in isolation, the decrease in human capital imply that the fund's risk has grown.

Figure 7: Human capital in 2007, 2013[5] and 2016



Source: Ministry of Finance (Perspektivmeldingen 2009 & 2017, Nasjonalbudsjettet 2015)

6.4.1 Human capital related to other assets

For the Norwegian national wealth, human capital is the most important single component, accounting for approximately three quarters of the total wealth. Given its significant size, we find it useful to investigate some of the properties of human capital related to the other assets, to capture the total risk in the portfolio.

Norway is in a nearly unique position with its relatively large sovereign wealth fund compared to other countries. This may be one of the reasons that there are no directly relatable studies to optimal portfolio allocation for countries. Nevertheless, several studies have researched corresponding topics for households. Although,

[5] National wealth in 2013 was presented by the Mork Commission in 2016.

they are not directly comparable, they give a general understanding to the challenges Norway faces.

Risk can be divided into tradable and non-tradable risk. Example of tradable risk is equity, which offers a risky return, and can be easily traded. Future labor income and economic rent from natural resources are examples of non-tradable risk as they also provide uncertain returns but are more difficult to trade than equities. The quantities and qualities of non-tradable assets as well as what the resources are used for, need to be considered when managing the risk and composition of the tradable financial assets (Norwegian Ministry of Finance, 2017).

The asset allocation decision for households should consider the different elements on the balance sheet. An individual's value of future salaries, which is an example of households' asset, is relatively higher at the beginning of the career than closer to retirement. Future salaries are comparable to fixed income securities as income is earned on a regular basis. This indicates that individuals should hold more risky assets, like equities, in the beginning of their career and switch to holding more and more of fixed income securities when approaching the retirement age (Norwegian Ministry of Finance, 2017). However, Benzoni, Collin-Dufresne and Goldstein (2007) state, that the relation is not that clear if there is correlation between labor income and long-term equity returns. The definition of households' future salaries is applicable to human capital from the national wealth. Since human capital is the present value of the nation's future labor income streams, and equity returns and human capital have a very weak negative correlation of 0.08 (appendix 5), it can be argued that human capital has a similar risk profile to a fixed income portfolio.

An example of household's liability is future consumption of goods and services, which most households prefer to keep steady over time. Commitment to steady future consumption is comparable to holding a negative risk-free asset, which should be compensated by taking on less financial risk. On the contrary, if future consumption behavior is risky and positively correlated with risky financial assets, the ability to carry on risk is higher (NOU 2016:20, 2016). This theory is transferable to GPFG. The desired risk is dependent on the fund's future liabilities which are discussed earlier in this chapter.

In addition, the asset allocation decision should take into account the other assets, such as non-tradable natural resources. Having more risky non-tradable assets indicates that the allocation in the financial portfolio should be less risky, holding all other components constant. This suggests that holding constant asset allocation in the financial portfolio might not be optimal, because relative values of different wealth components, such as natural resources, might change in the future. Future petroleum revenues (natural resources) are uncertain due to the future oil price and the estimate of remaining sources. Therefore, these revenues are comparable with a diversified equity portfolio. Theory states that a negative correlation between future petroleum revenues and equity returns imply a higher equity allocation in financial wealth (NOU 2016:20, 2016). We find a negative correlation of 0.43 (appendix 5) implicitly indicating a higher equity share. In the future, when natural resources accounts for a smaller share of the total wealth, it would be optimal to gradually reduce the allocation towards equity in the financial portfolio.

Human capital plays an important role in Norway's national wealth, and it is therefore necessary to understand how it behaves relative to the other assets. We measure the correlation between a change in non-petroleum related GDP and a change in oil prices for the period 2003-2016 and find a correlation coefficient of 0.81 (appendix 5). Hence, when oil prices increase, the part of GDP related to non-petroleum industry rises as well. Economic growth, which is change in GDP, is directly related to human capital. Countries with higher GDP per capita tend to have a higher average number of years of schooling. This means that the high correlation between oil prices and non-petroleum related GDP is transferable to a strong relation between non-petroleum related human capital and natural resources. Statistics Norway estimated that approximately seven percent of total employment was working directly or indirectly in the petroleum sector in 2016 (Norwegian Petroleum Directorate & Ministry of Petroleum and Energy. 2018a). If we assume a moderately higher salary of five percent for workers in this sector, we find that petroleum related human capital accounts for 7-8 percent of the total human capital. Norway has a significantly higher exposure towards the risky petroleum sector compared to most other countries. As a consequence, some of the petroleum related human capital should be diversified away with assets from non-oil related

industries. This way, Norway could reduce their overall risk towards the petroleum industry.

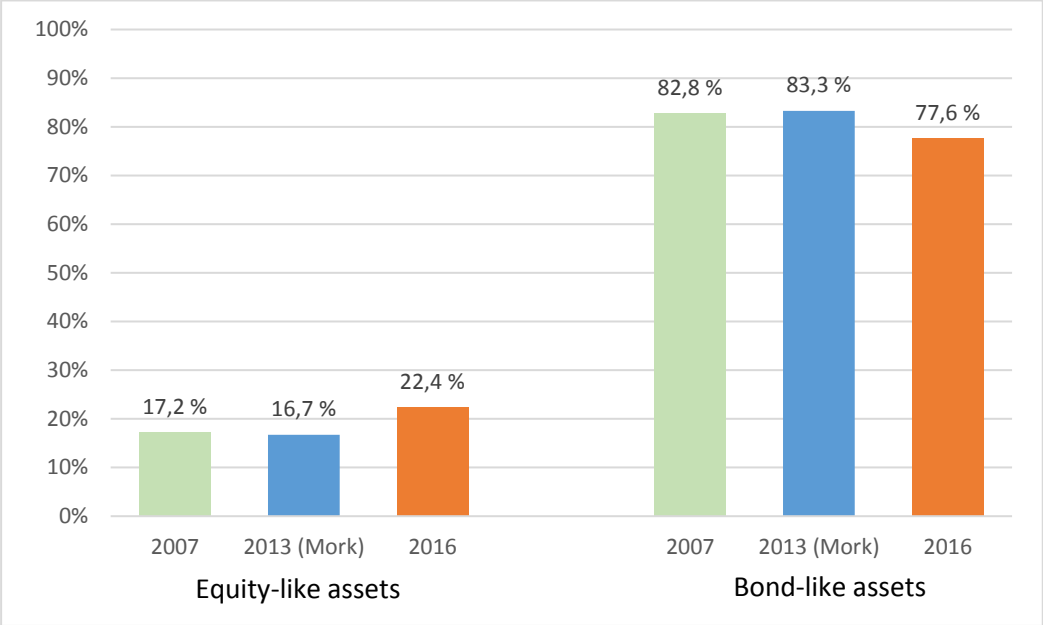
6.4.2 Risk tolerance in the national wealth

In 2017, Norges Bank recommended GPFG to sell their current portfolio of oil and gas stocks. The high correlation between these stocks and the remaining petroleum resources, made the country less diversified between financial assets abroad (GPFG) and domestic remaining natural resources (Norges Bank, 2017).

