A Review of Norges Bank's Active Management

of the Government Pension Fund Global

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Executive summary and recommendations

We have reviewed Norges Bank's active management of the Government Pension Fund Global (hereafter the "Fund"). We build on previous reviews when discussing the theoretical issues in our mandate, extending them and incorporating more recent discussions from the academic and practitioner communities. In our empirical evaluations of the Fund, we mainly consider two sample periods, January 1998–June 2017 and January 2013–June 2017, and per our mandate we emphasize the results in the latter period. We note that the latter sample period in particular is short, making it difficult to measure performance with great statistical precision. Below, following our mandate, we summarize our findings and recommendations.

1. On the Fund's current main investment strategies and most significant investment strategies within the equity and fixed-income portfolios, respectively

We find that the Fund's total portfolio has generated a mean return of 6.0% per year with a standard deviation of 7.4% per year over the full sample period. The corresponding mean return and standard deviation in the more recent sample period are 8.6% and 6.3% per year, respectively.[1]

We find that the single most important determinant of the Fund's total risk is the benchmark choice. In the full sample period, 99.4% of the variance in the total portfolio is attributable to the benchmark and the remaining 0.6% to benchmark deviations; in the more recent sample period, 99.6% is attributable to the benchmark choice. Note that the benchmark is set by the Ministry of Finance, not Norges Bank. In light of this attribution measure, the degree of active management of the Fund seems to have decreased over time. The risk attributable to the benchmark is higher for the equity portfolio and lower for the fixed-income portfolio, i.e., 99.8% and 97.8%, respectively, in the more recent sample period. We find that the total risk is predominantly equity risk.

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[1]For the purpose of evaluating the Fund's performance and undertaking statistical analyses, we use arithmetic mean returns throughout the report. Arithmetic mean returns differ from the geometric mean returns, regularly reported by the Ministry of Finance and Norges Bank.

For the more recent sample period, we also consider the Fund's main strategies (i.e., fund allocation, security selection, and asset management) and discuss the decentralization of investment decisions. We find that it is the security-selection and asset-management strategies that positively contribute to the Fund's active return, whereas the fund-allocation strategy contributes negatively. Clearly, it is the equity portfolio rather than the fixed-income portfolio that contributes to the Fund's active return. Overall, we find evidence consistent with specialization among the main strategies. However, as the strategies are interrelated in various ways, it is difficult for us to isolate the contributions of the various strategies. We would like to better understand the development of the internal benchmarks and their implementation. Finally, we consider the performance of the external mandates, as their benchmarks are well defined. We find that the external mandates outperform their benchmarks by approximately 2% per year after costs, contributing substantially to the Fund's total performance.

2. On the Fund's active management results

We consider the return difference between the Fund and the benchmark (i.e., the active return) when evaluating the active management. The mean active returns are 0.29% and 0.25% per year before management costs (0.20% and 0.20% after costs) in the two sample periods. The equity portfolio has contributed the most, whereas the fixed-income portfolio performed positively in the full sample period but negatively in the more recent period.

We consider the value added, i.e., the total amount in NOK that the Fund extracts from the capital markets and the amount after costs that can be transferred to its asset owner. The Fund has extracted NOK 111.7 billion from capital markets relative to its benchmark since 1998, of which NOK 75.4 billion can be directly transferred to its asset owner. The lion's share of the value added comes from the Fund's equity portfolio, whereas the Fund's fixed-income portfolio has not added any value over its benchmark. In the more recent sample period, the Fund has provided its owner with NOK 49.7 billion in value, all stemming from the equity portfolio.

We analyze holdings in the equity portfolio and decompose the Fund return into a policy component (or benchmark), a selection component, and a timing component. We find that the Fund's positive mean active return is attributable to selection rather than to timing. The interpretation is simply that, for a given weight in a country, industry, or sector, the Fund has achieved a higher return than the benchmark.

We evaluate the performance using factor regressions and alpha analyses. The main analysis uses five equity factors (related to the market, size, value/growth, profitability, and investment risks) and two fixed-income factors (related to duration and credit risks). These factors capture more than 50% of the total variation in the active return. The mean active return can then be decomposed into a term stemming from the exposure to the factors and a pure alpha term. We extensively discuss the implementation of factor models and interpretation of the alphas and betas. We acknowledge the argument that some of the beta exposures can be credited to the Fund's successful factor investing. We emphasize the results in the most recent period, in which we find that the alpha before costs is 0.17% per year and the alpha after costs is 0.12% per year. Again, we conclude that the equity portfolio has outperformed its benchmark, whereas the performance of the fixed-income portfolio has been neutral or negative.

3. On the real estate portfolio

Our evaluation of the real estate portfolio has been limited, primarily due to the short return history and to the illiquid nature of real estate investments. We illustrate the pitfalls of appraisal-based returns and discuss the effect of currency fluctuations on returns. Due to these measurement issues, we consider annual returns on a country-by-country basis and in the currency of each country. Overall, we find that the performance of the Fund's real estate investments is in line with the performance of the country benchmarks, with outperformance in the UK and underperformance in the USA. We briefly discuss the real estate strategy in light of previous reviews of the real estate investments. Finally, we point out that the tracking error of the real estate portfolio substantially exceeds the tracking

errors of the equity and fixed-income portfolios and is potentially a major contributor to the expected shortfall. With a greater appetite for investments in real estate, increasing the tracking error limit set by the Ministry of Finance and the expected shortfall limit set internally by Norges Bank may be justified.

4. On the opportunities to obtain excess returns relative to the current benchmark

We consider the Fund's strategic and actual benchmarks, and the mandate set by the Ministry of Finance. We discuss the benchmarks in terms of properties such as being unambiguous, measurable, specified in advance, tradable, and appropriate. More specifically, we relate the benchmarks to the risk limit in terms of the tracking error set by the Ministry of Finance. We identify concerns with the use of the tracking error pertaining to (i) the efficiency of the benchmarks and (ii) career concerns. While the Fund has limits on both asset weights and tracking error, we wonder whether it might be worthwhile to focus on using ranges in asset weights rather than the tracking error to better set risk limits. We also wonder whether it would be worthwhile to have an absolute return target, a benchmark outperformance target, and/or a tracking error target.

The traditional view of active management is that delegated fund managers on average add no value to investors and that the managers who do add value ex post could have simply been lucky. Does this imply that the Fund should refrain from seeking active management itself and/or delegating assets to other active fund managers? Not in our opinion. The traditional view of active management has been challenged both conceptually and empirically. First, the Fund is not an average investor. It has certain comparative advantages (and disadvantages) that suit it for different kinds of strategies. We follow previous reviews and discuss the Fund's comparative advantages and three key features: diversification, long-term investment horizon, and size.

In light of models of active management, we consider recent theoretical and empirical findings in the academic literature that are relevant to the Fund's role as a manager and as an investor. Equilibrium models of active management typically assume or imply that fund

returns decrease with fund size. However, in many ways, the Fund resembles an index fund more than an actively managed fund. When not seeking active trades, the Fund's size becomes a comparative advantage. Size is also an advantage, especially combined with the advantage of being an investor with a long-term investment horizon, when trading in near-arbitrage situations and in securities lending. The Fund manages most of its assets itself, but also delegates the management of certain assets to external managers. Simply allocating assets to external managers does not affect the costs and benefits of active management. However, to the extent that the Fund can identify skilled managers ex ante, allocating assets to active fund managers may create value for the Fund. We discuss arguments for why the Fund can use its size and characteristics as comparative advantages when allocating money to other managers.

5. **On the relative risk budget (tracking error limit) and other recommendations**

We were asked to make a recommendation on the Fund's tracking error limit.

Since inception, the Fund has operated with an annual tracking error of 0.2–0.6%, significantly below its limit (currently 1.25%, but it has varied over time). The only time the Fund has approached its tracking error limit was during the financial crisis in 2008. The tracking errors vary between asset classes (currently being similar for the equity and fixed-income portfolios) and strategies (currently being high for internal and external security selection). However, understanding the allocation of these risk budgets requires a better understanding of the strategies and incentives within the Fund.

The strategy that stands out the most in terms of tracking error is that of real estate, which was merged into the equity and fixed-income portfolios at the beginning of 2017. While the tracking error for real estate is much higher than the tracking errors for equity and fixed income, real estate still constitutes only 2.5% of the Fund's assets, meaning that it has a small effect on the total tracking error. Overall, this suggests that there is no need to adjust the limit. The Fund (and its managers) may simply not find a use for the risk budgets allocated. However, as asked above, what incentives does a tracking error

limit give the Fund (and its managers)? Are career concerns inhibiting the Fund? Career concerns aside, what could justify a higher limit? If the real estate investments increase significantly or the Ministry of Finance introduces other unlisted asset classes, the limit needs to be re-evaluated.

Finally, we recommend further analysis and clarifications of the internal benchmarks developed by Norges Bank. The internal benchmarks are important for understanding the Fund's return opportunities, risk budgeting, costs, incentives, and performance. If the development and use of the internal benchmarks became more transparent, this would allow for a richer evaluation of the strategies pursued by the Fund.

Acknowledgements

Contents

1 Introduction

This is the third academic review of the active management of the Norwegian Government Pension Fund Global (hereafter the "Fund"). The first review was conducted in 2009 (Ang et al., 2009) and the second in 2014 (Ang et al., 2014). Though all three reviews empirically evaluate the active management of the Fund, they differ in certain respects. For example, Ang et al. (2009) theoretically described the efficient market hypothesis and extensively surveyed empirical studies of the hypothesis, whereas Ang et al. (2014) emphasized factor investing and downside risks, considering the delegation of investment decisions to Norges Bank and the potential to improve the Fund's expected return and risk profile relative to that of the current benchmark.

Our mandate, presented in Appendix A, certainly overlaps with the previous mandates. However, we believe that the earlier reviews focused on various theoretical issues in asset management partly in response to a lack of data. In principle, the previous two reviews relied on historical monthly returns on the Fund's total portfolio, divided into fixed-income and equity portfolios. We now have access to more detailed data. For example, in addition to the returns data mentioned above, we now have data on strategy returns (grouped by fund allocation, security selection, asset management, and real estate), holdings (grouped by countries, industries, and sectors), costs, and various risk measures.

We build on the previous reviews when discussing the theoretical issues, but extend them and incorporate more recent discussions from the academic and practitioner communities. Using data on various aspects of its investment activities, we empirically evaluate the Fund's investment performance. The mandate needs to be viewed in terms of the aggregated nature of the data we use, which are returns and other characteristics of either the whole fund or its main strategies. The analysis will reflect broad properties of the Fund's investment decisions, as reflected in its actual portfolio.

The mandate requires that we assess the active management since 1998 while empha-

sizing the most recent years. We therefore report the results for the full 1998–2017 sample period but emphasize the results for the 2013–2017 sample period. We begin the more recent sample period in 2013 to make full use of more detailed data.

To make an everyday analogy, we can compare our evaluation to the routine safety inspection of a car. The activities of a mechanic are well known: the mechanic conducts emission and noise tests, checks the tire pressure and wear, adjusts the wheel alignment, tests the brakes and oil, and conducts numerous other standard tests. Many issues with a car will be detected in such an inspection, but not all: for example, metal fatigue is hard to detect until something actually breaks.

In that spirit, we will conduct investigations that are standard in empirical portfolio choice and asset pricing research. We are the first to acknowledge that we cannot identify all potential issues, so it is important that various evaluation teams consider the issues from different viewpoints.

In what follows, Section 2 briefly describes the history of the Fund, as it has implications for the risk and return characteristics of the Fund and our review. Section 3 presents an overview of the Fund's strategic and actual benchmarks, comparative advantages in relation to active management, and main strategies. Section 4 reviews the data we use, and describes the Fund's returns, risks, and costs. Section 5 presents a first analysis of the Fund's performance. Section 6 uses factor models to characterize and evaluate the Fund's performance. Section 7 considers a value-added measure to study how much the Fund extracts from capital markets. Section 8 uses holdings data to attribute the Fund's equity returns to selection and timing components. Section 9 considers the main strategies (i.e., fund allocation, security selection, and asset management) that the Fund uses in seeking additional returns. Section 10 discusses and evaluates the Fund's real estate portfolio. Section 11 concludes.

2 An overview of the Fund

In this section, we briefly review the history of the Fund, as it has implications for the risk and return characteristics of the Fund and for our review (see Appendix B for a chronology).

2.1 Background and asset classes

The Fund was established in 1990 to help manage petroleum revenues from the North Sea. The first injection of capital took place in 1996. The early investments were in government bonds, which was one reason why Norges Bank (the Norwegian central bank) was chosen as the asset manager, as it had experience trading such bonds in its monetary policy role. As the Fund grew, there was a need to expand to other asset classes. In 1998, the Fund began to acquire equities, with a target portfolio of 40% equity and 60% fixed income (i.e., a 40/60 portfolio). This target has since changed several times. To illustrate this, consider Figure 1, which depicts the evolution of total fund value by asset class. One major change was the 2007 shift from 40/60 to 60/40 equity/fixed-income allocations. Another major change was the 2010 introduction of real estate into the portfolio. Numerous other changes to the Fund are not visible in the figure, such as expansions in the range of countries and asset types eligible for investment. For example, initially the fixed-income investments were exclusively in government bonds. The fixed-income universe has since been expanded to include corporate bonds (2002) and emerging market bonds (2012). Today, the Fund is a mega fund with more than NOK 8 trillion (more than USD 1 trillion) in assets under management (AUM).

Figure 2 illustrates in a complementary way the changing nature of the Fund, plotting the changing weights (i.e., fractions of AUM) of the three asset classes.

Withdrawals from the Fund can only be made at the direction of the Norwegian parliament—the Storting. A fiscal policy rule (Norwegian *handlingsregelen*) was introduced in 2001, stating that, to maintain the long-term value of the Fund, average annual

Figure 1 Market value by asset class.
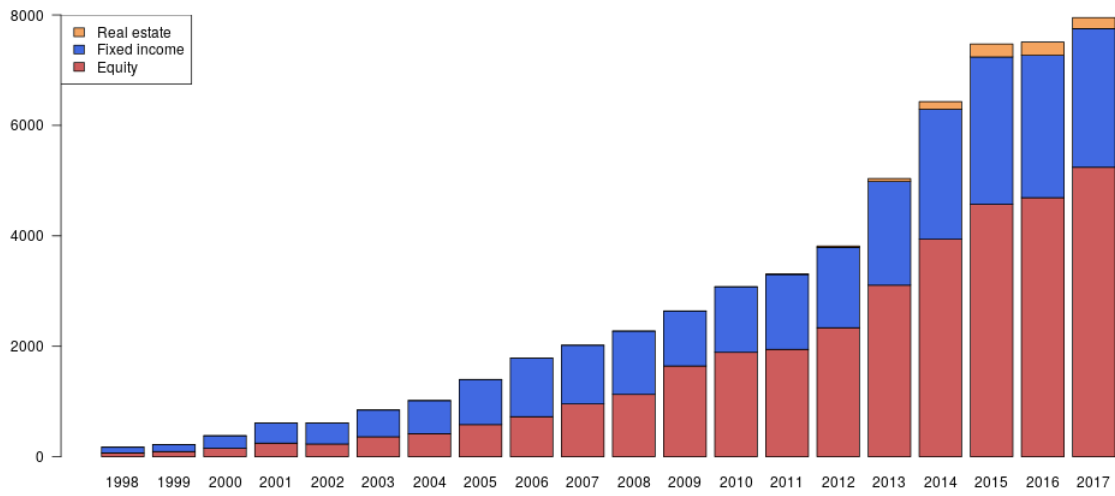
The figure plots the Fund's annual market value (NOK billion) for the three asset classes: equity (red), fixed income (blue), and real estate (orange). Data source: NBIM.

Figure 2 Weights in equity, fixed income, and real estate.
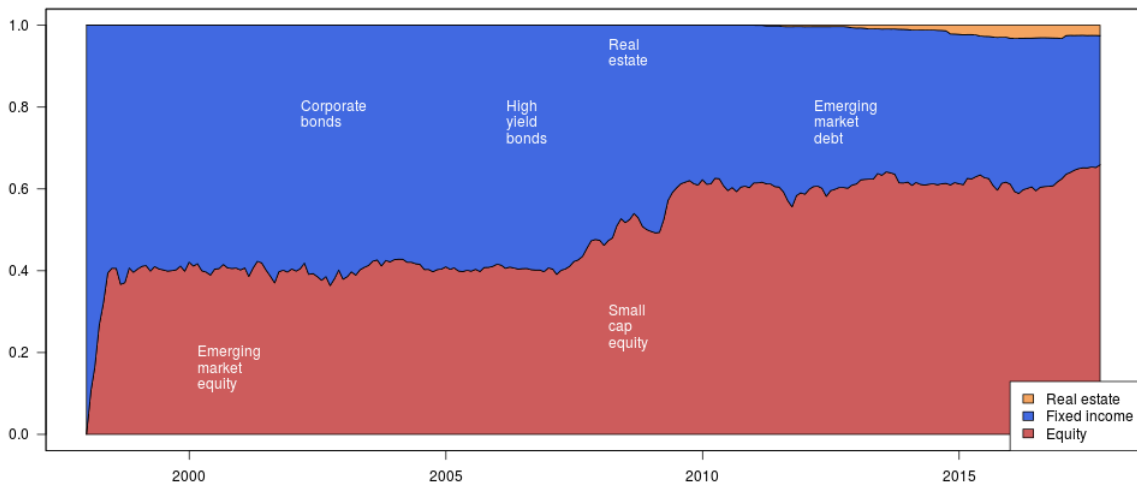
The figure plots the Fund's monthly weights in three asset classes: equity (red), fixed income (blue), and real estate (orange). Data source: NBIM.

withdrawals should be limited to the expected real return.

As petroleum revenues have fallen gradually and withdrawals from the Fund have increased, in line with the fiscal policy rule, net inflows to the Fund have decreased, becoming negative in 2016. The decrease in net inflows could have implications for the operational management of the Fund. Up to 2015, there were continued net inflows to the Fund, simplifying rebalancing at low cost. With net inflows, down-weighting an asset is more a matter of not buying more of it rather than of selling. As the Fund moves toward a "maintain value" mode, this aspect of asset management becomes somewhat more challenging.

In 2016 and 2017, several changes to the Fund's mandate and governance structure were made or proposed. In terms of the mandate, a governmental investigation proposed that the asset mix of the Fund should be changed to 70% equity and 30% fixed income (Norwegian Ministry of Finance, 2016). This change in allocation, later confirmed by the Storting and to be implemented by the Fund, will not affect our evaluation.

2.2   Responsible investment efforts

The Fund's responsible investment efforts are extensively described in NBIM's various reports (see, e.g., NBIM, 2017b). Norges Bank has structured its responsible investment into three areas: standard setting, ownership, and risk management.

In its standard-setting activities, Norges Bank aims to contribute to the development of standards and practices that serve the long-term interests of the Fund. The Bank's principles, expectations, and positions build on internationally recognized standards. To contribute to improved disclosure, standards, and practice development, the Bank prioritizes aspects of corporate governance and sustainability in defined initiatives. It also promotes research aimed at understanding factors that can affect future investment risk and return, and the Fund's responsible investment priorities.

The Fund is an active owner, using its voting rights to safeguard its investments and promote sustainable development and good corporate governance. Norges Bank aims to

vote at every shareholder meeting. Investment knowledge from the Fund's portfolio managers is integrated into the voting decisions and other responsible investment activities. As an owner, Norges Bank engages directly with companies' boards and managements.

The Fund's risk management work concerns risk management in a broad sense, as the Fund monitors and analyzes risks arising from environmental, social, and governance issues. As part of this work, the Fund emphasizes the development of high-quality data and corporate disclosure, and is building internal databases of non-financial data. Risk assessments may lead to portfolio adjustments and divestments.

Complementing the Fund's work on responsible investment, there is also external monitoring involving ethical considerations. New ethical guidelines for the Fund were adopted by the Ministry of Finance in December 2004. The Fund had already introduced "negative screening" of certain companies found to be in conflict with Norway's commitments under international law in 2001. In addition to criteria for product-based observation and the exclusion of companies, the new ethical guidelines specify criteria for conduct-based observation and the exclusion of companies.

As part of the ethical guidelines, the Ministry introduced a Council of Ethics outside the Fund, which makes recommendations regarding the observation and exclusion of companies from the Fund's investment universe to the Executive Board of Norges Bank, which makes the final decision in accordance with the guidelines. The recommendations from the Council of Ethics come in addition to Norges Bank's work on responsible investment. The ethical guidelines state that the Bank shall consider the full range of measures at its disposal and apply measures in a coherent manner. The Bank shall consider whether other measures, including the exercise of ownership rights, may be more suited to reducing the risk of continued norm violations.

Responsible investment activities thus affect the Fund in several ways and require resources, particularly for building databases and knowledge used in evaluating companies' corporate governance and sustainability. Additionally, investment knowledge from internal and external portfolio managers is incorporated into responsible investment activities.

2.3 Fund governance

In terms of governance, the Storting has made the Ministry of Finance responsible for the management of the Fund (see the Government Pension Fund Act); the Ministry has in turn made Norges Bank responsible for the Fund's operational implementation. Since 1998 the Fund has been run as a division of Norges Bank. As mentioned earlier, one reason for this was that the Fund's initial investments were in government bonds, which the Bank had expertise in trading. As it became clear that the Fund would increase substantially in size and that its asset mix would expand to include equities, the Bank set up a separate division that would later become NBIM.

In the organizational structure of Norges Bank, NBIM's operations are kept separate. The main interaction happens at the top of the organization, where the Executive Board of Norges Bank has a dual role, overseeing both monetary policy and NBIM decisions. In 2015, a separate vice governor was appointed to oversee the investment arm of the Bank. Importantly, the Fund does not invest in Norwegian assets and the Fund's value is measured in terms of a currency basket.

NBIM activities are kept separate from those of the rest of Norges Bank for several reasons. One important reason is remuneration. NBIM is run as an investment company, in which some of the employees are given incentives linked to investment goals. Consequently, these employees' salaries vary with the performance of the Fund. This performance-based remuneration clashes with the fixed salaries of traditional central bank employees.

Concerns about the organization of Norges Bank led to the 2015 appointment of a governmental committee to make recommendations about the Bank's future organization. Its main recommendation with implications for the Fund was that the Fund should be moved outside of Norges Bank (Norwegian Ministry of Finance, 2017) and configured as a government-run corporation (Norwegian, *særlovselskap*). This is the same model as that of Folketrygdfondet, a fund with a remit similar to that of NBIM, but which invests in listed equity and fixed income only in Norway and some Nordic countries. The committee's

secondary recommendation was that the status quo should be maintained, except that NBIM should have a separate board within Norges Bank. At the time of writing, no decision has been made on whether the Fund should be moved outside of Norges Bank.

2.4   Challenges in evaluating the active management

The many changes to the Fund's asset allocation, investment universe, and benchmarks make our evaluation challenging. In the empirical analysis of the Fund's activities, one of our underlying assumptions is that the drivers of returns and risks have remained the same throughout the period examined. The above overview of the Fund's history since 1998 makes it clear that this assumption may be unrealistic. Nonetheless, such an assumption is standard in empirical performance evaluations. The changing and expanding nature of the asset mix has affected the Fund's investment opportunities throughout the evaluation period.

One way to alleviate such concerns is to analyze objects that are less likely to change. This consideration has led us to focus on the *active return*, i.e., the difference between the Fund's return and the benchmark return. However, we should still bear in mind the potential dynamics of the underlying process generating the active return. When we later analyze the Fund's active return and the factors generating it, we should remember the changing risk characteristics of the Fund. One illustrative example is the fixed-income portfolio, which in the Fund's early years comprised government securities only, but in recent years has also included corporate and emerging market bonds. Another such example is that effective January 1, 2017, there was no longer a separate allocation to real estate, making real estate return an inherent part of the Fund's active return.

3 Fund strategies

As part of our mandate, we are to investigate whether the Fund can generate returns in excess of a benchmark return and, if so, how. It is therefore necessary to understand the Fund's strategies. In this section, we present an overview of the Fund's strategic and actual benchmarks, comparative advantages in relation to active management, and main strategies.

3.1 Strategic and actual benchmarks

The Ministry of Finance decides on the benchmarks for the Fund. The benchmarks have two roles, reflecting the preferences of the asset owner (i.e., the Ministry of Finance) and being used for performance evaluations of the Fund.

The current *strategic* benchmark for the Fund's portfolio consists of an equity benchmark and a fixed-income benchmark. (In the past, it has also included a separate real estate benchmark.) The equity benchmark constitutes 62.5% and the fixed-income benchmark 37.5% of the strategic benchmark. As mentioned above, it was recently decided to gradually increase the equity weight to 70%. The equity benchmark is based on market capitalization weights, but with Europe (excluding investments in Norway), developed markets, and emerging markets being overweighted relative to Canada and the USA. The fixed-income benchmark consists of 70% government bonds and 30% corporate bonds. Appendix C provides details regarding the equity and fixed-income benchmarks. Below, we abstract from many other considerations set out in the Fund's mandate (e.g., maximum investments in individual stocks and credit risk restrictions) to simplify our discussion.

As the returns on the equity and fixed-income benchmarks do not move in lockstep, the allocation weights in the *actual* benchmark are allowed to drift from the strategic weights. The actual benchmark will therefore deviate from the strategic benchmark, and the Ministry of Finance has established rules on the rebalancing of the actual benchmark. When deviations exceed predetermined limits, the actual benchmark is brought back to

the strategic benchmark. The rebalancing brings the risk in the actual benchmark back to the risk of the strategic benchmark. (Later we comment on the advantages of the rebalancing rule for the Fund.) The actual benchmark is the basis for the performance evaluation of the Fund's active management.

The Fund is allowed to deviate from the actual benchmark within risk limits specified in the management mandate given by the Ministry of Finance to Norges Bank. The risk limits include restrictions on weight deviations and an expected tracking error limit. The equity portfolio weight should constitute 50–80% of the total portfolio and the fixed-income portfolio 20–50%. While real estate investments are not part of the strategic benchmark, real estate may have a weight of 0–7% of the total portfolio. The annual expected tracking error limit is 1.25% (i.e., the expected standard deviation of the relative return between the Fund's portfolio and the actual benchmark should not exceed 1.25% per year).

Figure 3 Benchmarks and the Fund.

Ministry of Finance

Strategic benchmark
(fixed weights: 62.5%
equity, 37.5% fixed income)

Actual benchmark, R_t^b
(drifting weights within
a rebalancing band)

Norges Bank

Fund, R_t

The figure shows the division of responsibility, with benchmarks set by the Ministry of Finance and the operational management of the Fund carried out by Norges Bank.

We summarize the benchmarks in Figure 3. The Ministry of Finance sets a strategic benchmark with fixed weights for the equity and fixed-income components. The strategic

benchmark takes into account tilts toward non-market capitalization positions, including country weights and ethical screenings. The actual benchmark deviates from the strategic benchmark, as the equity and fixed-income benchmark returns develop differently. The rebalancing rule brings back the weights in the actual benchmark to the strategic weights when the deviations exceed limits.

We evaluate the Fund's performance relative to the actual benchmark. Let R_t and R_t^b denote the return between time $t - 1$ and t on the Fund and its actual benchmark, respectively. The return difference between the Fund and the benchmark is then the active return:

$$R_t - R_t^b, \tag{1}$$

where the active return can be for the total, equity, or fixed-income portfolios. The expected tracking error is then an estimate of the expected standard deviation of the active returns.

What is the purpose of allowing deviations from the actual benchmark? One reason is that such deviations would make it possible for NBIM to cost-effectively implement the benchmarks even if it did not undertake active management. This is especially important for the efficient rebalancing of the equity and fixed-income portfolios. Another reason is that such deviations are necessary for NBIM to use its comparative advantages and potentially outperform its benchmark. Interestingly, the mandate states that the equity and fixed-income portfolios should be composed in such a way that the active return is exposed to several systematic risk factors. However, the mandate is not explicit as to which systematic risk factors the Fund should invest in. Ang et al. (2014) discussed at length factor investing and the harvesting of factor risk premia. Two examples of such factors are size (as measured by market capitalization) and value/growth (as measured by price relative to fundamentals). Academic studies and the financial industry have documented empirical patterns, resulting in these factor strategies. For example, historically, over long sample periods, small stocks (with low market capitalization) have outperformed big stocks (with

high market capitalization) and value stocks (with low prices relative to fundamentals) have outperformed growth stocks (with high prices relative to fundamentals). Ang et al. (2009) summarized the economic rationale for these and many other factor returns. We consider a number of factors in Section 6.

What constitutes a good benchmark? Fischer and Wermers (2013) described valid benchmarks in terms of properties such as being unambiguous, measurable, specified in advance, tradable, and appropriate. The strategic and actual benchmarks of the Fund are unambiguous, measurable, and specified in advance. They are also tradable, but at some cost, a matter to which we return when discussing the estimated costs of passively managing the benchmark. Also, the chosen benchmarks seem appropriate in that they reflect the preferences of the asset owner. However, what incentives does the asset owner give the Fund when setting a tracking error limit on the active return? We identify two potential concerns with a tracking error limit that may have implications for NBIM's active management and our evaluation.

The first concern pertains to the efficiency of the benchmarks and the use of tracking error in asset allocation. The strategic and actual benchmarks are fairly simple equity/fixed income portfolios. At the same time, the Ministry of Finance's mandate states that the Fund's equity and fixed-income portfolios should be composed in such a way that their active returns (relative to their benchmarks) are exposed to several systematic risk factors. Relatedly, the mandate allows the Fund to invest in unlisted real estate even though real estate is not represented in the strategic or actual benchmarks. However, this suggests that the Fund can outperform its benchmark by investing in factors and/or real estate. If the benchmark in this sense is not efficient, and a better risk–return tradeoff can be achieved by factor and real estate investing, then a tracking error limit can be problematic. It is well known that optimizing the tracking error leads to inefficient mean-variance allocations unless the benchmark itself is mean-variance efficient (see Roll, 1992; Jorion, 2003). Still, a tracking error limit can be justified when agency problems are severe, or when the costs associated with including effective exposure to strategies or assets in the

benchmark are potentially large. While the Fund has limits on both asset weights and tracking error, it seems as if there is more emphasis on the tracking error. It may be worthwhile to focus more on the asset weights rather than adjusting the tracking error in order to set better risk limits.

The second concern pertains to the use of the tracking error and to career concerns. We note that the tracking error is a *limit* rather than a *target.* If the Fund does not use all of its risk budget (i.e., tracking error), this could simply be because the Fund does not see any opportunities in the capital markets or because it is inhibited in taking risk. The costs of deviating, due to career concerns, may simply be greater for the Fund (and its managers) than the reward for taking risks. It may be worthwhile to have an absolute return target, a benchmark outperformance target, and/or a tracking error target. For example, a combination of the last two would be a targeted information ratio (i.e., the ratio between the expected active return and the standard deviation of the active return), the purpose of which would be to align the incentives of the asset owner and the Fund (including its managers).

3.2   Active management

The traditional view of active management, emerging from the academic literature of the 1970s, 1980s, and 1990s, is that delegated fund managers on average add no value to investors and that the managers who do add value ex post could have simply been lucky (see, e.g., Jensen, 1968; Fama, 1970; Carhart, 1997). Sharpe's (1991) famous arithmetic of active management states that "before costs, the return on the average actively managed dollar will equal the return on the average passively managed dollar," and thus "after costs, the return on the average actively managed dollar will be less than the return on the average passively managed dollar." French (2008) used the same logic, referring to active management before costs as a zero-sum game and after costs as a negative-sum game. Consistent with this view, Fama and French (2010) revisited the performance of actively managed mutual funds in the framework of Sharpe's (1991) equilibrium account-

ing, finding little evidence that mutual funds produce risk-adjusted returns that cover their costs.

Does this imply that the Fund should refrain from seeking active management itself and/or delegating assets to other active fund managers? Not in our opinion. The traditional view of active management has been challenged both conceptually and empirically.

First, the equilibrium accounting is for the average investor, which the Fund is not. It has certain comparative advantages (and disadvantages) that suit it for different kinds of strategies (see below). The empirical literature has acknowledged that, while the average active mutual fund manager apparently continues to deliver no abnormal returns to investors after costs, the average hides significant cross-sectional variation—see, for example, Cremers and Petajisto (2009) and Amihud and Goyenko (2013) on patterns related to activity, Khorana et al. (2007) and Evans (2008) on managerial ownership, and Del Guercio and Reuter (2014) on distribution channels.

Second, Pedersen (2017) has argued that even "passive" investors, that is, investors who buy and hold the market, regularly need to trade as the market portfolio changes (e.g., when new securities are issued or deleted). Sharpe (1991) acknowledged that even passive investors need to trade, but this seems to have been forgotten in subsequent discussions. For example, an investor could try to proxy the market by buying an index fund. Even an index fund is not an entirely passive instrument, however, because it will have to trade to incorporate index additions/deletions and corporate actions. To the extent that these trades are predictable, they give rise to profit opportunities for arbitrageurs or, more generally, for liquidity providers (see Petajisto, 2011, who considers the hidden costs to index funds arising from such predictable trading, and Pedersen, 2015, who discuss further examples).

Below, we first discuss the Fund's comparative advantages and key features; we then consider these advantages from the perspective of the Fund as both a manager that manages assets and an investor that delegates assets to external managers.

Comparative advantages and Fund features

In previous reviews, Ang et al. (2009) and Ang et al. (2014), as part of their mandates, extensively assessed and discussed the comparative advantages of the Fund. Ang et al. (2014) divided the comparative advantages into structural characteristics and developed advantages. By structural characteristics, they were referring to the Fund's cash flows and lack of immediate liabilities; by developed advantages, they were referring to the investment management organization, governance structure and reporting, and management and personnel.

We agree with these reviews and only briefly discuss three key features of the Fund: diversification, long-term investment horizon, and size.

Diversification. The Fund invests broadly in equity and fixed-income markets across various countries, sectors, and firms/issuers. The Fund also undertakes factor investing by tilting the portfolio (relative to its benchmark) toward certain factors. Taken together, these investments reduce diversifiable risks in the equity and fixed-income asset portfolios and potentially provide further diversification through themes such as value and quality. The Fund is currently building up its real estate portfolio, which will inevitably lead to undiversified real estate risks in the short term but not necessarily in the long term. The Fund could potentially diversify further into other asset classes; for example, there are ongoing discussions on extending the investments to encompass unlisted equity.

Long-term investment horizon. The Fund's asset owner has a goal of preserving assets. The fiscal rule states that to maintain the long-term value of the Fund, average annual withdrawals should be limited to the expected real return. This suggests that the Fund has little need for short-term liquidity and does not face capital and liquidity constraints as many other investors do. Hence, the Fund can apply a long-term perspective to its investments, harvesting return rewards from various factors as well as trading against perceived mispricing. With the rebalancing

rule, the Fund's investment strategy also becomes countercyclical: the Fund will buy the asset class that has decreased in relative value terms and sell the asset class that has increased in relative value terms. The value of rebalancing was emphasized by Ang et al. (2014). Historically, there has been a return reward for rebalancing. The rebalancing rule helps the Fund to stay the course ("tying itself to the mast"), maintaining its long-term allocation and not over-reacting to short-term movements in the capital markets. While the rebalancing rule seems to have been favorable around the time of the financial crisis, we note that it resembles a short volatility strategy with skewness risks (see, e.g., Ang, 2014; Granger et al., 2014), risks that a long-term investor may be willing to take.