Human capital, which accounts for 75 percent of the total wealth, has bond-like properties. However, the level of risk within human capital varies a lot, from risky oil-related workers that we discussed above, to non-risky government employees. Future petroleum revenues (natural resources) are characterized as equity-like assets. However, the natural resources are transferred into less risky financial fortune abroad through the GPFG. The financial fortune today consists of 69 percent equity and equity-like assets and 31 percent fixed income. The fixed assets have primarily equity-like characteristics. Overall, the national wealth of Norway has similar characteristics to a corporate bond, which advocates for a higher equity allocation.

In figure 8, we classify national wealth from 2007, 2013 and 2016 into bond-like and equity-like assets. Bond-like assets have decreased by five percentage points, whereas equity-like assets have increased by the same amount since 2007. The decrease in bond-like assets is a result of a decline in human capital, while a raise in fixed assets and financial wealth have caused equity-like assets to increase. The riskiness of the national wealth has increased since 2007, as the value of equity-like assets have grown.

Figure 8: Classified national wealth in 2007, 2013[6] and 2016

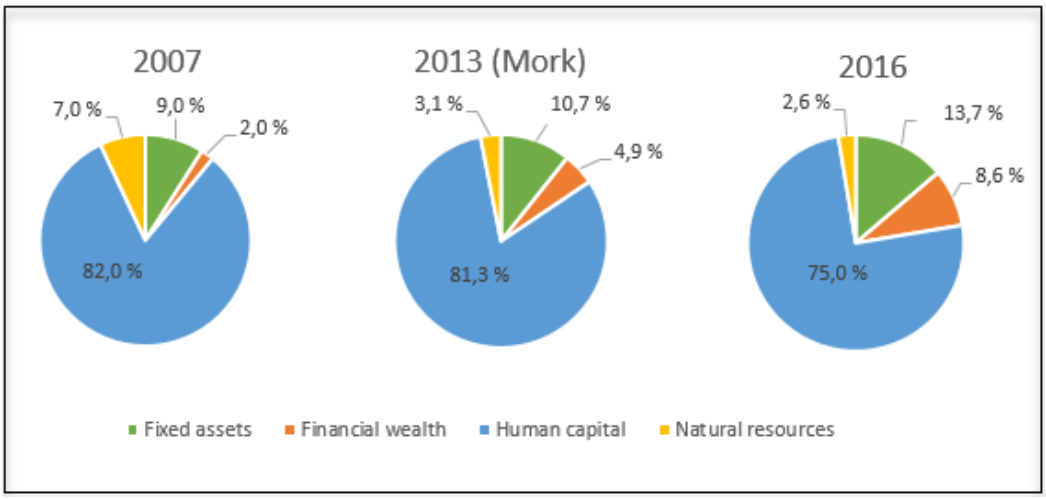


Sources: The Ministry of Finance and own calculations

Figure 9 shows that the composition of the national wealth has changed since the previous assessment of the equity share in 2017 (national wealth from 2013 was used in the equity assessment 2017). The largest change has been in human capital, a decrease of nearly seven percentage points. In addition, fixed assets has increased by 3 percentage points. These decreases advocate for lower risk tolerance in the fund, in isolation from the other components. Furthermore, financial wealth has experienced an important change. A rise of approximately 4 percentage points in a well-diversified financial portfolio, combined with a minor decline in risky petroleum resources, indicates an increase in the ability of the fund to absorb risk, when taken in isolation. As a result of these changes, the overall risk of the national wealth has increased, which favors a lower equity share in the GPFG.

[6] National wealth in 2013 was presented by the Mork Commission in 2016.

Figure 9: National wealth in 2007, 2013[7] and 2016



Source: Ministry of Finance (Perspektivmeldingen 2009 & 2017, Nasjonalbudsjettet 2015)

7. Capital Market Assumptions

7.1 Today's environment: Historically low interest rates

Interest rates have been historically low in recent years. This also applies if we look back at the past century, or even 5000 years back in time (Haldane, 2015). From 1900 to 2017 the annual real return on a global portfolio of government bonds was two percent, while the risk-free rate (T-bills) yielded 0.8 percent measured in US Dollar (Dimson et al., 2018). The current low interest rates can be explained by several macroeconomic factors. We will focus on some of the more enduring factors, such as slowing global growth expectations, change in investment preferences and shift in savings that could possibly affect the equilibrium interest rate for a relatively long period.

Slowing population growth and trade slowdown are two drivers of slowing global growth expectations. Slowing population growth due to a reduction in the fertility rate, results in a decline in the labor force. In addition, as the average worker gets older, learning of new skills becomes more difficult and labor productivity drops (World Bank Group, 2018). The trade slowdown is a partial cause to the significant decrease in private investments after the financial crisis. The number of business opportunities decreases with a deceleration in trade, weakening investment demand.

[7] National wealth in 2013 was presented by the Mork Commission in 2016.

In developed countries, the investment rate has still not recovered to pre-crisis levels, even after adjusting for price decrease on real assets (NOU 2016:20, 2016).

Demographics, inequality and increased financial integration of emerging markets are the major drivers for the shift in savings. With a rise in high-saving age groups, total savings increase, and interest rates will decrease if all else being equal. Furthermore, rising inequality might lead to increased savings, because the wealthy are able to save relatively more of their income. This trend leads to lower interest rates. Further, excess savings in emerging markets has contributed to a gradual decrease in interest rates in developed countries (Sajedi & Thwaites, 2016).

7.2 Expected future interest rates

The macroeconomic factors discussed above will affect the future real interest rate. However, the magnitude of the effect depends on the persistence of these factors. According to OECD (2012), savings are expected to decrease over the next decades as high-saving age groups are starting to retire. When a larger share of the population retires, average savings decline, which will have an upward effect on interest rates. Further, the setback in investment growth post the financial crisis is expected to recover, which will raise interest rates. However, it is unlikely that the interest rates will get back to the same levels as in the early 2000s (World Bank Group, 2018). According to PwC (2018), global economic growth will increase at an annual average rate of 2.6 percent until 2050. McKinsey (2015) projects a corresponding number of 2.1 percent until 2064. The difference in the long-term projections proves that these estimates are subject to a large amount of uncertainty. Nonetheless, most of the future growth will originate from emerging markets and developing economies.