Size. On one hand, the size of the Fund allows for economies of scale. This provides cost effectiveness and, all else being equal, leads to lower management costs as a fraction of the AUM. On the other hand, the size of the Fund restricts its management: certain profit opportunities may be hard to scale up and portfolio reallocations may be costly to execute in a short time. This limits the Fund's opportunities to deviate from the benchmark and be an active manager. However, the size of the Fund allows internally managed assets and external mandates to be tailored based on skills and experience. The size of the Fund also allows it to access companies in virtually any national market. Consequently, its size enables the Fund to influence corporate management and be a responsible investor.

The three key features above are interrelated and provide opportunities for a blend of indexing and active management. They also provide opportunities in the Fund's real estate investments, discussed later. Next, we consider recent theoretical and empirical findings in the academic literature that concern the Fund's role as a manager and as an investor in models of active management.

The Fund as a manager

When evaluating the Fund's activities as a manager that manages its own assets, the Fund's size plays a crucial role. The Fund is simply a mega fund, and any evaluation of the Fund's performance must carefully evaluate the costs and benefits of running such a large fund. For example, the Fund's trades may have price impacts that can erode otherwise profitable investment opportunities. This leads us to later consider achievable factor investing.

Equilibrium models of active management typically assume or imply that fund returns decrease with fund size (see, e.g., Berk and Green, 2004). Empirically, while the precise relationship between fund returns and fund size is debated (see, e.g., Pastor et al. 2015; Reuter and Zitzewitz, 2015), arguably profitable trades are not scalable by arbitrary amounts. Undoubtedly, when seeking return-enhancing active trades, the Fund's size is, ceteris paribus, a comparative disadvantage. Modeling fund returns as a decreasing function of size is, however, a reduced-form approach and not ubiquitously applicable to all funds. For example, index funds face increasing returns to scale, that is, their costs decrease and their after-cost returns increase as the fund size increases. In many ways, the Fund resembles an index fund more than it resembles the average actively managed mutual fund (Hoberg et al., 2017, emphasize that ultimately the crowdedness of a particular fund's strategy should affect its outperformance). When not seeking active trades, the Fund's size becomes a comparative advantage. Size is also an advantage, especially combined with the advantage of being an investor with a long-term investment horizon, when trading in near-arbitrage situations and in securities lending. In fact, NBIM (2017c) reported that the estimated costs of managing the passive benchmark (passive management costs, transaction costs related to replicating the benchmark, and transaction costs related to net inflows and extraordinary benchmark changes), adding revenues from securities lending, have decreased from 0.04% per year in the last five years to 0.01% per year in the last three years. The main reason for the recent lower costs seems to be decreasing transaction costs due to net inflows and extraordinary benchmark changes.

The Fund as an investor

The Fund manages most of its assets itself, but also delegates approximately 4.5% of its assets to external managers. The arguments in the previous subsection of course carry over to this subsection—simply delegating assets to external managers does not affect the costs and benefits of managing sizable asset portfolios. However, to the extent that the Fund can identify skilled managers ex ante, delegating assets to active fund managers may create value for the Fund. Dyck et al. (2013) found that active fund managers particularly add value in niche markets. Their evidence supports the Fund's arguments for delegating money to external managers in emerging markets (e.g., specialized knowledge possessed by local managers).

Pástor and Stambaugh (2012) reconciled the large size of the active management industry with investors' slow learning about the precise relationship between aggregate fund returns and the overall size of the industry. While Berk and Green (2004) and the baseline calibration of Pástor and Stambaugh (2012) assume perfect competition among investors, which implies zero abnormal returns after costs for investors, Pástor and Stambaugh (2012) also analyzed rent sharing among delegated managers and investors in cases of imperfect competition. Rent sharing with market power of investors may be relevant to the Fund when delegating AUM among different strategies. For example, when delegating assets to an emerging market manager, the Fund with its long-term horizon may face a multitude of external managers who are all willing to manage the Fund's money. In that case, the Pástor and Stambaugh (2012) model predicts that managers will compete by lowering fees and that the Fund itself can earn an abnormal return. The analysis of the Pástor and Stambaugh (2012) case of one investor and many managers reflects a basic economic principle: In the case of perfect competition with substitutable products, economic agents compete by lowering prices; in our example, external managers compete by lowering the fees they charge to the Fund. As an investor, the Fund can use its size and characteristics as comparative advantages when delegating money to other managers.

While both Berk and Green (2004) and Pástor and Stambaugh (2012) focused on the

case of perfect competition among investors, implying few economic rents for investors, Gârleanu and Pedersen (2017) acknowledged the existence of different types of investors. While there is mounting empirical evidence that household and retail investors on average lose money relative to benchmark models with their delegated investments, institutional investors seem able to earn abnormal returns by choosing the right asset managers (see, e.g., Gerakos et al., 2017; Del Guercio and Reuter, 2014). Gârleanu and Pedersen (2017) extended the seminal Grossman and Stiglitz (1980) model with a second layer of costly information search, namely, the search for skilled asset managers, to reconcile these empirical findings within an equilibrium model. In their model, an investor with low search costs, such as a large institutional investor, can capture economic rents by identifying informed delegated assets managers.

In sum, these arguments suggest that the Fund's search for skilled external managers could in fact result in additional value creation.

3.3   Main investment strategies

We now consider NBIM's main investment strategies. Relatedly, NBIM regularly publishes strategy documents (see NBIM, 2017d, for the latest one) outlining the Fund's objective and comparative advantages. In the autumn, we met with the managements of NBIM (i.e., the CEO, the deputy CEO, three CIOs, and the CRO) and NBREM (i.e., the CRO), and the following summarizes their presentations of the Fund's internal organization and main investment strategies. We concentrate on aspects that are relevant to our review.

The Fund groups its investment activities into four strategies:

- Fund allocation (i.e., aggregate exposure),

- Security selection (i.e., company-specific exposure),

- Asset management (i.e., management of assets given certain exposure decisions), and

- Real estate.

Real estate is organized as a separate unit (i.e., NBREM) inside NBIM, and is sometimes presented as part of the Fund's allocation strategy. We look separately at real estate in a later section, leaving it out of the following discussion. The other three strategies have both equity and fixed-income components. Fund allocation handles the sub-strategy allocation decisions and the internal reference portfolio (i.e., the internal benchmark). Security selection groups its activities around internal and external security selection, with external security selection being organized as mandates assigned to third-party asset managers. Asset management handles an asset positioning strategy as well as securities lending. While we discuss these strategies as different, we recognize that they overlap and that NBIM views them as complementary.

This overview of the Fund's investment strategies considers the teams' own views on the sources of active returns. Figure 4 presents a simplified schematic of the strategies. We think of the three main strategies, i.e., fund allocation, security selection, and asset management, and their sub-strategies as providing input for the portfolio decisions of the Fund. Implementation (i.e., trading) is done in one location, as part of asset management. The real estate portfolio is then added to the total portfolio. We again emphasize that many of the strategies overlap and are linked through the funding model of the external mandates and the real estate investments; we return to this matter later.

We explore the workings of some of these strategies in detail, starting with fund allocation.

Allocation strategies

Fund allocation has a diverse set of responsibilities. The team (i) provides advice to the asset owner, (ii) develops starting points for portfolios, and (iii) manages emerging market assets.

The first responsibility is to provide advice to the asset owner with the objective of improving the Fund's long-term risk–return profile. Examples of past activities include

Figure 4 Simplified schematic of the Fund's strategies.
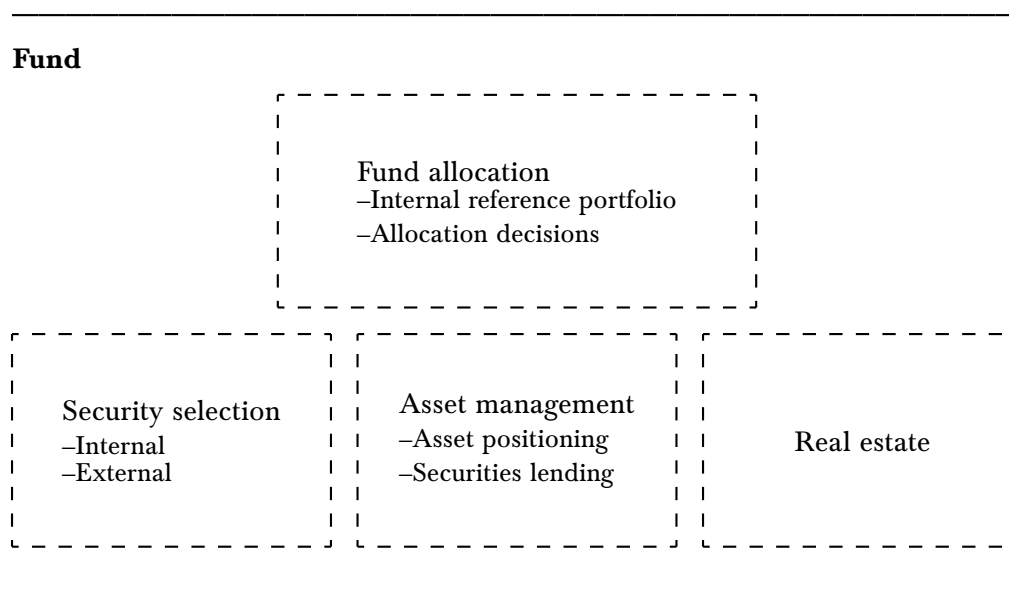
Fund

The figure shows the main strategies (i.e., fund allocation, security selection, asset management, and real estate) and some of the sub-strategies. The strategies are not independent, but overlap and are linked through the funding model of the external mandates and the real estate investments.

preparing letters from the Executive Board to the Ministry of Finance, supported by analyses published in discussion notes. These letters can be about advice to the Ministry of Finance regarding elements of the Fund's investment universe, such as infrastructure and private equity. Moreover, the Executive Board has also recommended reducing the components of the strategic benchmark from three (including real estate) to two (i.e., only equity and fixed income) asset classes.

The second responsibility is to develop the starting point for portfolios with the objective of improving the Fund's long-term risk–return profile within the management mandate. This responsibility concerns the capital allocation and the investment universe used internally by the Fund. For example, fund allocation is responsible for determining the investable countries of the Fund. The allocation strategies team starts with the countries in the strategic benchmark and then considers whether additional countries should be included in the investment universe managed internally (see Appendix C). Other examples of how to increase the opportunity set for internal use are the systematic factor strategies

related to size (small versus large market capitalization), quality (robust versus weak profitability), valuation (value versus growth), and foreign-exchange carry. This responsibility also includes the funding of real estate investments, a matter addressed later.

The final responsibility is to manage the emerging market investments in the Fund's portfolio. Emerging market debt investments are managed internally, while emerging market equity investments are largely managed by external managers. The team advocates using local managers to cover their home markets, arguing that local knowledge is particularly important in what are deemed less transparent markets. Local presence is arguably also important for the NBIM's ethical mandate and being a responsible investor. However, the team does manage some emerging market investments itself to complete the emerging market exposure.

Next, we explore the equity strategies of the security selection team.

Security selection

As a starting point for understanding the equity strategies team at security selection, consider two distinct objectives in running the Fund, i.e., that Norges Bank shall seek to (1) achieve the highest possible return after costs and within the applicable management framework, and (2) integrate its responsible management efforts into the management of the Fund. These goals may at times conflict with each other. A first step in handling them is to understand the potential for conflict, which requires detailed company knowledge. Part of the merit of the equity strategies team is to generate detailed company knowledge that, through an internal database, is available to all of NBIM.

The equity strategies team has set up its internal analysis by grouping activities into four focus areas: (i) credit and capital markets (i.e., selection of investments in credit and coordination of capital market activities); (ii) sector strategies (i.e., selection of investments within industries by highly specialized managers); (iii) special mandates (i.e., managing mandate requirements and long-term allocation decisions, including Chinese investments and environmental investments); and (iv) ownership strategies (i.e., coordi-

nating responsible management activities, such as active ownership, policy development, and sustainability initiatives).

Some of the activities of the equity strategies team start with fundamental research. This involves gathering company-specific information from numerous sources (e.g., companies, investment banks, industry experts, regulators, and data providers). In undertaking this research, the team conducts about 4000 meetings per year. These meetings may be with a company's CEO, CFO, investor relations officer, other managers, or the chair and other board members. An important part of fundamental research is the maintenance of individual financial valuation models for the most significant holdings.

The team also takes care of ownership responsibilities, i.e., corporate governance aspects of interactions with companies, such as voting, maintaining company relationships, and following up environmental, social, and governance (ESG) risks. These interactions contribute to updating the Fund's internal knowledge bank.

Asset management

Asset management has a variety of tasks, which can be grouped into (i) investment strategies (i.e., constructing trading strategies based on comparative advantages) and (ii) trading (i.e., seeking to conduct cost-effective rebalancing and trading).

We will examine these two types of tasks, starting with the investment strategies. The asset management team considers the following sources of active returns:

- Factor strategies—diversified active positions based on security characteristics (i.e., accounting for market frictions and persistent anomalies on a risk-based foundation);

- Relative value—finding attractive opportunities arising from market imperfections stemming from market segmentation (e.g., intra- or cross-issuer and cross-instrument segmentation) or liquidity provisioning (e.g., primary market, block pricing, and directional flow). An example of a fixed-income trade is a trade in similar bonds but

with different yields (i.e., going long the "cheap" bond and shorting the "expensive" bond); an example of an equity trade is a trade based on passive investors distorting prices around an index reconstitution; and

- Securities lending—asset utilization and fees depending on borrower demand.

The second concern of the asset management group pertains to interactions with financial markets, with the aim of achieving efficient rebalancing and trading. A key goal here is to *trade less*. One strategy for trading less is to let portfolio construction be affected by turnover, while another strategy is to internalize trades as much as possible. A second key goal is to *trade better*. This strategy is to participate in primary markets (e.g., bond issues, stock IPOs, and stock SEOs) and work on minimizing trading costs in secondary markets by means of patient execution.

In seeking cost-effective markets, asset management also tries to use its influence to improve markets, by articulating views and reflections on issues topical for the financial industry, and by participating in practitioner committees and consultations. It has also chosen to selectively support certain market initiatives, such as the IEX alternative exchange.[2]

Summing up

We close this section with some remarks about the Fund's strategies that are relevant to our later analysis.

First, we recognize many of the investment strategies and sources of active returns mentioned in the earlier academic reviews of the Fund as ways that a large, long-term investor can exploit its comparative advantages. The focus on minimizing transaction costs is crucial for any investment organization. Attempting to identify sources of factor exposure is a key activity for an investor like the Fund.

Second, it is not obvious that the strategies are independent and can be evaluated independently when it comes to performance and costs. For example, a database of

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[2]Lewis (2014) vividly presents the early history of the IEX exchange.

firm information created by the security selection team may also be used by the other teams. Moreover, the funding model of external mandates and the real estate investments suggests a close relationship between the strategies.

Third, the Fund displays an overlap in the investment strategies. For example, in our meetings, the term *factor* (as a strategy or enhancement) was mentioned in a range of configurations and contexts. Such overlap creates potential for conflicts between the strategies.

4 Characterizing returns, risks, and costs

4.1 Data

Our prime source of data for this review is NBIM. Most of our analysis is based on the Fund's history of monthly returns, at the aggregate level but also disaggregated based on asset classes or strategies. We also have access to corresponding benchmark returns. In addition, we have obtained monthly observations of portfolio weights, as well as information on risk measures and costs. The return data begin in January 1998 and end in June 2017. Not all of the other data are available for the entire period. Thus for some analyses we rely on observations for shorter periods.[3]

We mainly consider two sample periods, 1998–2017 and 2013–2017. The mandate asks us to "evaluate Norges Bank's active management results for the GPFG since 1998," but an "emphasis should be put on the most recent years." As per our mandate, we focus on the 2013–2017 sample period.

In addition to performance data from the Fund, we use financial market data in performing factor analyses. We collected the factors and relevant data from various sources and constructed some factors ourselves. These factors and data are described in Appendix E. The data are available on a monthly basis for our sample periods unless otherwise stated.

According to Norges Bank's mandate, the Fund is evaluated in terms of its currency basket (CB), that is, the CB is the measurement currency. However, international and US factors are considered from the perspective of US investors and expressed in US dollars (USD), i.e., the USD is the base currency. We therefore convert all factors from USD to CB. Appendix D describes the currency conversions and lists the 34 currencies in the CB.

Below, we briefly characterize the returns, risks, and costs of the Fund.

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[3] For the total and fixed-income portfolios, we have monthly returns from January 1998 to June 2017 (234 observations); for the equity portfolio, we have returns from February 1998 to June 2017 (233 observations). In return analyses of the main strategies, we use data from January 2013 to June 2017 (54 observations); in analyses of holdings and returns, we use data from January 2013 to September 2017 (57 observations).

4.2 Returns

Table 1 presents summary statistics of the monthly returns on the total, equity, and fixed-income portfolios for the 1998–2017 and 2013–2017 sample periods. Panel A reports the return statistics of the Fund.[4]

The annualized mean and standard deviation of the Fund's total portfolio for the full sample period are 6.02% and 7.43%, respectively. A simple annualized reward-to-variability ratio (where the return is not in excess of a risk-free rate and hence not strictly a Sharpe ratio) is then 0.81. The annualized mean returns of the equity and fixed-income portfolios are 7.12% and 4.77%, respectively. The higher mean return on the equity portfolio comes with a substantially higher volatility. The annualized standard deviations are 14.73% and 3.35% for the equity and fixed-income portfolios, respectively. The returns display modest positive serial correlations, as indicated by first-order autocorrelation coefficients of 0.17–0.19. The skewness and excess kurtosis statistics indicate common deviations from normally distributed returns. The returns are negatively skewed (i.e., having a longer left tail and more mass of the return distribution to the right). They also have fatter tails relative to the normal distribution, as indicated by the positive excess kurtosis.

The more recent sample period has a higher return on the total portfolio accompanied with lower standard deviations, so the more recent years offer a more attractive risk–return tradeoff. This stems from a period of high equity returns and low volatility. The fixed-income portfolio has had a lower mean return but also an unusually low volatility. There is less serial correlation in the returns in the more recent sample period. The skewness and excess kurtosis statistics still indicate deviations from normality, but less so, as the extreme observations around the 2008–2009 financial crisis are not included in this sample period.

Panel B reports corresponding return statistics for the actual benchmarks. The mean returns on the benchmarks are lower, but also come with somewhat lower standard devi-

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[4]For the purpose of evaluating the Fund's performance and undertaking statistical analyses, we use arithmetic mean returns throughout the report. Arithmetic mean returns differ from the geometric mean returns, regularly reported by the Ministry of Finance and Norges Bank.

Table 1 Summary statistics of returns.

	Mean	Standard deviation	AC(1)	Skewness	Excess kurtosis
Panel A: Fund returns					
1998–2017					
Total	6.02	7.43	0.19	−0.91	3.54
Equity	7.12	14.73	0.19	−0.80	1.55
Fixed income	4.77	3.35	0.17	−0.39	1.13
2013–2017					
Total	8.61	6.29	−0.09	−0.49	0.45
Equity	12.02	9.69	−0.09	−0.45	0.56
Fixed income	2.97	2.76	0.00	−0.37	0.28
Panel B: Benchmark returns					
1998–2017					
Total	5.73	7.03	0.15	−0.79	2.63
Equity	6.63	14.43	0.18	−0.78	1.51
Fixed income	4.61	3.21	0.10	−0.09	0.47
2013–2017					
Total	8.36	6.17	−0.10	−0.48	0.45
Equity	11.65	9.48	−0.09	−0.45	0.59
Fixed income	3.00	3.02	0.02	−0.38	0.12

The table presents summary statistics (i.e., arithmetic means, standard deviations, first-order autocorrelations, skewness, and excess kurtosis) of monthly returns in the 1998–2017 and 2013–2017 sample periods. Means and standard deviations are expressed in % per year. Means are annualized by multiplying the monthly mean return by 1200; standard deviations are annualized by multiplying the monthly standard deviation by $\sqrt{12} \times 100$. Panel A reports the statistics for the Fund's total, equity, and fixed-income portfolios. Panel B reports the statistics for the actual benchmarks. All returns are expressed in the Fund's currency basket.

ations. The benchmark returns exhibit similar, but somewhat less pronounced, patterns in serial correlation, skewness, and kurtosis.

Table 2 reports statistics on the active returns. The annualized mean active returns of the total, equity, and fixed-income portfolios are 0.29%, 0.49%, and 0.15% in the full sample period, respectively. With annualized standard deviations of 0.70%, 0.80%, and 1.04% for the total, equity, and fixed-income portfolios, the information ratios are 0.41, 0.61, and 0.14, respectively. A word of caution here: the first-order autocorrelations of the total and fixed-income portfolios are high (i.e., 0.51 and 0.68, respectively), so the common annualization of standard deviations (i.e., multiplying a standard deviation of monthly returns by the square root of twelve, justified by an IID assumption) may be questioned (see Lo, 2002). The active returns also exhibit deviations from normality (i.e., negative skewness and positive excess kurtosis). The sensitivity of the skewness and kurtosis statistics to outliers is well known. That the financial crisis is manifested in these statistics was demonstrated by Ang et al. (2014). In the more recent sample period, the annualized mean active return on the total portfolio is somewhat lower (i.e., 0.25% versus 0.29%), but the standard deviation is lower (i.e., 0.39% versus 0.70%), giving a higher information ratio (i.e., 0.64 versus 0.41). Again, it is mainly the equity portfolio that contributes to the mean active returns.

Figure 5 shows the cumulative returns of the total portfolio. Panel A plots the cumulative returns of the Fund's portfolio (solid line) and its actual benchmark (dashed line). The higher mean return of the Fund is clearly visible. Some of the higher return stems from a higher than one-to-one co-movement with the benchmark (i.e., the Fund has a beta relative to the benchmark above one); some stems from outperforming the benchmark, as evaluated and discussed later. Panel B plots the difference in the cumulative returns between the total portfolio and the benchmark. It highlights the effects of the financial crisis, when the difference in cumulative returns was wiped out, before quickly recovering.

Figure 6 shows the difference in cumulative returns for the equity and fixed-income portfolios. The higher return on the Fund's equity portfolio is clearly visible. The relative

Table 2 Summary statistics of active returns.

	Mean	Standard deviation	AC(1)	Skewness	Excess kurtosis	Information ratio
1998–2017						
Total	0.29	0.70	0.51	−2.26	16.61	0.41
Equity	0.49	0.80	0.18	−0.69	8.55	0.61
Fixed income	0.15	1.04	0.68	−0.58	16.07	0.14
2013–2017						
Total	0.25	0.39	0.20	−0.19	0.47	0.64
Equity	0.37	0.47	0.30	−0.87	0.95	0.79
Fixed income	−0.03	0.50	0.09	−0.05	−0.46	−0.06

The table presents summary statistics (i.e., arithmetic means, standard deviations, first-order autocorrelations, skewness, and excess kurtosis) and information ratios for the return difference between the Fund and the actual benchmark (i.e., the active return) in the 1998–2017 and 2013–2017 sample periods. Means and standard deviations are expressed in % per year. Means are annualized by multiplying the monthly mean return by 1200; standard deviations are annualized by multiplying the monthly standard deviation by $\sqrt{12} \times 100$. "Information ratio" refers to the mean divided by the standard deviation. All returns are expressed in the Fund's currency basket.

loss on the fixed-income portfolio during the financial crisis is also visible: the steady increase in the difference in cumulative returns is conspicuously followed by a dramatic decrease. This makes us speculate as to whether there were hidden risks in the fixed-income portfolio that were first realized during the crisis. In the more recent sample period (beginning in 2013 and indicated by the vertical line), the difference in cumulative returns between the fixed-income portfolio and its benchmark is approximately flat.

4.3 Risk attributions and contributions

How much of the variation in the Fund's returns can be attributed to the choice of strategic and actual benchmarks? We decompose the return variance by running a simple regression of the Fund's return on its actual benchmark return. The R^2 value of this regression measures the fraction of the variance captured by the benchmark. The remaining fraction is due to deviations from the benchmark (i.e., mainly due to variation in active returns). The deviation from the benchmark exactly corresponds to the active return if the beta of

Figure 5 Cumulative returns of the total portfolio.

Panel A: Cumulative returns of the total portfolio and its benchmark
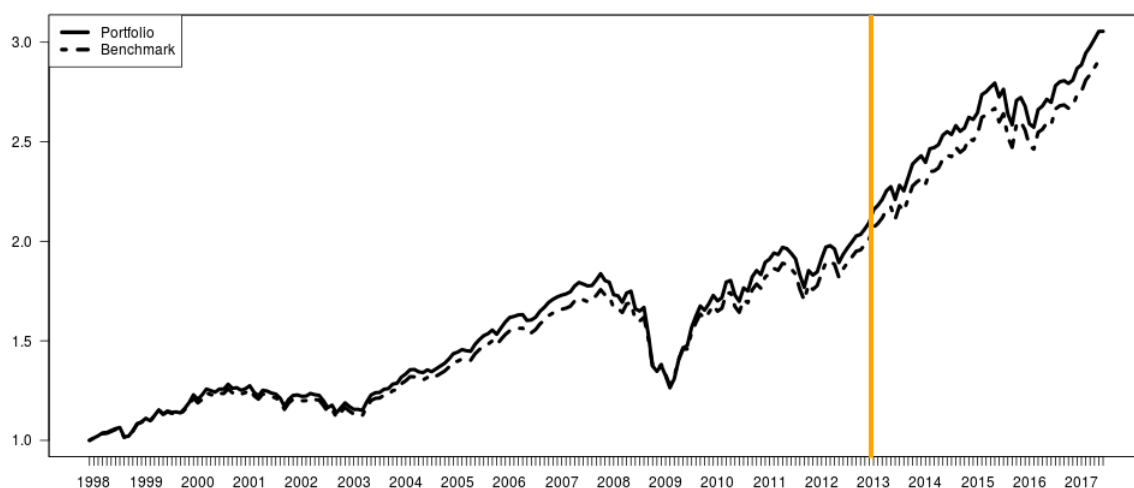
Panel B: Difference in cumulative returns between the total portfolio and its benchmark
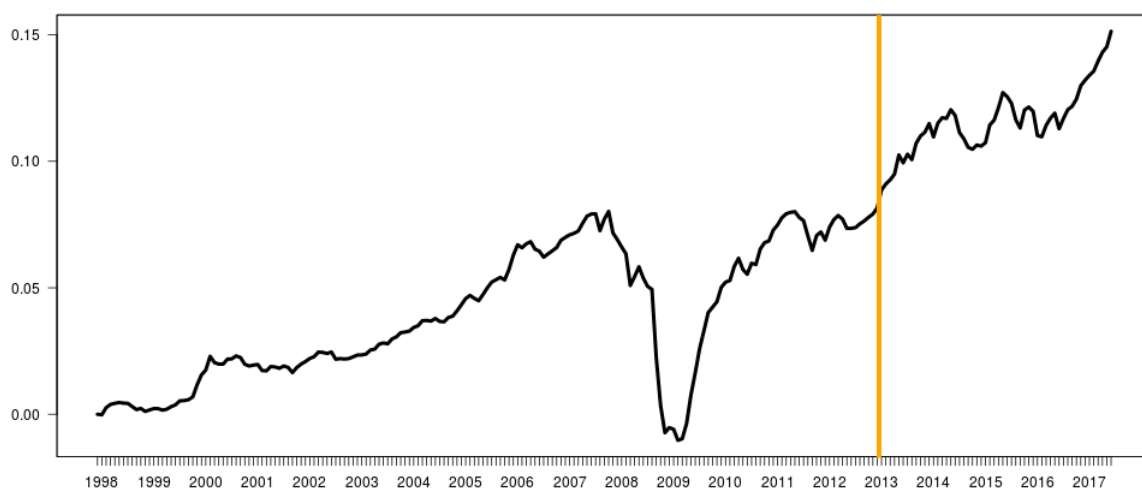
Panel A plots the cumulative returns of the total portfolio and the actual benchmark; Panel B plots the difference in cumulative returns between the total portfolio and the actual benchmark (i.e., the difference between the cumulative returns in Panel A). Cumulative returns are calculated from monthly returns, R_t, as $\prod_{t=1}^{T}(1 + R_t)$. Returns are expressed in the Fund's currency basket. The vertical line (orange) indicates the beginning of 2013.

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Figure 6 Difference in cumulative returns.

Panel A: Equity portfolio
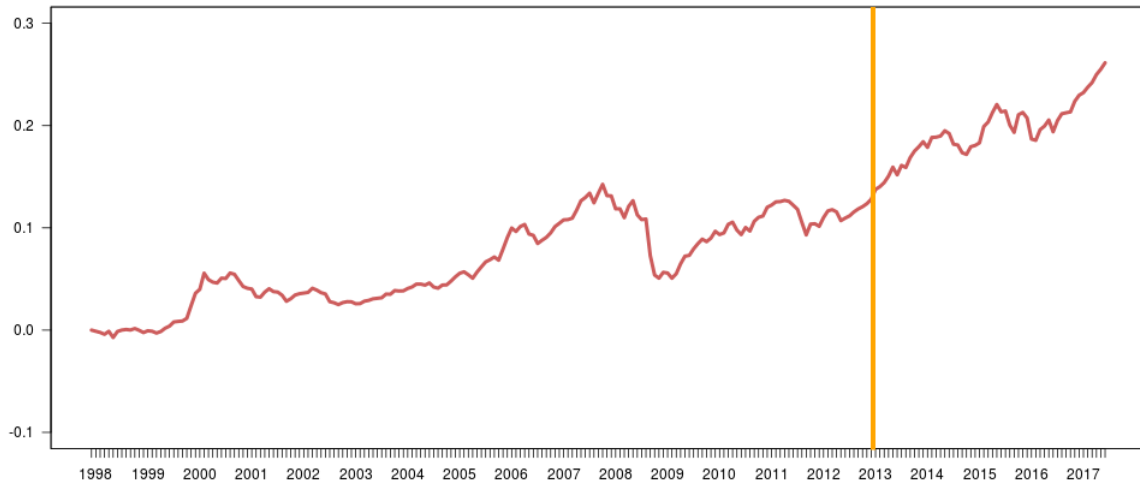
Panel B: Fixed-income portfolio

Panel A plots the difference between the cumulative returns of the equity portfolio and its benchmark; Panel B plots the difference in cumulative returns between the fix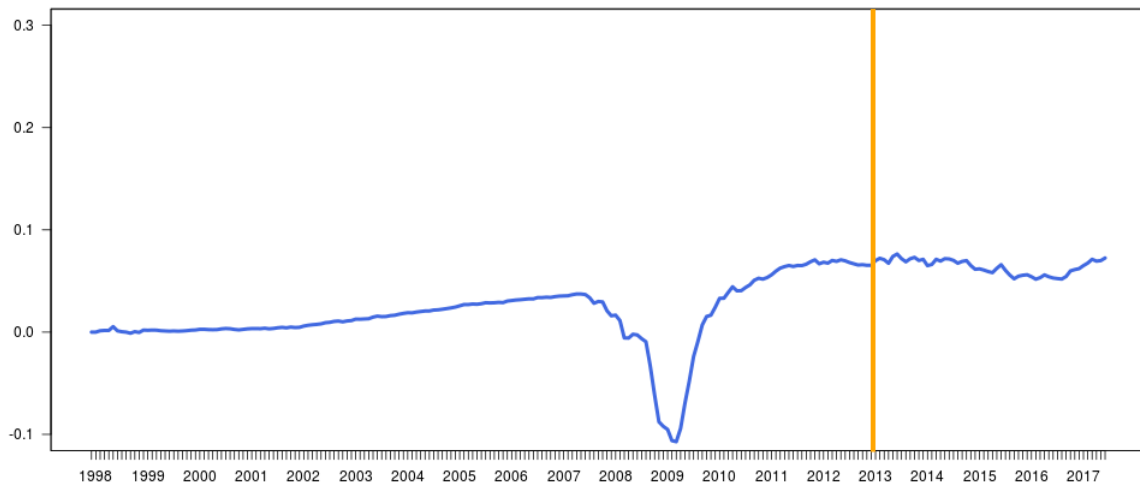ed-income portfolio and its benchmark. Cumulative returns are calculated from monthly returns, R_t, as $\prod_{t=1}^{T}(1 + R_t)$. Returns are expressed in the Fund's currency basket. The vertical line (orange) indicates the beginning of 2013.

the Fund relative to its benchmark is one; otherwise there is minification/magnification of the benchmark through the Fund's beta relative to the benchmark.

Table 3 presents such variance decompositions. For the 1998–2017 sample period, 99.4% of the variance in the total portfolio is due to the benchmark and 0.6% is due to benchmark deviations. Hence, the single most important determinant of the Fund's total risk is the benchmark choice. Recall that the strategic and actual benchmarks are chosen by the Ministry of Finance, outside Norges Bank.

The risk attributions are slightly higher for the equity portfolio, i.e., 99.7%, and much lower for the fixed-income portfolio, i.e., 90.3%, in the 1998–2017 sample period. The result for the fixed-income portfolio seems to be due to larger deviations from the benchmark in the early part of the sample period and during the financial crisis. In the more recent 2013–2017 sample period, the risk attributed to the benchmark is higher for the total portfolio and for the equity and fixed-income portfolios. Considering this attribution as a measure of active management, the degree of activity of the Fund has apparently decreased over time.

Table 3 Risk attributions.

	Benchmark return	Benchmark deviation	Total return
1998–2017			
Total	99.4	0.6	100.0
Equity	99.7	0.3	100.0
Fixed income	90.3	9.7	100.0
2013–2017			
Total	99.6	0.4	100.0
Equity	99.8	0.2	100.0
Fixed income	97.8	2.2	100.0

The table presents a variance decomposition of the Fund's return into the variance due to the actual benchmark return and the remaining variation due to deviations from the benchmark for the total, equity, and fixed-income portfolios in the 1998–2017 and 2013–2017 sample periods. The variance due to the benchmark is the R^2 value of the regression: $R_t = a + bR_t^b + \varepsilon_t$. The attributions to the components are expressed in %. All returns are expressed in the Fund's currency basket.

The variance decomposition reveals how much of the total variance of the Fund's

return is captured by the chosen benchmark. A complementary way of understanding the riskiness of the portfolio is to consider the equity versus fixed-income parts of the total portfolio. In terms of portfolio weights, the mix has historically been 40/60 or 60/40; recently, it was decided to change the mix to 70/30. However, in terms of risks, not weights, the fractions are very different. The financial industry often uses measures of how much an asset (or asset class) contributes on the margin to a portfolio's standard deviation and how much it contributes as a fraction of the portfolio's standard deviation. These measures are referred to as the marginal contribution to total risk (MCTR) and the percentage contribution to total risk (PCTR), respectively. Mathematically, these measures for asset class i can be written as:

$$\text{MCTR}_i = \frac{\partial \sigma_p}{\partial w_i} = \frac{\sigma_{ip}}{\sigma_p} = \beta_{ip} \sigma_p, \tag{2}$$

and

$$\text{PCTR}_i = \frac{w_i \frac{\partial \sigma_p}{\partial w_i}}{\sigma_p} = w_i \frac{\sigma_{ip}}{\sigma_p^2} = w_i \beta_{ip}, \tag{3}$$

where σ_p is the portfolio standard deviation, w_i is the weight in asset class i, σ_{ip} is the covariance between asset class i and portfolio p, and β_{ip} is the beta between asset class i and portfolio p (i.e., the covariance between asset class i and portfolio p divided by the portfolio variance). The above expressions are derived by taking the derivative of the portfolio standard deviation with respect to the asset class weight, where the portfolio's weights in all asset classes are taken as given. It is straightforward to demonstrate that: (i) the weighted sum of the marginal contributions of all assets equals the portfolio standard deviation; (ii) the sum of the percentage contributions of all assets is one; and (iii) the weighted sum of the betas is one. These results follow from the sum of the weights being equal to one.