OECD estimates the real long-term interest rates to be 2.2, 2.3, 2.8 and 3.3 percent in 2020, 2030, 2050 and 2060, respectively. For the next decade, interest rate is expected to remain stable, since governments are planning to reduce their debt-to-GDP ratios. This reduced demand for debt, puts downward pressure on interest rates. The gradual increase over the decades following year 2030 is largely explained by the reduction in global savings and come as a consequence of changing demographics (OECD, 2014).

Rachel and Smith (2015) forecast the global neutral real rate to be approximately one percent over the medium to long-term. Over the next decade they expect the real interest rate to be slightly below their medium to long-term estimate. Rachel and Smith argue that the downward pressure savings have had on real interest rates in the past, will not have a similar magnitude as the trend reverses. Furthermore, they expect lower relative prices on real goods. Similarly to savings, the degree of change will not be as significant as in the past. As a result, interest rates will not return to prior levels (Rachel & Smith, 2015).

In the developed world interest rates are expected to slightly increase in the years to come. However, the low interest rates combined with the low inflation environment in recent years, may indicate that interest rates will not return to historical levels. The CEO of Federal Reserve Bank of San Francisco, John C. Williams (2017) claims that the "new normal" nominal interest rate is likely to be lower than in the 1990s and early 2000s, when short-term interest rates were above 4 percent on a regular basis. The "new normal" short-term rate is expected to be around 2.5 percent, while the spread between short and long-term interest rates will fall from 1.5 to one percentage point. Taking inflation into consideration, the real long-term interest rate will settle around 1.5 percent in the US. Williams justifies the estimate based on similar arguments as the ones provided by OECD and Rachel and Smith, such as slower economic growth rate, an aging population and longevity (FRBSF, 2017).

Currently, the average real interest rate for 10-year treasury bills is negative in the OECD area (Norges Bank, 2018). In our view, the interest rate will increase slightly in the upcoming years. However, it will not return to historical levels, as the macroeconomic factors impacting the real interest rate are unlikely to return to the previous patterns. Due to the large uncertainty of long-term forecasts, the expected real interest rate for the next few years will weigh more in our analysis.

7.3 Estimate of fixed income return

We acknowledge that returns on government and corporate bonds differ, due to different risk level, but the difference is relatively small. Therefore, a good proxy

for the expected real return during the next decade is given by today's yield on 10-year government bonds that are adjusted for inflation (Cochrane & Piazzesi, 2005). There are signs from the macroeconomic factors indicating that the interest rate will increase somewhat over the next decades.

Table 6: Real annualized forward yield according to GPFG's regional allocation

Period	S(0,10)	F(10,20)	F(20,30)
Estimated fixed income return	0,13 %	0,54 %	0,70 %

Sources: US Department of the Treasury, Bloomberg and own calculations

The real interest rate is calculated using long-term government bonds from the four countries - US, Germany, UK and Japan – which have the largest exposures to the GPFG. Table 6 shows the yield on 10-year government bonds now, and expected forward interest rates. By combining government bonds with different long-term maturities, we can estimate the future long-term interest rates. Expected forward 10-year interest rate in 10 and 20 years' time is anticipated to increase from current levels, indicating that the yield curve is in contango. This result in an annualized real return of 0.13 percent for the next decade, 0.54 percent for the period 2028-2037 and 0.70 percent for the period 2038-2047, with a weighted average real return of 0.46 percentage in continuously compounded terms. However, we put more emphasis on the near future and therefore find 0.35 percent (table 7) as a reasonable estimate of the real return in our analysis.

Table 7: Long-term estimate of real fixed income return

	Mork Commission	Ministry of Finance	NBIM	Own assumptions
Fixed income	0-1 %	0,5-1 %	0,75 %	0,35 %

Sources: Ministry of Finance, NOU 2016:20 and NBIM

7.4 Return and risk in the equity market

Equity returns are more volatile than bond returns, hence investors need to be compensated to take on this additional risk. Investors are compensated through the risk premium yielding the investor a higher expected return than fixed income securities. However, there is no guarantee that actual equity returns will be higher than returns on fixed income in the future. From a historical standpoint, the equity

returns far outperform the returns from fixed income securities. However, during some time periods the return on stocks have underperformed compared to the return on bonds. To decide upon an expected return for equity investments in the future, we investigate the equity risk premium.

7.5 The equity risk premium

The equity risk premium (ERP) can be defined as the excess return required over the return on risk-free assets, for holding risky securities. Normally, the ERP has been significantly positive, averaging at 5.5 and 7.5 percent in developed and US markets, respectively. The high average ERP is hard to explain from a macroeconomic standpoint, giving foundation for the terminology known as the "equity premium puzzle". There exists no specific model to explain the high ERP, but it has been suggested that it can be time-varying (NBIM, 2016c).

Table 8: Realized ERP relative to T-bills and T-bonds in the period 1928-2017

	Geometric mean return	Volatility	Standard error
S&P 500 Total Return	9,7 %	19,5 %	2,1 %
3-month US T-bills	3,4 %	3,0 %	0,3 %
10-year US T-bonds	4,9 %	7,7 %	0,8 %
ERP Stocks vs bills	6,1 %	19,8 %	2,1 %
ERP Stocks vs bonds	3,9 %	21,2 %	2,3 %

Sources: NBIM discussion note (2016/1), Damodaran data available at: http://www.stern.nyu.edu/~adamodar/pc/datasets/histretSP.xls, own calculations

The results provided in table 8 are based on Damodaran data and show that stocks have received a significant excess return over Treasury bills and Treasury bonds in annual continuously compounded terms (geometric) in the US market. For our analysis, the geometric mean is more appropriate than arithmetic mean, given the focus on long-term future return. During the period 1928-2017, equities outperformed bills and bonds with 6.1 percent and 3.9 percent, respectively. Corresponding numbers from the Mork Commission are 4.2 percent and 3.2 percent for a global equity portfolio measured with 116 years of data (NOU 2016:20, 2016).

7.6 Estimate of equity return

As previously discussed, interest rates in the recent years have been historically low. With a constant equity premium, one would expect a significantly lower return in the future. Research shows that there has been a higher frequency of positive economic shocks, like high productivity growth, especially in the post World War II period. Consequently, investors have received a higher compensation for holding equities than initially expected. As less positive shocks are expected in the future, the equity risk premium should be scaled down compared to the historical average (Samfunnsøkonomene, 2005). Hence, basing the ERP solely on historical data may result in an unrealistically high estimate. Furthermore, making projections about the future involves a large amount of uncertainty. Therefore, we make a cautious estimate for the expected long-term equity risk premium over the return of 10-year treasury bonds (table 9). We base our analysis on a real ERP of 3 percent.