Table 4 presents marginal and percentage contributions to risk, i.e., MCTRs and PCTRs, respectively. We estimate the variance–covariance matrix and assume 60/40 equity/fixed-income weights. The MCTR for the equity portfolio is 14.6% per year, in-

dicating that a one-percentage-point increase in the equity weight (i.e., from 60% to 61%) leads to a 0.146-percentage-point increase in the portfolio standard deviation (i.e., from 8.90% per year to 9.06% per year). The MCTR for the fixed-income portfolio is much smaller, 0.4% per year. Taken together, the PCTRs for the equity and fixed-income portfolios are 98.2% and 1.8%, respectively. Hence, the risk of a 60/40 portfolio is simply dominated by equity risk.

Table 4 Risk contributions.

	MCTR	PCTR
1998–2017		
Equity	14.6	98.2
Fixed income	0.4	1.8
2013–2017		
Equity	9.5	94.7
Fixed income	0.8	5.3

The table presents marginal and percentage contributions to risk (i.e., MCTRs and PCTRs) for the 1998–2017 and 2013–2017 sample periods. The measures are computed from the sample variance–covariance matrix using the Fund's return on the equity and fixed-income portfolios, and assume 60% equity and 40% fixed-income weights. The portfolio standard deviations in the two sample periods are 8.90% and 6.04% per year. The MCTR is expressed in % per year and the PCTR in %. All returns are expressed in the Fund's currency basket.

The PCTR due to the fixed-income portfolio is higher in the 2013–2017 sample period, mainly due to a higher correlation between the equity and fixed-income portfolios (the correlations are –0.03 in the full sample period and 0.11 in the more recent sample period). Still, the equity risk dominates the fixed-income risk in the Fund's total portfolio.

Our conclusion from the attribution and contribution analyses is that the Ministry of Finance's benchmark choice largely determines the total risk of the Fund and that the risk is predominantly equity risk.

4.4 Tracking error

The management mandate given by the Ministry of Finance to Norges Bank sets a limit on the expected tracking error (or expected relative volatility). This limit has varied over

time, and currently the annual expected tracking error limit is 1.25% (i.e., the expected standard deviation of the relative return between the Fund's portfolio and the actual benchmark should not exceed 1.25% per year). We have obtained time series of the expected tracking error for the total portfolio and for the equity and fixed-income portfolios, by strategy and internal/external mandates. At any point in time this is an estimate and the estimation approach has varied over time (see NBIM, 2016, p. 50). With the currently used approach, the estimate at a given point in time is based on the current positions (at the security level) in the portfolio, the positions' exposures to risk factors, and the forecasted volatility and correlations of the risk factors.

Figure 7 depicts the monthly tracking error estimated by NBIM. Panel A plots the tracking error for the total portfolio, together with a dashed line showing the limit. As the figure indicates, for most of the period, the Fund has operated with a tracking error of 0.2–0.6%, significantly below its limit. We deemphasize the high tracking error in the first few months, which occurred when the Fund was building up its equity portfolio.[5] The only time the Fund has approached its tracking error limit was during the financial crisis in 2008 (see, Ang et al., 2014, for a discussion).

The tracking error of the Fund has decreased in recent years. To understand why, Panel B shows the tracking errors separately for the equity (red, solid line) and fixed-income (blue, dashed line) portfolios of the Fund. In the period before the financial crisis, the major source of the tracking error was equities. In recent years this has been reversed, with the tracking error of the equity portfolio being substantially below that of the fixed-income portfolio.

We note two potential reasons for the recent decline in the expected tracking error of the Fund. First, the volatility of the world's equity and fixed-income markets has fallen substantially in recent years. Reduced market volatility would lower the expected tracking error of the Fund for any given benchmark deviation. Figure 8 plots the evolution of

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[5]The benchmark switched from 100% fixed income to 40% equity and 60% fixed income at the beginning of 1998. The buildup of the equity portfolio was gradual, and it took a few months to accumulate an equity portfolio of approximately NOK 25 billion. See Næs and Ødegaard (2006) for insight into this process.

Figure 7 Tracking error.

Panel A: Total portfolio
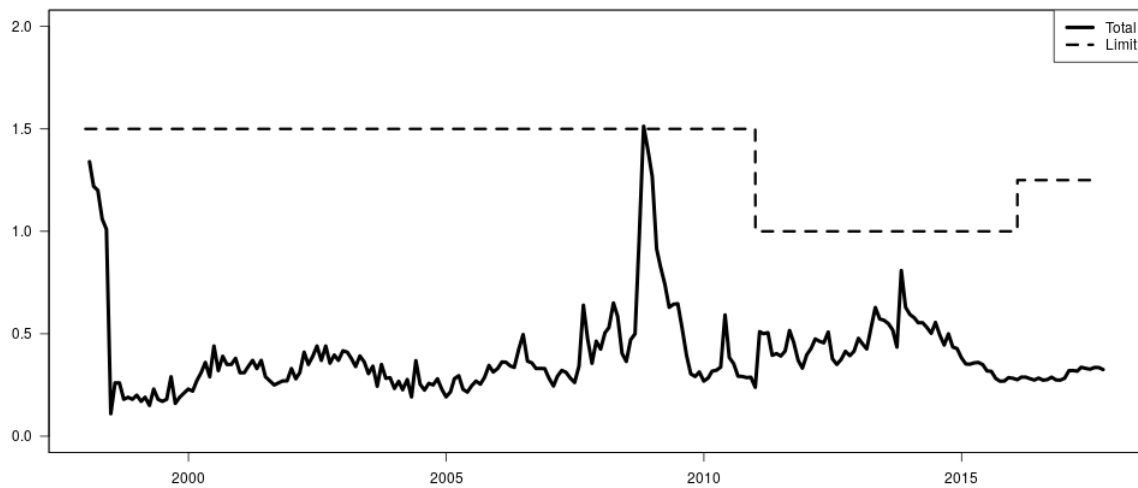
Panel B: Equity and fixed-income portfolios
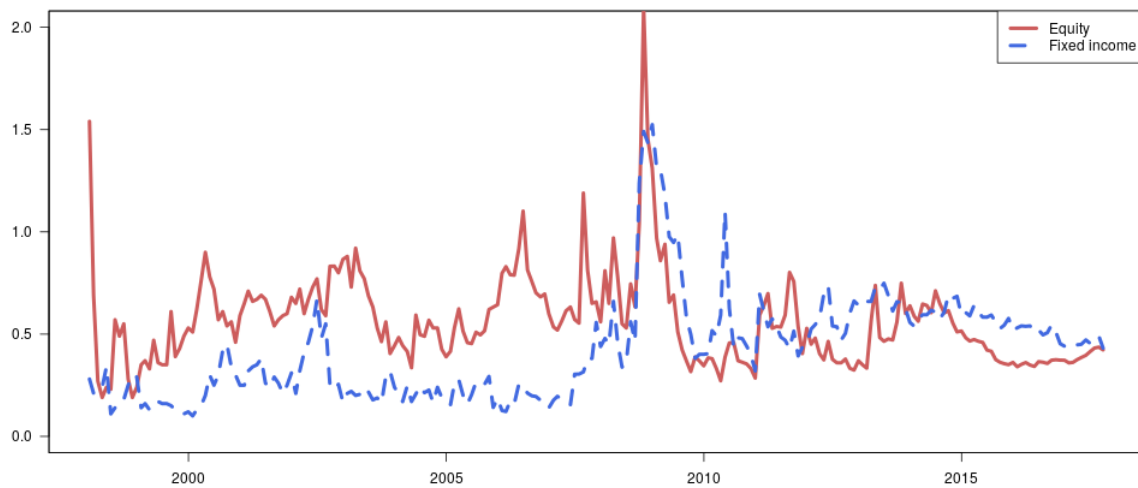
The figure plots the tracking errors (i.e., expected relative volatility) expressed in % per year for the total portfolio and the limit set by the Ministry of Finance in Panel A, and for the equity (red, solid line) and fixed-income portfolios (blue, dashed line) in Panel B; see NBIM (2016, p. 50) for calculation details. Data source: NBIM.

Figure 8 Evolution of the VIX and TYVIX.

Panel A: VIX
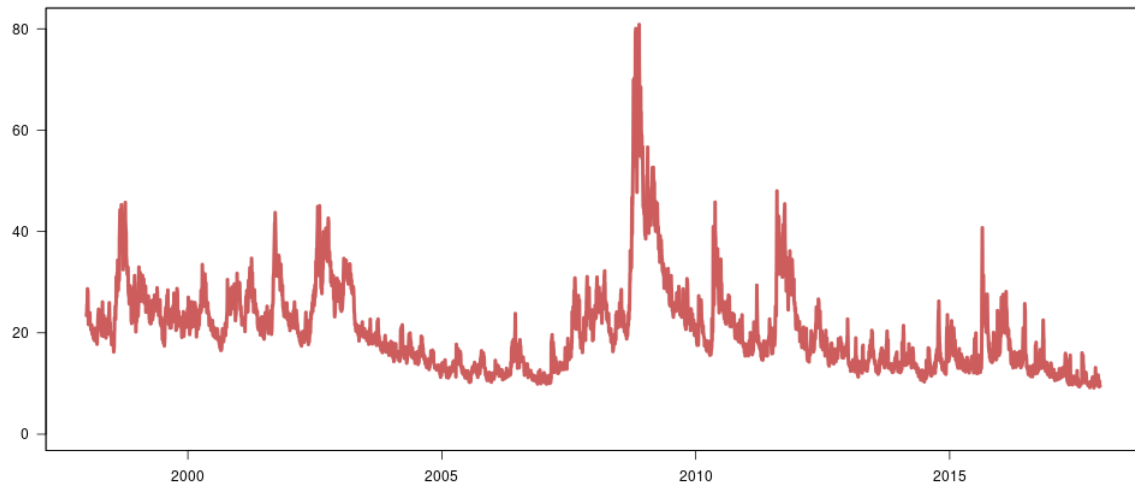
Panel B: TYVIX
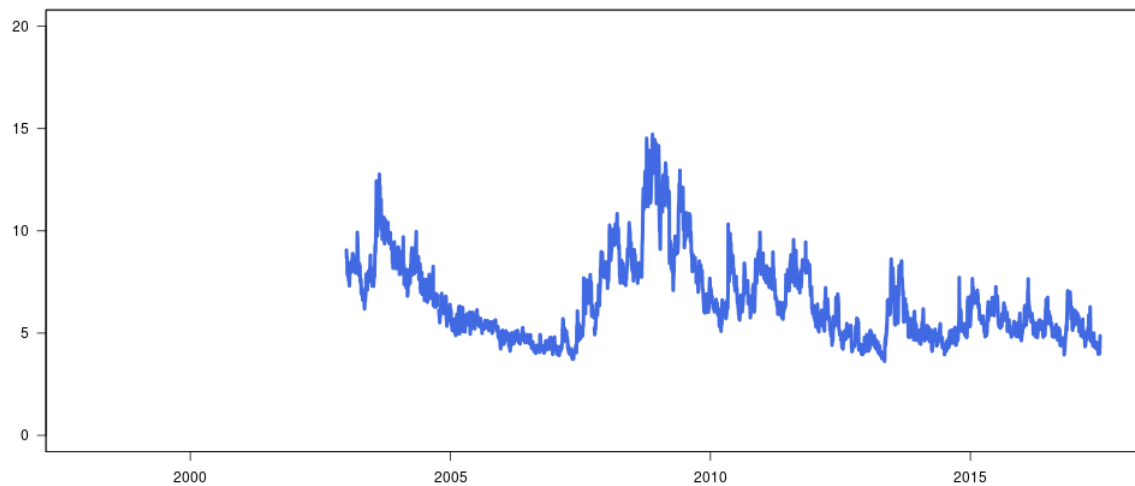
The figure plots the evolution of the VIX (implied equity volatility) in Panel A and TYVIX (implied Treasury volatility) in Panel B. The implied volatilities are expressed in % per year. Data sources: *FRED* at St. Louis Federal Reserve Bank and *Bloomberg*.

the VIX, an index of implied US equity volatility, and TYVIX, an index of implied US Treasury volatility. The figure shows a general decrease in volatilities in the most recent years. Second, the equity and fixed-income portfolios have been moving closer to their benchmarks in recent years (as we found earlier when analyzing the risk contributions due to the benchmarks).

We also note that the low tracking error for the fixed-income portfolio before the financial crisis and then the increase during the crisis go hand in hand with the possibility of hidden fixed-income risk discussed in the previous subsection. Since the financial crisis, the tracking error has established itself at a higher level than before the crisis. Some of the increase in tracking error may be due to the gradual widening of the range of fixed income in the benchmark to encompass, for example, high-yield bonds and emerging market debt.

Finally, we note a small increase in tracking error in January 2017, shown in Figure 7a. This is due to changes in the real estate mandate. Real estate went from a separate asset class (included in the Fund's strategic and actual benchmarks) to being measured as a benchmark deviation, so the calculation of tracking error then needed to include real estate. The weight in real estate is only 2.5% of the AUM, but real estate has a tracking error of around 7%. We return to the matter of real estate investments in a separate evaluation.

We also consider how risk is allocated to the Fund's different investment strategies. The tracking errors for the investment strategies are always relative to internal benchmarks developed by the Fund (and discussed later). Figure 9 shows NBIM's estimated tracking error broken down by the three main investment strategies: fund allocation, security selection, and asset management. Note that these tracking errors have been calculated only for 2016 and 2017, not for the whole 2013–2017 period we analyze. The strategy with the largest tracking error for the equity portfolio is security selection; for the fixed-income portfolio, the differences in tracking error between strategies are less pronounced. However, note that we cannot infer the contributions to the total risk from these tracking

errors as we do not have the asset bases for the strategies or information on cross-strategy effects.

We separately investigate the part of the Fund's portfolio managed by external mandates. Figure 10 shows the tracking errors estimated separately for the assets managed internally and by external mandates, indicating that they have similar tracking errors.

4.5 Expected shortfall

Next, we consider the expected shortfall, also referred to as conditional value at risk, used as a measure of downside risk. The expected shortfall was introduced only recently into the Fund's reporting. Effective February 1, 2016, the Ministry of Finance required Norges Bank's Executive Board to set an upper limit for the expected shortfall between the return on the Fund and its benchmark. The Executive Board has set a limit on the expected shortfall of 3.75%.

The expected shortfall measures the average expected loss in the worst q percent of observations, where q is the tail probability. We have obtained the expected shortfall estimates from NBIM. The shortfall is calculated using a 97.5% confidence level (see NBIM 2016, p. 53). That is, the Fund is to be managed in such a way that the expected shortfall for the Fund relative to its benchmark does not exceed 3.75% in extreme situations.

Figure 11 shows NBIM's estimates of the expected shortfall of the Fund starting in 2016, together with the limit set by the Executive Board. In 2016, the actual level was 0.87%. At the beginning of 2017, we observe a jump in the expected shortfall to 1.35%. This is due to the inclusion of real estate in the benchmark, and is similar to the behavior of the expected tracking error in Figure 7a.

We have also obtained the expected shortfall calculated separately for the Fund's strategies. Figure 12 shows estimates of expected shortfall broken down by the three strategies: fund allocation, security selection, and asset management. The expected shortfalls for the strategies are relative to internal benchmarks developed by the Fund. The strategy with the largest expected shortfall is security selection. Again, note that we cannot infer

Figure 9 Tracking error by strategy.

Panel A: Equity portfolio
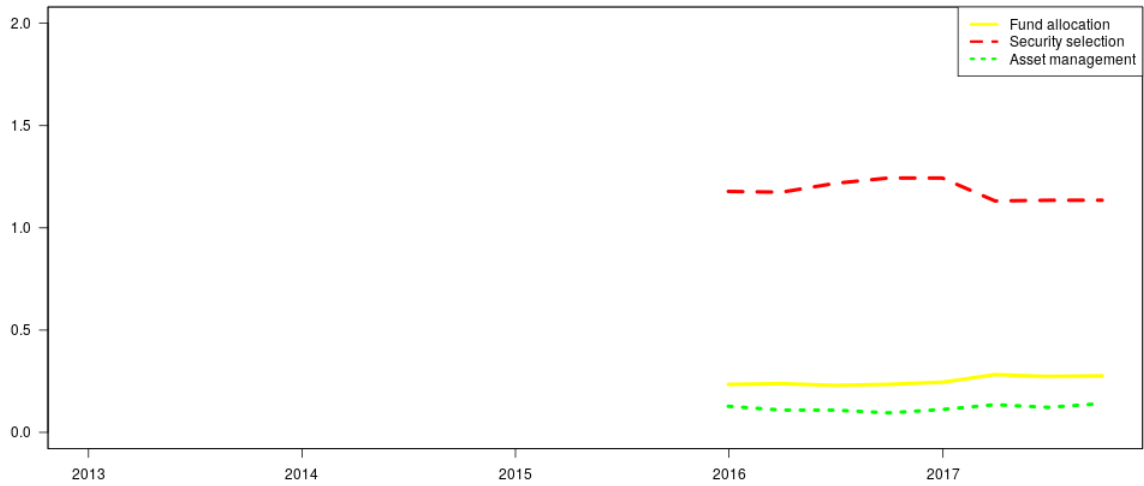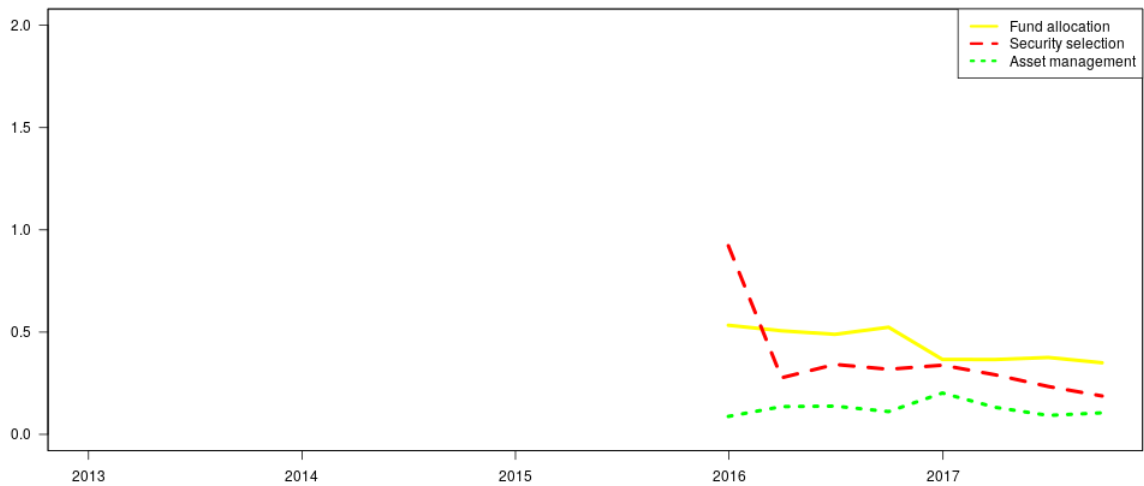
Panel B: Fixed-income portfolio

The figure plots the tracking errors (i.e., expected relative volatility) expressed in % per year for the three main strategies (i.e., fund allocation, security selection, and asset management) in the equity portfolio (Panel A) and fixed-income portfolio (Panel B); see NBIM (2016, p. 50) for calculation details. The tracking errors for the strategies are relative to internal benchmarks developed by the Fund. Data source: NBIM.