Table 9: Long-term estimate of the equity risk premium

	Mork Commission	Ministry of Finance	NBIM	Own assumptions
Equity premium	2-4 %	3 %	3 %	3 %

Sources: NOU 2016:20, Norges Bank and the Ministry of Finance

7.7 Volatility and correlation

For the volatility, we use the current estimates provided by the Ministry of Finance, the Mork Commission and NBIM. In table 10, we see strong consensus about the volatility estimates. This gives us a volatility estimate on GPFG's equity and bond portfolios at 16 and 6 percent, respectively. These numbers are based on historical annual volatility from 1900-2009 and are higher than the realized volatility since 1998 (Ministry of Finance, 2010). However, this gives room for higher return fluctuations in the future.

Table 10: Long-term volatility estimates

	Mork Commission	Ministry of Finance	NBIM	Own assumptions
Fixed income	6 %	6 %	6 %	6 %
Equity	16 %	16 %	16 %	16 %

Sources: NOU 2016:20, Norges Bank and the Ministry of Finance

An important assumption when deciding upon an equity share, is the level of correlation between equity and fixed income. Historically, equity and fixed income have had positive correlation close to the current estimates provided by the Mork Commission of 0.4. However, in recent years the correlation has been negative. A negative correlation occurs when stock prices increase while bond prices decrease, and vice versa. Consequently, fluctuations in overall portfolio returns decrease. The correlation is not constant over time, due to for instance changes in monetary policy regimes.

Table 11: Long-term correlation estimates

	Mork Commission	Ministry of Finance	NBIM	Own assumptions
Correlation	0,4	0,1	0	0,4

Sources: NOU 2016: 20 green paper, Norges Bank and the Ministry of Finance

NBIM and the Mork Commission have taken significantly different assumptions for correlations in their forecasts. The Mork Commission assumed a positive correlation of 0.4, while NBIM assumed either negative or zero correlation. The short-term correlation between bonds and equities has been negative since the turn of the millennium. However, in the simulations we care about long-term returns, and thus we need to consider the long-term correlation. The long-term correlation between these assets tend to be positive, because both assets relate to economic activity. Therefore, we find it reasonable to use a correlation of 0.4 between these assets.

8. Expected real return, risk and development in the GPFG with different allocations towards equity

8.1 Mean-variance optimization

Allocation to equities in the GPFG, is the single decision with the greatest impact on expected portfolio return and risk. A high allocation towards equities results in higher expected long-term return on capital, but simultaneously higher risk. The allocation decision is a result of the investor's preferences, and thus represent a trade-off between risk and expected return. The portfolio return matrix in table 12

is based on our capital market assumptions and shows return and volatility for different portfolio weights.

Table 12: Geometric real return matrix

Weights		Expected real return	Standard deviation	Sharpe ratio
Equity	Fixed income			
45 %	55 %	1,70 %	9,04 %	18,80 %
55 %	45 %	2,00 %	10,19 %	19,64 %
65 %	35 %	2,30 %	11,40 %	20,17 %
75 %	25 %	2,60 %	12,67 %	20,51 %
85 %	15 %	2,90 %	13,98 %	20,74 %
95 %	5 %	3,20 %	15,32 %	20,88 %

Source: own calculations

Given the correlation of 0.4, and the low expected return on fixed income, the Sharpe ratio increases with the equity share. For comparison, if correlation is zero, the Sharpe ratio would be maximized with an equity share of 58 percent. This illustrates the importance of the correlation assumption for the optimal allocation.

8.2 Simulation results

8.2.1 Introduction

For the GPFG allocation case, there is large uncertainty about future return and risk, but also about future inflows and outflows. Inflows depend on government income from petroleum extraction, while outflows depend on factors such as economic conditions and fiscal policy. To capture some of this uncertainty, we use Monte Carlo simulations to model the range of outcomes for the real value of the fund in 40 years, with different allocations towards equity and a no inflow assumption. These simulations do not provide any clear answers about allocation, as they build on assumptions about the future. However, the purpose is to highlight the possible consequences on the fund's sustainability with the current Tobin rule, a case that will increase in relevance when inflows stop sometime in the future. Also, it is interesting to see how the simulation results change when we adjust the input variables.

8.2.2 Simulation assumptions

Table 13: Capital market assumptions

	Return	Volatility	Correlation
Fixed income	0,35 %	6 %	-
Equity	3,35 %	16 %	-
Fixed income/Equity	-	-	0,4

The model in the simulations assumes log-normally distributed returns based on our own estimates, with mean and volatility according to the allocation weights. The yearly return and volatility for fixed income are based on our earlier estimates given in table 13. The standard normal model draws random returns on an annual basis, and the summary statistics provided in this chapter are a result of 5000 simulations paths for the next 40 years. It is also worth mentioning that the summary statistics are in real terms. In the simulations, payouts equal the weighted expected returns, and are deducted from the fund value on a mid-year basis based on the end-of-year value. Our simplified model does not include fluctuations in payouts, hence it assumes a neutral fiscal policy over time. All model calculations require simplifications of the reality and we find it interesting to assume no government inflows from petroleum activities. As inflows from petroleum activities are gradually decreasing, this scene becomes very important in a few decades when the fund must remain sustainable on its own. Further, the simulation model does not consider exchange rate fluctuations. For rebalancing, we assume no deviations from the chosen equity share, as the model rebalances the fund continually. Equity shares of 55 percent, 65 percent, 75 percent and 85 percent are tested in the model. We provide summary statistics for equity shares of 65 percent and 85 percent in this chapter, and summary statistics for all equity shares are given in appendix 6A-6C.

8.2.3 Scenario 1

In scenario 1, we apply the assumptions chosen in previous chapters. The real return depends on the allocation towards equity and it is 2.3 percent with an equity share of 65 percent, and 2.9 percent with an equity share of 85 percent. In practice the outflows vary with the equity allocation, from 195 billion to 246 billion with 65 and 85 percent equity, respectively, in 2018. The correlation between fixed income and equity is expected to be 0.4 in the long-run.

8.2.4 Scenario 2

The difference from scenario 1 is a correlation of 0 between fixed income and equity. As previously discussed, the correlation tends to be positive in the long run. However, one can argue that a lower correlation than the historical may be realistic also in the long run. The correlation is the most critical assumption in the simulations, and it is thus intriguing to study how a decrease in correlation would affect the allocation decision.

8.2.5 Scenario 3

In this scenario, the equity premium is lowered from three to two percent. Hence, the expected real equity return is 2.35 percent in this scenario. Payouts equal the real return with different equity weights and are therefore 1.7 percent with a 65 percent equity allocation and 2.1 percent with 85 percent equity allocation. Further, the correlation is the same as in scenario 1.