Figure 10 Tracking error by internal and external equity mandates.
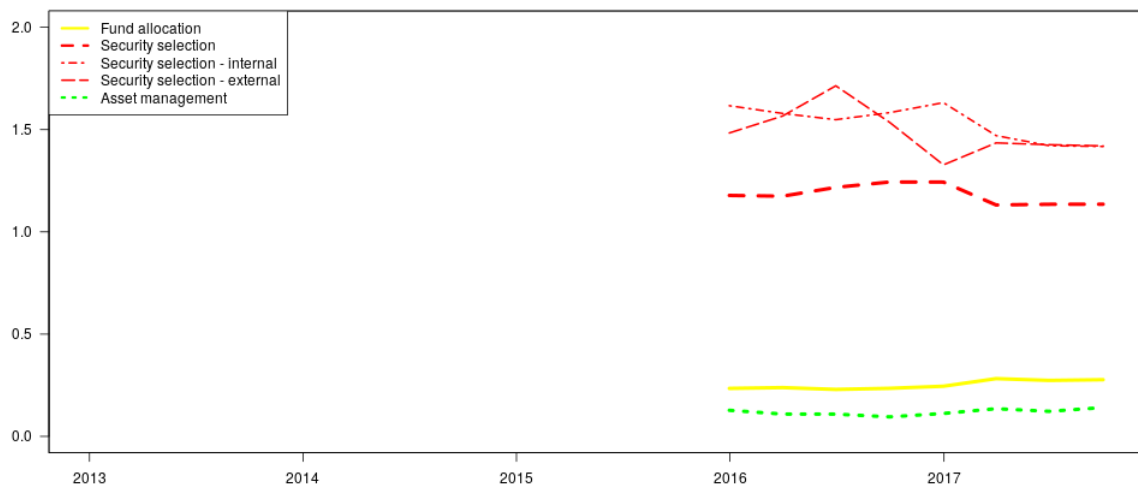
The figure plots the tracking errors (i.e., expected relative volatility) expressed in % per year for the three main strategies (i.e., fund allocation, security selection, and asset management) and for two sub-strategies of security selection (i.e., external and internal); see NBIM (2016, p. 50) for calculation details. The tracking errors for the strategies are relative to internal benchmarks developed by the Fund. Data source: NBIM.

Figure 11 Expected shortfall of the total portfolio.
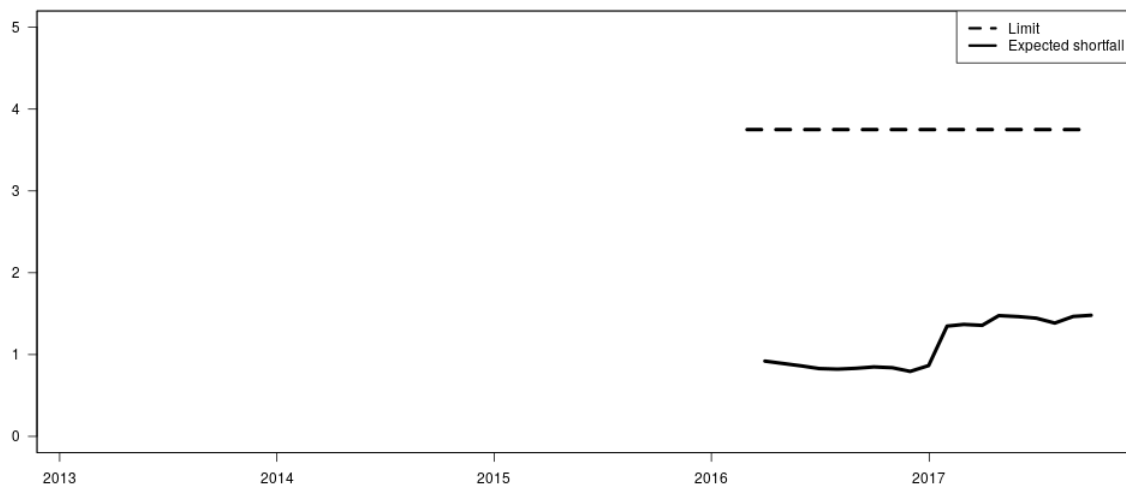
The figure shows the expected shortfall estimated using historical simulation based on current exposure for the total portfolio. The measure calculates the average loss in the worst 2.5% of weekly returns and is annualized by multiplying by $\sqrt{52}$; see NBIM (2016, p. 53). Data source: NBIM.

the contributions to the total risk from these expected shortfalls.

Figure 12 Expected shortfall by strategy.
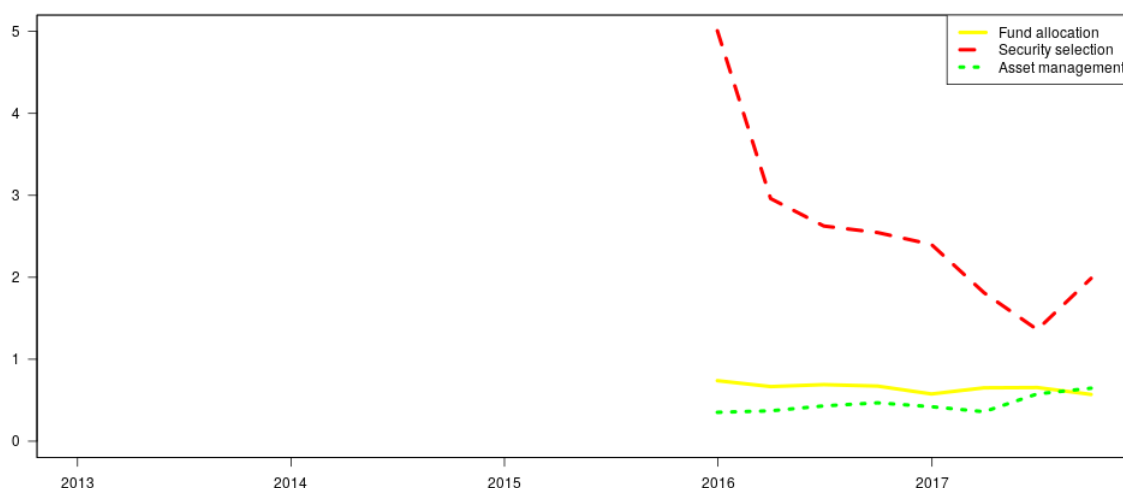
The figure shows the expected shortfall estimated using historical simulation based on current exposure for the three main strategies (i.e., fund allocation, security selection, and asset management). The measure calculates the average loss in the worst 2.5% of weekly returns and is annualized by multiplying by $\sqrt{52}$; see NBIM (2016, p. 53). The expected shortfalls for the strategies are relative to internal benchmarks developed by the Fund. Data source: NBIM.

4.6 Management costs

The costs involved in running the Fund fall into two categories: the transaction costs involved in trading financial assets, and the costs of running the Fund's operations, i.e., the management costs. The direct transaction costs are accounted for in the Fund's returns, but the management costs are calculated separately. The management costs include items such as salary, custody costs, IT systems, research, and offices in Norges Bank (NBIM, 2017c).

In this section we present management costs as reported by NBIM. Figure 13 reports the annual management costs, as percentages of market value, for the total Fund and separately for the equity and fixed-income portfolios.

We note that the management costs of the Fund have recently fallen relative to AUM.

Figure 13 Management costs by asset class.
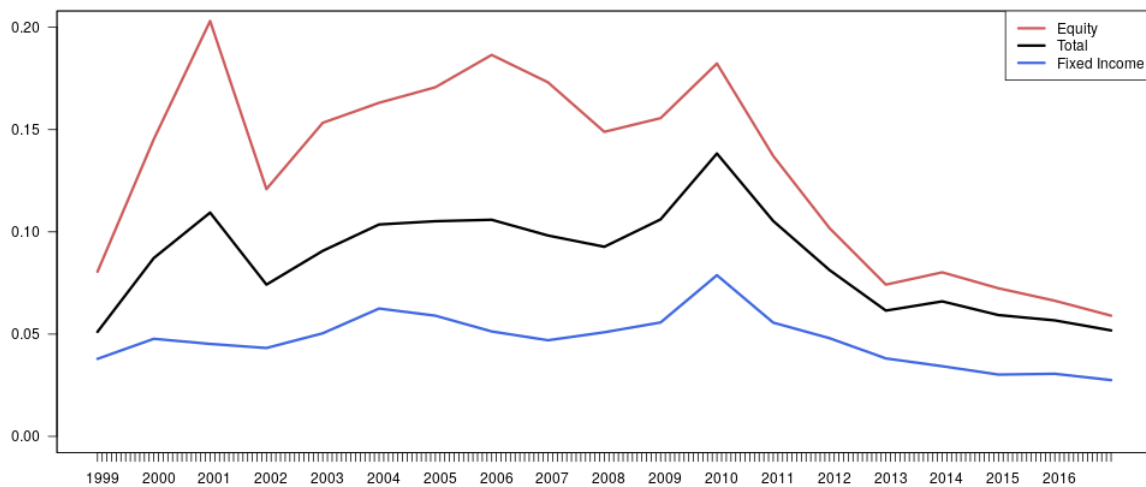
The figure shows the annual management costs of the total (exclusive of real estate), equity, and fixed-income portfolios expressed in % of AUM in each portfolio. Data source: NBIM.

The types of costs discussed here (e.g., salaries, IT systems, and offices) usually have both fixed and variable components. As the AUM increases, the fixed-cost part of the relative costs falls. To gain some perspective on this, it is interesting to consider the total costs in NOK. Figure 14 reports the annual costs, which have increased. The costs may level off, but much of the decline in relative costs is simply due to the increase in AUM. Some of the increase in total costs in the last few years is due to the introduction of real estate in the Fund.

We will later evaluate the external equity mandates of the Fund. As part of that analysis, we want to understand the costs involved. Figure 15 presents fees paid to the external managers as a percentage of AUM for the external mandates. The external costs are consistently higher than the internal costs. We note an increase in external manager fees around the years 2009 and 2013, whereas the internal costs stayed low and even declined at those times. The 2009 peak in external manager fees is largely due to performance-based fees (see NBIM 2017a, p. 65). This peak carries over to the total management costs presented in Figure 14.

Figure 14 Total management costs.
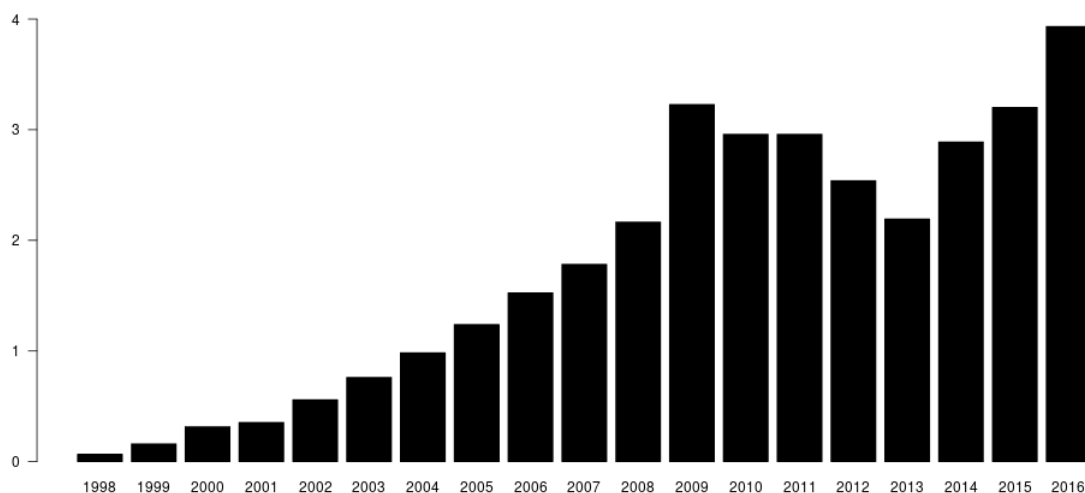
The figure shows the annual management costs in NOK billion. Data source: NBIM.

Figure 15 Management costs of external equity mandates and internally managed equities.
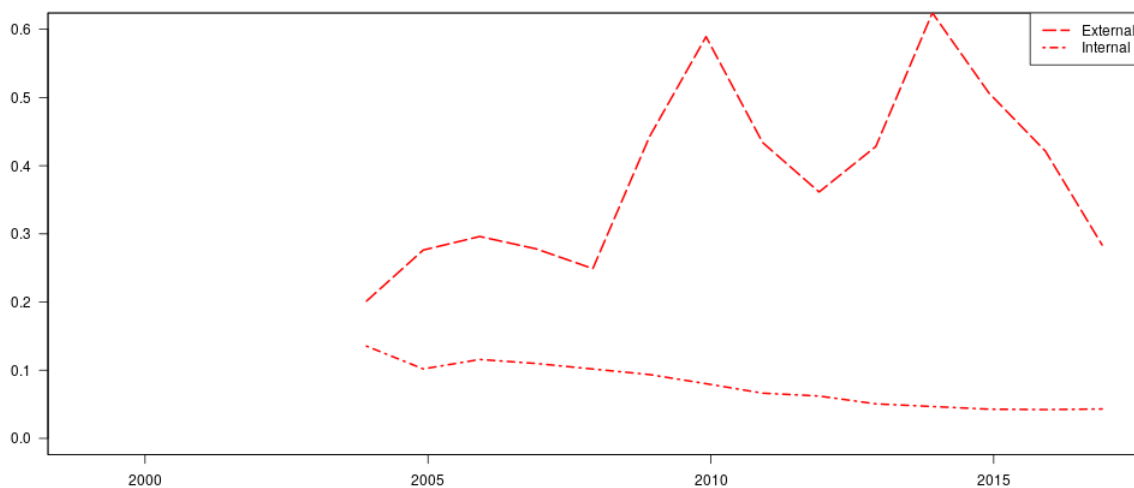
The figure shows the annual costs of external equity mandates (dashed line) and internal equity security selection (dashed-dotted line) in % of AUM. Data source: NBIM.

We have also obtained information on the costs assigned to the various investment strategies in 2016. These are NBIM's estimates of the internal management costs per strategy: asset management, 0.03%; and security selection, 0.20% (internal, 0.07%; external, 0.50%). The corresponding contributions to the Fund's total management costs of 0.05% in 2016 are approximately 0.02% from each of asset management and security selection, with the remainder coming from fund allocation and real estate.

5 A first performance analysis of active returns

5.1 Mean active returns

We first evaluate the Fund based on its mean active returns, $R_t - R_t^b$, that is, the mean return difference between the Fund and the actual benchmark. The assumption is that the benchmark captures the risks of the Fund on a one-to-one basis (i.e., the Fund has a beta of one relative to the actual benchmark). We then consider the mean risk-adjusted active returns, allowing for a beta different from that of the Fund relative to its benchmark. Later, we consider factor regressions, taking into account various factor tilts, and discuss the performance in terms of alphas and betas.

Table 5 presents the mean active returns before and after costs for the 1998–2017 and 2013–2017 sample periods. In the full sample period, the means of the active returns are 0.29%, 0.49%, and 0.15% per year for the total, equity, and fixed-income portfolios, respectively, with the mean for the equity portfolio being statistically significant at the 5% level. The estimated annual costs for the equity and fixed-income portfolios are 0.13% and 0.05%, respectively. The estimated costs for the total portfolio are the weighted average costs for the equity and fixed-income portfolios, giving annualized costs of 0.09%. The means after costs are then 0.20%, 0.36%, and 0.11% per year for the total, equity, and fixed-income portfolios, respectively. In the more recent sample period, the means of the active returns are lower but the costs are also lower: the means after costs are now 0.20%, 0.30%, and –0.06% per year for the total, equity, and fixed-income portfolios, respectively.

Taken together, assuming the actual benchmark captures the proper risks, the Fund in total has outperformed by 0.20% per year. The equity portfolio has contributed the most, whereas the fixed-income portfolio performed positively in the full sample period but negatively in the more recent period.

There are two issues that are worth noting. First, it is well known that estimating a mean return with precision requires a long sample period (see, e.g., Merton, 1980; Campbell et al., 1997). Note that it is not the number of observations per se that matters,

Table 5 Mean active returns.