8.2.6 Results

Table 14 shows the real value of the fund in 40 years, with our assumptions on correlation and return for different scenarios and equity shares. At the end of 2017, the fund's market value was NOK 8488 billion, hence different allocations and scenarios have almost no significance on the mean terminal value with our assumptions. The main reason it that the payouts from the fund equal the expected real return, hence the aggregate payouts for the scenarios with 85 percent equity share are significantly higher than the corresponding number with 65 percent equity. A higher equity share yields a higher expected return, and thus the annual withdrawals will be higher given our assumptions.

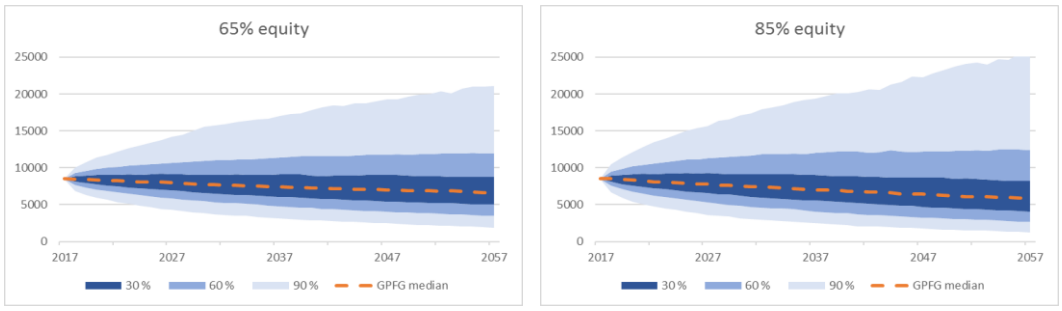
Table 14: Summary statistics from Monte Carlo simulations

Equities/FI	65 / 35			85 / 15		
	Main	S1	S2	Main	S1	S2
Mean	8 536	8 485	8 307	8 423	8 450	8 619
Median	6 668	6 826	6 399	5 743	5 903	5 807
Volatility	11,4 %	10,6 %	11,4 %	14,0 %	13,6 %	14,0 %

On the other hand, the simulated median value is lower, the higher the allocation towards equities. If we look at scenario 1, half of the terminal values in the simulations are below NOK 6 668 billion for 65 percent equity allocation compared to NOK 5 743 billion for 85 percent allocation. The other scenarios show similar results. This combined with the mean values proves that with a higher equity allocation, the dispersion in distribution is significantly higher. From these results, we cannot expect GPFG to be able to preserve its wealth for future generations, when inflows stop. In the simulations, payouts happen in the middle of each year, which is a good proxy since payouts happen on a regular basis throughout the year.

Scenario 2 stands out in the sense that the low correlation has a great significance on the expected volatility. The low correlation results in a lower standard deviation for the portfolio. The increased diversification benefits lead to a higher bond share in the fund. Wrongly assuming a too low correlation can result in a portfolio with poor return performance and higher risk than necessary.

Figure 10: Simulated real value distribution charts for scenario 1



Our simulations generate a high number of possible outcomes. The actual value of the fund in four decades may deviate significantly from the results in these simulations, since the fund still has inflows from petroleum activities. With our assumptions, it is a 90 percent chance that GPFG's real value will develop within the fan plots above with 65 and 85 percent allocation to equity (figure 10). The orange line shows the median value, indicating that many real values are in the lower layers, while we have some extreme positive ending values. The median value is slightly declining over time and therefore the real value of the GPFG will most likely decrease over the next 40 years in a no-inflow scenario. Another important aspect about the simulations is that when the fund payouts equal the expected return, the fund is not drained completely in any of the simulation paths.

Table 15: Downside risk in NOK billion

Equities/Fixed income	65 / 35			85 / 15		
	S1	S2	S3	S1	S2	S3
Minimum value	354	476	498	141	250	257
Minimum value (end)	406	550	619	158	280	273
5th percentile	1 959	2 238	1 870	1 276	1 359	1 287

The simulation results make it reasonable to believe that the real value development of the fund in 40 years ends up below the current value. Consequently, we find it intriguing to look at the downside potential of the fund. From table 15, we see that the downside potential increases with the equity share. This increase in downside risk, raises the probability of large losses in the financial wealth. Table 15 shows some of the simulation outcomes for the real value development in the lower part of the distribution for each of the scenarios as well as for the allocations. With 5 percent probability, the real value of GPFG is going to be below NOK 1 959 billion in scenario 1, NOK 2 238 billion in scenario 2, and NOK 1 870 billion in scenario 3 with an equity allocation of 65 percent. What is interesting is that scenario 2 has a higher 5th percentile, which can be explained by lower volatility due to the low correlation input. We experience similar results for the simulations with 85 percent equity.

In the simulations, we have tracked both the minimum values across the whole simulation as well as the ending minimum value from all simulations. We see that the distribution of minimum values across the simulation history is lower than the minimum values at the end. Furthermore, the distribution of minimum values across the whole simulation is significantly lower for scenario 1 compared to the other scenarios. Scenarios 2 and 3 have moderately similar distributions of minimum values across the whole simulation for both equity allocations. Also, the distribution of minimum values at the end of the simulation is significantly lower in scenario 1 compared to the other scenarios. It is important to keep track of the minimum values because if the fund reaches these low values, it would significantly impact fund policies.

Table 16: Upside potential in NOK billion

Equities/Fixed income	65 / 35			85 / 15		
	S1	S2	S3	S1	S2	S3
Maximum value	107 544	77 187	103 080	123 032	132 684	118 257
Maximum value (end)	106 327	70 830	100 628	105 872	114 259	105 603
95th percentile	21 826	20 073	21 274	24 137	23 900	24 830

Like there is a possibility that the real value of the fund falls below the current value, there is also a possibility that the real value ends up above the current value in each scenario and in all allocations. The higher the equity share, the higher is the upside potential. The different simulation outcomes for the real value development in the upper part of the distribution can be seen in table 16. If we consider scenario 2, there is a 5 percent probability that the fund's real value will be above NOK 20 073 billion for the 65 percent equity portfolio and NOK 23 900 billion for the 85 percent equity portfolio. The other scenarios have even higher 95th percentile. The distribution of maximum values across in the whole simulation is higher than the distribution of maximum values at the end of the simulation for each scenario and for each allocation. In scenario 2 with 65 percent equity, the maximum values in the end, as well as across the whole simulation, are significantly lower than for the other scenarios. The reduced volatility in this case results in less dispersion, and hence we do not experience the extreme maximum values that occur in the other scenarios. On the other hand, with 85 percent allocation, the distribution of maximum values across the whole simulation and in the end of the simulation is considerably higher in scenario 2 than in the other scenarios. If we consider the distribution of maximum values in all scenarios, scenario 2 has a higher sensitivity to equity share changes. For scenario 1 and scenario 3, we see a strong similarity in the distribution of maximum values. However, scenario 1 has consistently higher maximum values, which can be explained by the higher equity premium.