	Total	Equity	Fixed income
Panel A: 1998–2017			
Mean (before costs)	0.29	0.49**	0.15
	(0.28)	(0.22)	(0.56)
Observations	234	233	234
Costs	0.09	0.13	0.05
Mean (after costs)	0.20	0.36	0.11
Panel B: 2013–2017			
Mean (before costs)	0.25	0.37	−0.03
	(0.22)	(0.30)	(0.22)
Observations	54	54	54
Costs	0.05	0.07	0.03
Mean (after costs)	0.20	0.30	−0.06

The table presents the arithmetic mean active returns (before and after costs) of the total, equity, and fixed-income portfolios. Panel A reports results in the 1998–2017 and Panel B in the 2013–2017 sample periods. Means and costs are expressed in % per year. Means (before costs) are annualized by multiplying the mean monthly active return by 1200. Standard errors of the means (before costs), robust to serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the period. "Costs" are the annual costs (using the 2016 costs as an estimate for 2017) of managing the Fund. "Mean (after costs)" is the mean (before costs) minus the costs. Note that costs do not take into account the costs of passively managing the benchmark. Hence, the mean (after costs) can be seen as a lower estimate of the true performance.

but the sample period's calendar length. Moreover, the power to reject the null hypothesis of a zero mean is typically low. Again, long sample periods are required in order to do so. In our case, with the sample periods 1998–2017 and 2013–2017, we will inevitably estimate mean returns with wide confidence bands and it will be difficult to statistically reject neutral performance (even if the Fund truly out- or underperforms its benchmark).

Second, we have estimates only of the Fund's costs, not of the cost of passively implementing the benchmark. However, NBIM (2017c) reported the estimated costs of passively managing the benchmark, identifying three types of costs: management costs (discussed above for the Fund), transaction costs related to replicating the benchmark, and transaction costs related to net inflows and extraordinary benchmark changes. However, revenues from securities lending mitigate these costs. NBIM estimated that the net costs of the passive benchmark were 0.08% per year from 1998 to 2016, but that in the last five years (three years) they have been 0.04% (0.01%) per year. Broadly speaking, all kinds of costs have decreased over time, whereas the revenues from securities lending have remained the same. The main reason for the recent lower costs is decreasing transaction costs due to net inflows and extraordinary benchmark changes. The estimated costs of managing the actual benchmark could in principle be added to the performance of the Fund (see Fama and French, 2010, for a discussion of costs in mutual funds and efficiently managed passive benchmarks). Adding the estimated costs of managing the actual benchmark would imply that the active return has been a good approximation of the performance of the Fund. Subtracting all costs, as in the bottom row in Table 5, can be seen as a conservative estimate of the performance.

Table 6 presents the mean risk-adjusted active returns before and after costs of the total, equity, and fixed-income portfolios for the 1998–2017 and 2013–2017 sample periods. The risk-adjustment is done by adjusting the Fund's beta relative to its benchmark. That is, we run a regression of the Fund's return in excess of a risk-free rate on the actual benchmark

return in excess of the risk-free rate:

$$(R_t - R_{f,t}) = a + b(R_t^b - R_{f,t}) + \varepsilon_t, \tag{4}$$

where $R_{f,t}$ is a proxy for a risk-free rate (converted into the CB from the US one-month T-bill rate; see Appendices D and E). The estimated slope coefficient b is the beta of the Fund relative to its benchmark and the estimated constant a is the risk-adjusted mean active return (or the alpha after adjusting for the difference in risk between the Fund and the benchmark). The risk-adjusted active return is a true excess return (zero-cost portfolio). For example, if the beta is 0.95 (1.05), it is like investing 95% (105%) in the actual benchmark and 5% (–5%) in the risk-free proxy. We later discuss the drawbacks of not having a risk-free rate in the CB.

As the beta of the total portfolio is above one and the returns on the Fund and the benchmark are above the risk-free proxy, the mean risk-adjusted active returns are now lower (0.15% and 0.18% per year before costs and 0.07% and 0.13% per year after costs). Again, note that we do not take into account the costs of passively managing the benchmark. We now have the added complication that when the beta is above one, an investment in the benchmark of more than 100% requires borrowing at the risk-free rate, potentially incurring additional costs due to this leverage. The mean beta-adjusted active returns are also lower for the equity portfolio in both sample periods and for the fixed-income portfolio in the full sample period (the mean is approximately the same in the more recent sample period).

Overall, we find that the Fund outperforms its benchmark, mainly due to its equity portfolio, by about 0.20% per year after taking into account all of the Fund's costs. Adjusting for a difference in risk between the Fund and its benchmark lowers the outperformance after costs to 0.07% and 0.13% per year in the two sample periods. As discussed above, we view these means as conservative performance estimates as they do not take into account the costs of passively managing the benchmark.

Table 6 Mean beta-adjusted active returns.

	Total	Equity	Fixed income
Panel A: 1998–2017			
Mean (before costs)	0.15	0.40**	0.07
	(0.23)	(0.19)	(0.49)
Observations	234	233	234
Costs	0.09	0.13	0.05
Mean (after costs)	0.07	0.27	0.03
Panel B: 2013–2017			
Mean (before costs)	0.18	0.22	−0.02
	(0.23)	(0.30)	(0.24)
Observations	54	54	54
Costs	0.05	0.07	0.03
Mean (after costs)	0.13	0.15	−0.05

The table presents the arithmetic mean of the beta-adjusted active returns (before and after costs) of the total, equity, and fixed-income portfolios. Panel A reports results in the 1998–2017 and Panel B in the 2013–2017 sample periods. The beta-adjustment allows for a beta different from that of the Fund relative to its benchmark. Means and costs are expressed in % per year. Means (before costs) are annualized by multiplying the monthly mean by 1200. Standard errors of the means (before costs), robust to conditional heteroskedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the period. "Costs" are the annual costs (using the 2016 costs as an estimate for 2017) of managing the Fund. "Mean (after costs)" is the mean (before costs) minus the costs. Note that costs do not take into account the costs of passively managing the benchmark. Hence, the mean (after costs) can be seen as a lower estimate of the true performance.

5.2 Remaining evaluations of the active management

Above, we presented a first performance analysis of the Fund's active management by considering the Fund's active returns. The remaining evaluations approach the Fund's active management from different perspectives. In Section 6 we evaluate the performance using factor models. Norges Bank's mandate states that the Fund's equity and fixed-income portfolios should be composed in such a way that their active returns (relative to their benchmarks) are exposed to several systematic risk factors. We therefore consider factor exposures to well-known equity and fixed-income factors and assess the performance taking these exposures into account. In Section 7 we measure what the Fund extracts from the capital markets and the value added it provides in NOK. In Section 8 we consider holdings data for the Fund's equity portfolio. We can then further assess the activity of the Fund and decompose its returns into policy (benchmark), selection, and timing components. In Section 9 we evaluate the performance of the Fund's main strategies (i.e., fund allocation, security selection, and asset management), including internally managed assets and external equity mandates. Finally, in Section 10 we evaluate the Fund's real estate investments.

6 Evaluating the performance using factor models

We will now use factor models to evaluate the performance of the Fund.

The factor model will decompose the return difference between the Fund and the actual benchmark (i.e., the active return) into an alpha term, a beta term, and a mean-zero residual term. The alpha term can be seen as the part of the mean active return that is not generated by the factors considered and is a standard performance measure. The beta term is the part of the mean active return that is generated by the Fund's exposures to the factors. Whether the Fund should be credited for the active return generated by factors is an open question. Suppose a particular factor performs well and the Fund benefits from exposure to it. This would lead to a lower alpha and could be interpreted as the Fund having poorer performance (relative to the mean active return). However, one could argue that the Fund should be credited for having chosen exposure to this factor. In other words, one could argue that the Fund is adding value through factor investing. Irrespective of the interpretation of the beta term, the exposures (the betas) to the factors help us understand how the Fund generates active returns.

We begin by discussing factor choices, the investability and construction of the factors, and certain issues related to estimating and interpreting factor models. We then provide summary statistics of active returns and factors, and present performance analyses using factor regressions for the total portfolio as well as for its equity and fixed-income portfolios. We finally discuss complementary factors.

6.1 Factor models

Choice of factors

We are guided by simplicity and robustness when choosing factors and models. To keep our review transparent, we focus on and present one main model, while separately considering alternative factors and specifications. Considering several alternative factors might also mitigate the concern that an unambiguous consensus factor model has yet to emerge

in the academic literature.

The literature on factor models typically does not explicitly specify the sources of the risks or priced factors. Many empirical factor models often use the capital asset pricing model (CAPM) of Sharpe (1964), Lintner (1965), and Mossin (1966) as a starting point, augmenting its market return with additional factors based on their observed performance. The additional factors may be justified with reference to theoretical multifactor models, such as the intertemporal CAPM (ICAPM) of Merton (1973) and the arbitrage pricing theory (APT) of Ross (1976), but are often only vaguely related and empirically documented. For many years the development and testing of new factor models has been an active research area. However, many of the factors that seem important for the cross-section of expected returns have recently been questioned mainly due to data mining (see, e.g., Harvey et al., 2016; McLean and Pontiff, 2016; see also Harvey, 2017, for a discussion of inference and statistical significance).

What factor model is reasonable for a global mega portfolio like that of the Fund? It was long commonly assumed that the riskiness of equity portfolios could be measured using the market, size, and value factors identified by Fama and French (1993), and sometimes augmented with the momentum factor of Carhart (1997). In Dahlquist et al. (2015), we concluded that for equity investments, the Fama and French (2015) five-factor model represents a suitable frontier model. It supplements the Fama and French (1993) three-factor model with profitability and investment factors. Fama and French (2016) found that their five-factor model helped explain anomalous return patterns in their three-factor model related to market beta, stock repurchases, and return volatility. We therefore view the Fama and French (2017) international five-factor model as a reasonable starting point. There are certainly competing factor models, for example, the investment-based four-factor model of Hou et al. (2015, 2017). This model has performed well on US data, though we are unaware of any published work estimating this model on non-US data.

The literature on factor models has focused more on the cross-section of expected returns on US stocks than on global stocks, so the global cross-section of expected re-

turns is arguably less well understood. Hou et al. (2011) and Fama and French (2012) suggested that local (i.e., country or regional) or international (comprising separate local and foreign components) versions of factors do a better job of pricing local assets than do purely global versions (see also Bekaert et al., 2009, for country-industry and country-style factors capturing international stock co-movements). Relatedly, the results of Fama and French (2017) suggest that the five-factor model performs better when estimated on a regional basis than when estimated for the world as a whole, using global factors. In actual performance evaluations, researchers have used US domestic factors (e.g., Berk and van Binsbergen, 2015), factors constructed for each individual country (e.g., Ferreira et al., 2013), or regional factors (e.g., Cremers et al., 2016) when evaluating international portfolios or funds. While we use the international version of the five-factor model for the total portfolio as well as the equity and fixed-income portfolios, we keep in mind its drawbacks for regional portions of the Fund. We also emphasize that we are evaluating the relative performance of the Fund versus its benchmark, rather than the absolute performance of the Fund.

Regarding fixed-income investments, there is less empirical academic work and, as we understand it, less consensus on the choice of factor model for performance evaluations. In particular, no factor model of fixed income enjoys a standing comparable to that of the Fama-French equity models discussed above. However, term and default factors, capturing duration and credit risks, respectively, have long been used by academic researchers (see, e.g., Fama and French, 1993). As corporate bonds tend to have a lower duration than do government bonds, we use a duration-adjusted default factor provided by NBIM to better isolate the default premium in the default factor (see Hallerbach and Houweling, 2013; Asvanunt and Richardson, 2017).

To sum up, as a base model, we consider five equity factors (representing market, size, value, profitability, and investment risks) and two fixed-income factors (representing term and default risks); we also combine them and consider a seven-factor model. The factors are listed in Table 7. All factors are excess returns (or zero-cost portfolios) and observed

Table 7 Factors in the seven-factor model.

Factor	Description
MKT	Market, the return on a world market portfolio minus the US one-month T-bill rate.
SMB	Small minus big, the return on a small stock portfolio minus the return on a big stock portfolio.
HML	High minus low, the return on a value portfolio minus the return on a growth portfolio.
RMW	Robust minus weak, the return on a robust-operating-profitability portfolio minus the return on a weak-operating-profitability portfolio.
CMA	Conservative minus aggressive, the return on a conservative investment portfolio minus the return on an aggressive investment portfolio.
TERM	Term premium, the return on a global Treasury index (containing Treasuries with maturities of more than ten years) minus the return on a global Treasury index (containing Treasuries with maturities of one to three years).
DEF	Default premium, the return on a portfolio of corporate bonds minus the return on a portfolio of Treasury bonds (both with more than ten years to maturity, and duration adjusted).

The table lists the five equity factors (i.e., MKT, SMB, HML, RMW, and CMA) and the two fixed-income factors (i.e., TERM and DEF) in the seven-factor model. See Appendix E for details and sources.

on a monthly basis. All returns and factors are expressed in terms of the Fund's currency basket (see Appendix D).

We finally recognize a literature that gives a different perspective on understanding the global cross-section of expected returns (across countries as well as asset classes) in the forms of themes or styles, such as value, momentum, quality, and carry, often used in academic research as well as in practice. See, for example, Asness et al. (2013) on value and momentum, Frazzini and Pedersen (2014) on betting against beta, and Koijen et al. (2017b) on carry; for fixed income in particular, see Litterman and Scheinkman (1991), Cochrane and Piazzesi (2005), Dahlquist and Hasseltoft (2013, 2016), and Brooks and Moskowitz (2017) on factor structures in Treasury bonds, and Koijen et al. (2017a) who integrated Treasuries with equity returns. At the end of this section, we consider some of these alternative factors together with various liquidity and funding factors.

Investability and construction of factors

To interpret an alpha estimate as a performance measure, the factors used in the regressions must be investable for the asset manager. If the factors are investable, the construction of factor returns should take into account the restrictions of the Fund (e.g., short-selling constraints, risk budget constraints, maximum holdings in individual companies, and sufficient trading volume). For example, in Dahlquist et al. (2015) we advised against including momentum as a factor when evaluating the performance of the total fund portfolio. Investing in the momentum factor would require frequent and extensive rebalancing of the portfolio. For a mega fund, it would therefore be practically impossible to obtain a profitable systematic exposure to momentum at the Fund level. (See Frazzini et al., 2015, and Novy-Marx and Velikov, 2016, for recent studies of the impact transaction costs may have on factor returns.) However, it could be interesting to examine whether certain sub-strategies of the Fund are exposed to momentum. Moreover, for the `HML`, `RMW`, and `CMA` factors, we consider versions that do not include small-cap stocks. These factors are provided by NBIM and we refer to them as "big" factors.

In Dahlquist et al. (2015), we briefly commented on international variations in accounting standards, as they may influence the analysis. For example, book value depends on the depreciation allowances assumed in each country. Moreover, the construction of a global factor (e.g., a value/growth factor) might involve large tilts in terms of countries and sectors. Fama and French (2012) discussed this in their work on international size and value factors. They used regional book-to-market break points when allocating stocks to the global portfolios to mitigate any effects of differences in accounting rules across regions. They also discussed related issues concerning size and momentum.

Estimating and interpreting the factor model

We consider the following seven-factor model:

$$R_t - R_t^b = a + b_{MKT}\text{MKT}_t + b_{SMB}\text{SMB}_t + b_{HML}\text{HML}_t + b_{RMW}\text{RMW}_t + b_{CMA}\text{CMA}_t$$

$$+ b_{TERM}\text{TERM}_t + b_{DEF}\text{DEF}_t + \varepsilon_t, \tag{5}$$

where $R_t - R_t^b$ is the return difference between the Fund and the actual benchmark (i.e., the active return), the right-hand-side variables are the factors described above, and ε_t is an error term. The estimate of the constant a will be the alpha and estimates of the b-coefficients will be the exposures (betas) to the factors. This seven-factor model nests a five-factor model (by excluding the fixed-income factors TERM and DEF) and a two-factor model (by excluding the equity factors MKT, SMB, HML, RMW, and CMA). It also trivially nests a simple mean active return by excluding all factor returns. This corresponds to assuming that the Fund's risk exposures are the same as those of the benchmark. All returns and factors are observed on a monthly basis and expressed in the Fund's currency basket.[6]

We estimate the factor models for several sample periods; however, we tabulate the results for only two sample periods, 1998–2017 and 2013–2017, and only comment on specific differences for other periods. While the full 1998–2017 sample period is of general

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[6]NBIM also uses factor regressions to evaluate the performance of the Fund; see NBIM (2017c). Note that our analysis is undertaken in the currency basket of the Fund, whereas NBIM's analysis is in USD. Nevertheless, conclusions are similar regarding which factors are important and the magnitudes of the estimated alphas.

interest, the analysis assumes that factor exposures (i.e., betas) remain constant over the entire period. Previous analysis by Ang et al. (2014) and our own analysis suggest that the Fund has changed its risk characteristics in ways not captured by the benchmark or the factor returns. Time variation in the betas makes it difficult to interpret the alphas for the full sample period. Consistent with our mandate, we therefore put more emphasis on the more recent sample period, i.e., 2013–2017. While it may be difficult to interpret alphas from factor models, our analysis serves an additional and important purpose: the beta estimates in factor model regressions are informative about how the Fund attempts to achieve performance. Observing a positive beta estimate for one particular factor, for example, the value factor, implies that the manager has tilted the Fund toward value (rather than growth) relative to its benchmark. This is important for understanding the risk-taking in the active management of the Fund.

Three details about the estimation of factor models deserve specific mention. First, we discussed above that estimating a mean return with precision requires a long sample period (see, e.g., Merton, 1980; Campbell et al., 1997). The same applies to alphas. More frequent sampling typically helps for the estimation of the volatility and betas but not for the mean or alpha. Moreover, as with the mean, the power to reject the null hypothesis of zero alpha is typically low. Again, long sample periods are required in order to do so. In our case, with the sample periods 1998–2017 and 2013–2017, we will inevitably estimate alphas with wide confidence bands and it will be hard to statistically reject neutral performance (even if the Fund truly out- or underperforms).