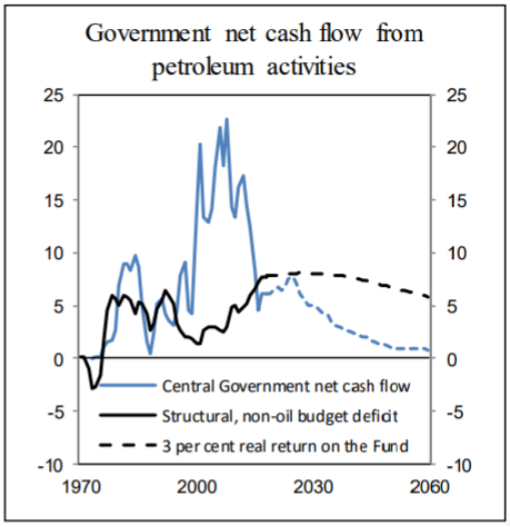
From the simulations, we experience that the mean values are expected to remain at the current levels. These values are consistent independently of the equity share. On the other hand, the median value decreases significantly from the current real value, and this tendency becomes stronger when the equity share increases. What strikes out from the simulations, is that approximately 62.5 percent of the simulations end up below the mean value. It is therefore unrealistic that the fund

would maintain the real value when inflows stop. Inflows are now lower than the outflows of the fund, and while expected to last for many more years, they will have increasingly marginal impact on sustainability of the fund relative to payouts. When inflows stop, the fund must be sustainable on its own, making the fiscal rule critical for the fund to succeed with the objective of benefiting future generations. When this occurs, payouts need to be lower than the expected real return. Furthermore, with a higher equity share, payouts need to be lower in relative terms compared to the expected real return because of the higher downside risk.

9. GPFG's role in fiscal policy

The fund was established to protect the Norwegian economy and the state budget from oil-price fluctuations. In addition, its purpose is to distribute the wealth over time to benefit both current and future generations. To ensure that the government follows these guidelines, the fiscal rule was introduced in 2001. The rule states that only the expected real return of the fund should be spent to fuel the economy. Currently, the fiscal rule is three percent per year, down from the original estimate of four percent, which implies that the preservation of wealth is important.

Figure 11: Petroleum income and expenditure in percent of trend-GDP for mainland Norway



Source: The Ministry of Finance (The National Budget 2018)

The estimates from the Ministry of Finance reveal that the petroleum production has peaked, hence inflows from this sector will gradually decline over the next

decades. When inflows decrease, it is critical that the government adheres to the fiscal rule. In figure 11, we see that the structural non-oil budget deficit is expected to far outgrow the government net cash flow from petroleum activities in the upcoming decades. The gap must be financed through GPFG transfers or by some other means, such as increasing tax rates (Ministry of Finance, 2018).

The state budget has become more dependent on transfers from the fund. As the fund has grown larger, steady access to capital has increased in significance. Approximately 18.4 percent of the state budget in 2018 is financed through transfers from the GPFG. According to the Ministry of Finance (2018), the expected withdrawals in 2018 account for 2.9 percent of the 2017 fund value. This corresponds to withdrawals lower than the current fiscal rule.

In our analysis, the expected real return is below three percent for all equity allocations. Consequently, we believe that the fiscal rule should be modified and set according to the expected real return, after the equity share has been decided. Hence, the fiscal rule should not be set independently of the expected real return in the fund. The Monte Carlo simulation demonstrates that if spending equals the expected real return, the fund will have a slight fall in the median value over the simulation period. Optimally, the fiscal rule should be modified and set below the expected real return, increasing the probability that the fund can provide fiscal policy with steady access to capital in the long-term.

10. Limitations

We do not consider the option to hedge the payouts at the beginning of each year. Hedging payouts could have an impact in the fund value and overall risk. This would be a natural next step in further analyzing the optimal equity allocation. To hedge the payouts, correlations between them should be investigated.

If the fund were to hedge 100 percent of the payouts, it would amount to three percent of the fund value with the current Tobin rule. This would most likely reduce the total risk in the GPFG. However, as hedging is costly, it is uncertain, whether the costs can justify the possible benefits from hedging.

In the national wealth of Norway, financial assets account for 8.6 percent in 2016. Hedging three percent of 8.6 percent means that 0.3 percent of the national wealth will be hedged. It should be further analyzed whether hedging will have a significant effect on Norway's overall risk.

11. Conclusion

GPFG's size and long-term investment horizon have a great influence on the equity allocation decision. Another aspect influencing the decision, is the trade-off between high long-term expected return and low short-term risk. The expected future real return has been reduced in recent years compared to prior estimates. However, this change in expectations does not justify a higher level of risk. We expect no change in the correlation between equities and fixed income compared to prior assessments of the equity share. These are arguments in favor of keeping the existing equity share.

Compared to the most relevant peers, GPFG's current equity and equity-like allocation is lower than the consensus between the peers, which ranges between 72 and 83 percent. This indicates that the GPFG has less risk than peers in their financial portfolio. Since GPFG and the peers have fairly similar fund characteristics, except for the size, it may be argued that GPFG can increase their equity allocation.

From a theoretical perspective, the optimal portfolio is the global market portfolio. The equity and equity-like assets account for 54 percent of the global invested market portfolio in 2017. Holding the market portfolio is optimal for the average investor. Fund characteristics, like the infinite investment horizon and inflows from petroleum activities, gives GPFG a competitive advantage compared to the average investor that separately advocates for a higher equity share than in the market portfolio.

Financial wealth should be allocated in a way that achieves the best trade-off between expected risk and return for the total national wealth. The transformation from risky petroleum resources to well-diversified financial wealth, all else being equal, leads to more diversified national wealth and is in favor of a higher equity

share in the GPFG. However, the recent decline in human capital, which is the dominant revenue component of national wealth, indicates for a lower risk tolerance in the fund, when taken in isolation. To ameliorate this, some of the human capital should be diversified away with assets from non-oil related industries. This would reduce Norway's exposure towards the petroleum industry. For Norway's total national wealth, the share of equity-like assets has increased since the equity share assessments in 2007 and 2017, indicating that the overall risk in the Norwegian national wealth has increased. The increased risk in national wealth advocates for a lower equity share in the GPFG.

From the Monte Carlo simulations, we document that payouts need to be lower than the net real return, for the fund to maintain its real value in the future. Hence, the allocation decision cannot be taken independently of the payouts. As long as the government can successfully implement a modified Tobin rule that secures the preservation of wealth, a high equity share can be justified.

Given the large change in equity and equity-like assets in the national wealth, this argument weights the most in our recommendation. The total risk has increased compared to the prior assessments, which favors a lower equity allocation in the fund. However, by implementing a new and improved Tobin rule, and diversifying away some of the risk in human capital, the overall risk can be reduced. Under the assumption that the government will execute our propositions to reduce the risk, our overall recommendation is that the equity share is kept at the current level of 70 percent.

Over time, we expect inflows to have an increasingly marginal impact on sustainability, and we find it likely that the equity share needs to be reduced in the future. We advise that the fund's equity share is revised regularly.

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Appendix

Appendix 1: Estimation of Global Market Portfolio 1996-2017 in USD trillion

Index name or source	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	Datasource
Equities	**13 554**	**15 492**	**18 881**	**25 130**	**23 059**	**19 485**	**15 439**	**21 363**	**24 886**	**28 127**	**33 638**	**36 072**	**20 515**	**28 029**	**32 292**	**29 062**	**32 921**	**40 302**	**41 373**	**39 982**	**42 248**	**51 548**	
MSCI AC World	11 287	13 241	16 408	21 862	20 055	16 639	13 247	18 244	21 308	24 226	29 217	32 216	18 484	24 975	28 418	25 820	29 477	35 740	36 893	35 723	37 648	45 876	Thomson Reuters
MSCI World Small Cap Index	2 514	2 459	2 674	3 513	3 223	3 026	2 352	3 411	4 061	4 522	5 125	4 411	2 339	3 506	4 486	3 910	4 299	5 522	5 717	5 541	5 926	7 167	Thomson Reuters
MSCI World REITs Index	159	135	131	158	142	117	104	189	313	403	456	359	199	282	370	420	558	590	761	803	842	960	Thomson Reuters/MSCI
MSCI World Small Cap REITs Index	86	73	71	86	77	64	56	102	170	218	248	195	109	171	242	247	297	370	477	479	484	535	Thomson Reuters
Private Equity	**188**	**249**	**352**	**461**	**716**	**751**	**767**	**866**	**958**	**1 234**	**1 694**	**2 264**	**2 270**	**2 470**	**2 737**	**3 031**	**3 270**	**3 620**	**3 972**	**4 165**	**4 580**	**4 910**	
Thomson Financial	188	249	352	461																			Leitner, Mansour and Naylor (2007)
Prequin					716	751	767	866	958	1 234	1 694	2 264	2 270	2 470	2 737	3 031	3 270	3 620	3 972	4 165	4 580	4 910	Prequin*
Real Estate	**1 175**	**1 368**	**1 897**	**2 017**	**1 828**	**1 832**	**2 161**	**2 132**	**2 171**	**3 326**	**4 000**	**5 443**	**4 619**	**2 059**	**3 733**	**5 035**	**5 141**	**6 358**	**6 991**	**8 019**	**7 517**	**8 446**	
RREEF Real Estate Research	1 175	1 368	1 897	2 017	1 828	1 832	2 161	2 132	2 171	3 326	4 000	5 443	4 619	2 059	3 733	5 035	5 141	6 358	6 991	8 019	7 517	8 446	Hobbs and Chin (2007)
High yield bonds	**203**	**226**	**252**	**281**	**312**	**348**	**444**	**651**	**718**	**696**	**779**	**752**	**477**	**932**	**1 168**	**1 172**	**1 523**	**1 827**	**1 897**	**1 715**	**1 845**	**1 938**	
Barclays Capital Global Corporate High Yield Index	203	226	252	281	312	348	444	651	718	696	779	752	477	932	1 168	1 172	1 523	1 827	1 897	1 715	1 845	1 938	Thomson Reuters
Emerging debt	**348**	**391**	**388**	**444**	**482**	**511**	**601**	**735**	**876**	**1 023**	**1 258**	**1 454**	**1 304**	**1 670**	**2 137**	**2 297**	**2 691**	**2 717**	**2 866**	**2 637**	**3 066**	**3 606**	
J.P. Morgan Government Bond Index - Emerging Markets Global Composite	37	44	52	61	72	85	129	188	272	331	468	553	459	611	802	840	965	930	941	793	965	1 203	Thomson Reuters
J.P. Morgan Emerging Markets Bond Index Global Components	159	180	154	182	189	183	203	250	271	292	299	295	249	342	407	457	577	586	651	672	776	913	Thomson Reuters
J.P. Morgan Corporate Emerging Markets Bond Index Broad	149	162	178	194	212	232	254	278	303	332	363	397	434	474	519	567	620	716	792	788	855	969	Doeswijk et al.
Barclays Capital Emerging Markets Government Inflation-Linked Index	3	4	6	7	9	11	15	18	30	68	129	209	162	243	410	433	530	485	483	383	471	521	Thomson Reuters
Investment grade credits	**2 933**	**3 233**	**3 561**	**3 921**	**4 207**	**4 424**	**6 583**	**8 902**	**10 578**	**8 897**	**9 823**	**11 261**	**11 689**	**14 310**	**14 814**	**15 374**	**16 761**	**17 030**	**17 516**	**17 581**	**18 530**	**20 896**	
Barclays Capital Multiverse Index	9 739	10 559	11 448	12 411	13 347	14 264	17 233	20 527	23 096	22 282	24 353	26 970	29 302	35 833	39 512	41 574	45 023	44 813	46 225	45 684	47 836	53 150	Thomson Reuters
Barclays Capital Multiverse Government Index	6 603	7 100	7 634	8 209	8 827	9 491	10 206	10 974	11 800	12 689	13 751	14 957	17 135	20 591	23 530	25 028	26 739	25 956	26 812	26 387	27 461	30 316	Thomson Reuters
Barclays Captial Global Corporate High Yield Index	203	226	252	281	312	348	444	651	718	696	779	752	477	932	1 168	1 172	1 523	1 827	1 897	1 715	1 845	1 938	Thomson Reuters
Government bonds	**6 603**	**7 100**	**7 634**	**8 209**	**8 827**	**9 491**	**10 206**	**10 974**	**11 800**	**12 689**	**13 751**	**14 957**	**17 135**	**20 591**	**23 530**	**25 028**	**26 739**	**25 956**	**26 812**	**26 387**	**27 461**	**30 316**	
Barclays Capital Multiverse Government Index	6 603	7 100	7 634	8 209	8 827	9 491	10 206	10 974	11 800	12 689	13 751	14 957	17 135	20 591	23 530	25 028	26 739	25 956	26 812	26 387	27 461	30 316	Thomson Reuters
Inflation-linked bonds	**117**	**140**	**201**	**349**	**263**	**269**	**475**	**458**	**682**	**793**	**995**	**1 229**	**1 222**	**1 412**	**1 527**	**1 812**	**2 062**	**2 131**	**2 388**	**2 364**	**2 547**	**2 866**	
Barclays Capital Global Aggregate Inflation-Linked Index	117	140	201	349	263	269	475	458	682	793	995	1 229	1 222	1 412	1 527	1 812	2 062	2 131	2 388	2 364	2 547	2 866	Thomson Reuters
Global invested Multi-asset market portfolio	25 122	28 199	33 166	40 811	39 695	37 111	36 676	46 081	52 669	56 786	65 938	73 432	59 233	71 473	81 938	82 812	91 109	99 941	103 815	102 851	107 795	124 527	
Commodities	**24**	**33**	**36**	**41**	**38**	**41**	**51**	**87**	**132**	**131**	**170**	**207**	**206**	**214**	**268**	**314**	**330**	**331**	**318**	**326**	**340**	**347**	
CTA-industry (AUM)	24	33	36	41	38	41	51	87	132	131	170	207	206	214	268	314	330	331	318	326	340	347	BarclayHedge
Hedge Funds	**-**	**118**	**143**	**189**	**237**	**322**	**505**	**826**	**1 229**	**1 361**	**1 713**	**2 137**	**1 458**	**1 554**	**1 694**	**1 710**	**1 799**	**2 157**	**2 508**	**2 797**	**3 020**	**3 538**	
Hedge Funds (AUM)	-	118	143	189	237	322	505	826	1 229	1 361	1 713	2 137	1 458	1 554	1 694	1 710	1 799	2 157	2 508	2 797	3 020	3 538	Barclay Hedge

*Prequin number in 2017 is from June instead of december.

Appendix 2: Regional weights in the listed equity market and in the GPFG

	World equity market			GPFG		
	1998	2007	2017	1998	2007	2017
Africa	0,7 %	1,6 %	1,6 %	0,0 %	0,7 %	0,8 %
Asia	12,7 %	27,8 %	33,0 %	15,1 %	12,9 %	20,5 %
Europe	28,4 %	26,8 %	18,4 %	51,8 %	50,1 %	36,4 %
Latin America	0,6 %	3,6 %	2,3 %	0,0 %	1,7 %	1,4 %
Middle East	0,2 %	0,8 %	0,7 %	0,0 %	0,1 %	0,4 %
North America	56,0 %	37,2 %	42,0 %	31,4 %	32,4 %	38,2 %
Oceania	1,4 %	2,3 %	2,0 %	1,7 %	2,1 %	2,3 %
Total	100,0 %	100,0 %	100,0 %	100,0 %	100,0 %	100,0 %

Source: NBIM, World Federation of Exchanges database, Borsa Italiana, London Stock Exchange

Appendix 3: Regional weights in the global fixed income market

	2007	2016
Europe	35 %	27 %
Japan	14 %	13 %
United States	42 %	43 %
Other developed markets	5 %	5 %
Emerging markets	4 %	12 %

Source: Bank of International Settlements (BIS)

Appendix 4: Regional fixed income weights for GPFG

	2007	2016
Europe	73 %	36 %
Japan	5 %	7 %
United States	19 %	36 %
Other developed markets	1 %	8 %
Emerging markets	2 %	12 %

Source: NBIM

Appendix 5: Correlation in the national wealth

	1.	2.	3.	4.	5.
1. Human capital	1,00	-0,08	-	-	-
2. S&P 500 annual returns	-0,08	-	-0,43	-	-
3. The government's net cash flow from petroleum activities	-	-0,43	-	-	-
4. National income from non-petroleum industry as of GDP	-	-	-	-	0,81
5. Oil prices	-	-	-	0,81	1,00

Source: The Ministry of Finance, Bloomberg, SSB, Norges Bank

Appendix 6A: Simulation results in scenario 1

Equities/Bonds	55/45	65/35	75/25	85/15
Min. value	561	354	271	141
Min value (end)	621	406	330	158
Max. Value	76 631	107 544	152 617	123 032
Max value (end)	59 445	106 327	129 236	105 872
Mean	8 447	8 536	8 572	8 423
Median	6 931	6 668	6 093	5 743
1% percentile	1 594	1 137	839	640
5% percentile	2 372	1 959	1 581	1 276
10% percentile	2 994	2 588	2 130	1 802
25% percentile	4 535	3 988	3 563	3 147
50 %	6 931	6 668	6 093	5 743
90 %	15 589	16 830	17 665	17 680
95 %	19 427	21 826	22 953	24 137
Real return (expected)	2,0 %	2,3 %	2,6 %	2,9 %
Volatility (expected)	10,2 %	11,4 %	12,7 %	14,0 %
Sharpe ratio	20,18 %	20,79 %	21,14 %	21,46 %

Appendix 6B: Simulation results in scenario 2 (reduced correlation)

Equities/Bonds	55/45	65/35	75/25	85/15
Min. value	802	476	313	250
Min value (end)	887	550	348	280
Max. Value	52 178	77 187	106 820	132 684
Max value (end)	49 982	70 830	88 310	114 259
Mean	8 424	8 485	8 376	8 450
Median	7 218	6 826	6 425	5 903
1% percentile	1 792	1 405	909	732
5% percentile	2 638	2 238	1 697	1 359
10% percentile	3 309	2 936	2 253	1 949
25% percentile	4 840	4 311	3 775	3 355
50 %	7 218	6 826	6 425	5 903
90 %	14 806	15 990	16 408	17 625
95 %	18 585	20 073	21 510	23 900
Real return (expected)	2,0 %	2,3 %	2,6 %	2,9 %
Volatility (expected)	9,2 %	10,6 %	12,1 %	13,6 %
Sharpe ratio	22,42 %	22,37 %	22,11 %	21,99 %

Appendix 6C: Simulation results in scenario 3 (reduced equity premium)

Equities/Bonds	55/45	65/35	75/25	85/15
Min. value	560	498	339	257
Min value (end)	632	619	350	273
Max. Value	64 501	103 080	118 995	118 257
Max value (end)	61 801	100 628	111 032	105 603
Mean	8 501	8 307	8 471	8 619
Median	6 947	6 399	6 185	5 807
1% percentile	1 530	1 229	822	677
5% percentile	2 380	1 870	1 581	1 287
10% percentile	3 026	2 421	2 155	1 792
25% percentile	4 486	3 839	3 662	3 227
50 %	6 947	6 399	6 185	5 807
90 %	15 686	16 343	17 082	18 109
95 %	19 806	21 274	22 949	24 830
Real return (expected)	1,5 %	1,7 %	1,9 %	2,1 %
Volatility (expected)	10,2 %	11,4 %	12,7 %	14,0 %
Sharpe ratio	14,59 %	14,90 %	15,01 %	15,14 %