Second, the common approach to implementing factor models in mutual fund evaluations is to let the left-hand variable in the regressions be the return of the Fund in excess of a risk-free rate. We lack a good proxy for the risk-free rate in the currency basket (see also the discussion in Dahlquist et al., 2015). Moreover, the Ministry of Finance has assigned a strategic benchmark for the Fund and the goal here is to measure the marginal contribution over and above the actual benchmark. It is therefore natural to let the left-hand variable in the regressions be the return difference between the Fund and the

actual benchmark. Note, however, that this approach may have a disadvantage: because the return of the Fund's benchmark may differ from that of the seven-factor model, the benchmark itself might be associated with an alpha, and the alpha estimated for the Fund would then incorporate the alpha associated with the benchmark. Our interpretation is that the "true" alpha is the difference between the Fund's estimated alpha and the alpha associated with the benchmark (see also Cremers et al., 2013, for a discussion of alphas in benchmarks). Hence, a possible advantage is that, as we are interested in the active return, a model with an equal pricing error for the Fund and its benchmark is still useful. We checked the sensitivity to this by (i) running the factor regressions in USD and (ii) including the benchmark as a factor, essentially allowing for a beta different from one; we obtained very similar results using the two methods (untabulated).

Third, in mutual fund evaluation it is common to consider fund returns net of costs (e.g., trading costs and expenses) when computing performance measures, as this is the return the investor actually obtains. For example, in a factor model regression, the Fund return on the left-hand side of the regression is measured after transaction costs. We use a similar approach, but start from the return after transaction costs but before management costs to obtain the gross alpha and then deduct the estimated management costs to obtain the net alpha. In principle, the adjustment should reflect all costs accruing due to the Fund's strategy. This would include the costs of investing in the factors and the costs associated with possible changes in the benchmark. The Fund's true alpha is thus the alpha estimated net of all costs, plus an assessment of how much extra it would cost for the Fund to implement the benchmark. Factors are typically not attainable for free (i.e., achieving exposure to factors entails rebalancing the portfolio, which in turn incurs trading costs). Therefore, achieving a desired exposure to factors at zero alpha, after costs, can be interpreted as an accomplishment. We only have estimates of the Fund's costs, not estimates of the cost of passively implementing the factors or the benchmark. NBIM (2017c) reported the estimated costs of managing a passive benchmark, identifying three types of costs: management costs, transaction costs related to replicating the bench-

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mark, and transaction costs related to net inflows and extraordinary benchmark changes. However, revenues from securities lending mitigate these costs. NBIM estimated that the net costs of the passive benchmark were 0.08% per year from 1998 to 2016, but that in the last five years (three years) they have been 0.04% (0.01%) per year. All kinds of costs have decreased over time, whereas the revenues from securities lending have remained the same. The main reason for the recent lower costs is decreasing transaction costs due to net inflows and extraordinary benchmark changes. The estimated costs of managing the actual benchmark could in principle be added to the performance of the Fund (see Fama and French, 2010, for a discussion of costs in mutual funds and efficiently managed passive benchmarks). Hence, the net alpha estimates we present can be seen as a lower estimate given the chosen model.

Summary statistics of the factors

Before presenting the factor-model regressions, we briefly characterize the factors.

Table 8 presents summary statistics of the monthly factor returns over the 1998–2017 (234 observations) and 2013–2017 (54 observations) sample periods. In the full sample period, the mean factor returns are 1.25–5.44% per year and the standard deviations 5.91–15.65% per year; taken together, these give annualized Sharpe ratios in the range of 0.17–0.73. In the more recent sample period, there is high dispersion in the means and standard deviations. The market factor is noteworthy with an annualized Sharpe ratio of 1.04. The fixed-income factors also performed well in the 2013–2017 period, with annualized Sharpe ratios of 0.61 and 0.51 for the term and default factors, respectively.

We also consider the correlations among the factor returns in the full sample period (untabulated results). The equity factors market, size, and value are fairly uncorrelated with one another. The profitability and investment factors are positively correlated (0.30) with each other and negatively correlated with the market factor (i.e., –0.46 and –0.47, respectively). The highest correlation is between the value and investment factors (0.73). This high correlation was investigated by Fama and French (2015) and Hou et al. (2016),

Table 8 Summary statistics of the factors.

	Mean	Standard deviation	Sharpe ratio
Panel A: 1998–2017			
MKT	5.44	15.65	0.35
SMB	2.48	6.73	0.37
HML	3.88	8.86	0.44
RMW	3.93	5.41	0.73
CMA	3.42	7.14	0.48
TERM	3.49	5.91	0.59
DEF	1.25	7.27	0.17
Panel B: 2013–2017			
MKT	10.76	10.31	1.04
SMB	1.08	4.64	0.23
HML	−0.90	5.97	−0.15
RMW	2.11	3.78	0.56
CMA	0.12	3.40	0.04
TERM	4.09	6.69	0.61
DEF	3.10	6.13	0.51

The table presents arithmetic means and standard deviations of the monthly factor returns in the 1998–2017 (234 observations) and 2013–2017 (54 observations) sample periods. Appendix E describes all factors. All factor returns are expressed in the Fund's currency basket. The means and standard deviations are expressed in % per year (obtained by multiplying the monthly means by 1200 and monthly standard deviations by $\sqrt{12} \times 100$). Monthly Sharpe ratios are annualized by multiplying monthly Sharpe ratios by $\sqrt{12}$.

who debated whether or not the value factor is encompassed by the investment factor. The fixed-income factors are fairly uncorrelated with each other and with the equity factors, with the notable exception of the default factor, which is positively correlated (0.44) with the market factor.

6.2 Results

In this section, we evaluate the performance of the Fund, analyzing the total portfolio and the equity and fixed-income portfolios separately.

Total portfolio

Table 9 presents the results for the total portfolio, with Panel A reporting the regression analysis and Panel B the alpha analysis. The mean active returns considered above do not take into account any factor tilts the Fund may have relative to the benchmark. Interestingly, as indicated by the adjusted R^2 values, the factors capture more than 50% of the total variation in the active return. The Fund's positions are systematically tilted toward some of the factors. In the full sample period, there are significant tilts toward the market, size, profitability, and investment factors, but not toward the value factor. That is, the Fund has a higher market beta than does the benchmark and it overweights small-cap stocks. It also overweights more profitable firms and firms that invest aggressively. Moreover, in the full sample period, the Fund tends to have less exposure to long-term bonds (i.e., duration risk) and more exposure to corporate bonds (i.e., credit risk). However, these fixed-income exposures are unstable, which we interpret as shifts in the Fund's strategy. In the more recent sample period with low interest rates, the Fund has had a much stronger negative duration risk exposure while the credit risk exposure is no longer significant. In the more recent sample period, the Fund seems to have maintained a stable equity exposure, though the investment beta switches sign and is no longer significant.

The gross alphas in the two sample periods are now 0.07% and 0.17% per year, respectively; with estimated annual costs of 0.09% and 0.05%, the net alphas are –0.02% and

Table 9 Estimated factor models of the total portfolio.

	1998–2017	2013–2017
	(1)	(2)
Panel A: Regression analysis		
Constant	0.006	0.014
	(0.010)	(0.012)
MKT	0.017***	0.015***
	(0.003)	(0.004)
SMB	0.034***	0.025***
	(0.005)	(0.009)
HML	0.010	−0.003
	(0.007)	(0.006)
RMW	0.021**	0.008
	(0.009)	(0.016)
CMA	−0.024***	0.021
	(0.009)	(0.015)
TERM	−0.010*	−0.038***
	(0.006)	(0.009)
DEF	0.029**	0.007
	(0.012)	(0.007)
Adjusted R^2	0.54	0.55
Observations	234	54
Panel B: Alpha analysis		
Gross alpha	0.07	0.17
Costs	0.09	0.05
Net alpha	−0.02	0.12

The table presents factor regressions in Panel A and alpha analyses in Panel B. We run the following regression:

$$R_t - R_t^b = a + b_{MKT}\text{MKT}_t + b_{SMB}\text{SMB}_t + b_{HML}\text{HML}_t + b_{RMW}\text{RMW}_t + b_{CMA}\text{CMA}_t + b_{TERM}\text{TERM}_t + b_{DEF}\text{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_t - R_t^b$, is the return difference between the Fund and the actual benchmark (i.e., the active return) and the right-hand variables are all factor returns (described in Appendix E). All returns are expressed in % and in the Fund's currency basket. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. "Gross alpha" is the constant expressed in % per year (i.e., the constant multiplied by 12). "Costs" are the annual costs (using the 2016 costs as an estimate for 2017) of managing the Fund. "Net alpha" is the gross alpha minus the costs. Note that costs do not take into account the costs of passively managing the benchmark or the costs of replicating the factors. Hence, the net alpha can be seen as a lower estimate of the true performance.

0.12% per year. Note that we deduct the costs of the Fund but assume that the benchmark and factor returns are attainable without any costs. In this sense, the alphas can be viewed as conservative. Recall that NBIM (2017c) estimated the annual costs of a passive benchmark strategy to be of the order of 0.08% since inception and 0.04% over the last five years. These costs could in principle be added to the performance of the Fund. This approach would lead to net alphas of 0.06% and 0.16% per year. As we find instability in the factor exposures over time, we hesitate to interpret the negative net alpha for the full sample period as evidence of underperformance.

Equity and fixed-income portfolios

Tables 10 and 11 present the analyses of the equity and fixed-income portfolios.

The equity portfolio exhibits exposures to the equity factors similar to those of the total portfolio. In the full sample period, the Fund invests in stocks with higher market beta than does the benchmark, and overweights small-cap and growth stocks. It also overweights firms that invest more aggressively, though less so in the more recent period. The equity portfolio also exhibits exposures to the fixed-income factors similar to those of the total portfolio, but with smaller magnitudes. As indicated by the adjusted R^2 values, the factors capture close to 40% of the equity portfolio's return variation in the full sample period and somewhat less in the more recent sample period. The gross alphas are approximately 0.40% per year in the full sample period and 0.25% per year in the more recent period. With annualized costs of 0.13% in the full sample period and 0.07% in the more recent period, the net alphas are 0.16–0.28% per year. The regression constants, yielding our gross alphas, are significant at the 5% level only in the full sample period. The net alphas are of substantial economic significance in both sample periods.

As a robustness exercise, we replace the value, profitability, and investment factors (i.e., the HML, RMW, and CMA factors) with their "big" alternatives. We justify this by the investability concern discussed above. In untabulated results, we find that the net alphas are 0.13–0.21% per year; while they are lower than in the regressions with the standard

Table 10 Estimated factor models of the equity portfolio.

	1998–2017		2013–2017	
	(1)	(2)	(3)	(4)
Panel A: Regression analysis				
Constant	0.033**	0.034**	0.022	0.019
	(0.015)	(0.015)	(0.018)	(0.017)
MKT	0.016***	0.013***	0.016***	0.017***
	(0.004)	(0.004)	(0.005)	(0.006)
SMB	0.045***	0.044***	0.015	0.027*
	(0.008)	(0.007)	(0.012)	(0.016)
HML	−0.014	−0.018**	0.010	−0.002
	(0.009)	(0.009)	(0.009)	(0.010)
RMW	0.009	0.011	−0.033**	−0.009
	(0.012)	(0.011)	(0.015)	(0.025)
CMA	−0.023**	−0.017*	−0.019	0.007
	(0.011)	(0.009)	(0.022)	(0.028)
TERM		−0.012*		−0.023*
		(0.006)		(0.013)
DEF		0.013		0.012
		(0.010)		(0.008)
Adjusted R^2	0.38	0.39	0.31	0.35
Observations	233	233	54	54
Panel B: Alpha analysis				
Gross alpha	0.39	0.41	0.26	0.23
Costs	0.13	0.13	0.07	0.07
Net alpha	0.26	0.28	0.19	0.16

The table presents factor regressions in Panel A and alpha analyses in Panel B. We run the following regression:

$$R_t - R_t^b = a + b_{MKT}\text{MKT}_t + b_{SMB}\text{SMB}_t + b_{HML}\text{HML}_t + b_{RMW}\text{RMW}_t + b_{CMA}\text{CMA}_t + b_{TERM}\text{TERM}_t + b_{DEF}\text{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_t - R_t^b$, is the return difference between the Fund and the benchmark (i.e., the active return) and the right-hand variables are all factor returns (described in Appendix E). All returns are expressed in % and in the Fund's currency basket. Regressions in columns 1 and 3 do not include fixed-income factors. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. "Gross alpha" is the constant expressed in % per year (i.e., the constant multiplied by 12). "Costs" are the annual costs (using the 2016 costs as an estimate for 2017) of managing the Fund. "Net alpha" is the gross alpha minus the costs. Note that costs do not take into account the costs of passively managing the benchmark or the costs of replicating the factors. Hence, the net alpha can be seen as a lower estimate of the true performance.

factors, they are consistently positive and economically significant.

Later we consider the Fund's sub-strategies for the equity portfolio and shed light on where the systematic tilts come from.

The fixed-income portfolio exhibits significant credit risk exposure in the full sample period and significant negative duration exposure in the more recent period. The high exposure to default risk at the time of the 2008–2009 financial crisis was discussed in Ang et al. (2014). We interpret the negative duration exposure as part of the Fund's strategy to lower the duration of the portfolio in the recent period of low interest rates. It is worth noting that the two-factor model does not capture all factor risks in the fixed-income portfolio. Many of the equity factors are also significant for the fixed-income portfolio, likely due to the exposure to corporate and emerging market bonds not captured by the default factor. The two-factor model yields gross alphas of 0.10–0.17% per year. With annualized costs of 0.05% and 0.03% in the two sample periods, the net alphas are 0.05–0.14% per year. The net alpha in the seven-factor model is –0.25% per year in the full sample period and –0.06% per year in the more recent sample period. Unreported rolling factor regressions suggest that these negative returns in the full sample period appear to stem largely from positive equity exposure during and after the financial crisis.

6.3 Alternative factors

The use of the five-factor model for the equity portfolio and the two-factor model for the fixed-income portfolio was to some extent motivated by simplicity. These models are at the academic forefront, and we view them as reasonable starting points as they capture various tilts the Fund may have. The seven-factor model combines the equity and fixed-income factors. Next, we investigate the sensitivity of the Fund's active return to alternative equity, fixed-income, foreign-exchange, trend-following, and liquidity and funding factors. We do this by investigating how each of these alternative factors correlates with the Fund's active return, controlling for the commonality of the seven factors. Formally, for each alternative factor we estimate partial correlations, that is, the correlations between the residuals of

Table 11 Estimated factor models of the fixed-income portfolio.

	1998–2017		2013–2017	
	(1)	(2)	(3)	(4)
Panel A: Regression analysis				
Constant	0.008	−0.017	0.014	−0.002
	(0.017)	(0.016)	(0.015)	(0.016)
MKT		0.019***		0.012*
		(0.005)		(0.007)
SMB		0.028***		0.019*
		(0.008)		(0.010)
HML		0.031**		0.003
		(0.014)		(0.013)
RMW		0.032***		0.041*
		(0.010)		(0.022)
CMA		−0.029		0.024
		(0.019)		(0.027)
TERM	−0.012	−0.009	−0.048***	−0.059***
	(0.009)	(0.008)	(0.008)	(0.011)
DEF	0.076**	0.050**	−0.002	−0.000
	(0.031)	(0.022)	(0.007)	(0.013)
Adjusted R^2	0.28	0.39	0.40	0.42
Observations	234	234	54	54
Panel B: Alpha analysis				
Gross alpha	0.10	−0.20	0.17	−0.03
Costs	0.05	0.05	0.03	0.03
Net alpha	0.05	−0.25	0.14	−0.06

The table presents factor regressions in Panel A and alpha analyses in Panel B. We run the following regression:

$$R_t - R_t^b = a + b_{MKT}\text{MKT}_t + b_{SMB}\text{SMB}_t + b_{HML}\text{HML}_t + b_{RMW}\text{RMW}_t + b_{CMA}\text{CMA}_t + b_{TERM}\text{TERM}_t + b_{DEF}\text{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_t - R_t^b$, is the return difference between the Fund and the benchmark (i.e., the active return) and the right-hand variables are all factor returns (described in Appendix E). All returns are expressed in % and in the Fund's currency basket. Regressions in columns 1 and 3 do not include equity factors. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. "Gross alpha" is the constant expressed in % per year (i.e., the constant multiplied by 12). "Costs" are the annual costs (using the 2016 costs as an estimate for 2017) of managing the Fund. "Net alpha" is the gross alpha minus the costs. Note that costs do not take into account the costs of passively managing the benchmark or the costs of replicating the factors. Hence, the net alpha can be seen as a lower estimate of the true performance.

the seven-factor model and the residuals of regressions of the alternative factors on the seven factors.

Table 12 presents partial correlations for each of the alternative factors (added separately) for the full 1998–2017 sample period. Appendix E provides a more detailed description of the factors together with their construction and sources. All factors are expressed in the Fund's currency basket.

Panel A reports the partial correlations of the Fund's active return, after controlling for the seven-factor model, with some well-known equity factors. We find a significant correlation between the equity portfolio and momentum. We argued above that it would be costly for the Fund, given its size, to apply a momentum strategy. Still, understanding the exposure to momentum is in the interest of risk management. We find little correlation between the total portfolio and short- and long-term reversals. Interestingly, the equity portfolio exhibits a weak negative correlation with the short-term reversal factor, interpreted by Nagel (2012) as a liquidity-provision factor. As expected returns from liquidity provision tend to spike during periods of financial market turmoil, this suggests that the Fund's equity portfolio underperforms its benchmark in these times. The total and fixed-income portfolios are negatively correlated with emerging market returns. We find little correlation with the quality-minus-junk factor of Asness et al. (2017). The fixed-income portfolio tends to be positively correlated with the betting-against-beta factor of Frazzini and Pedersen (2014). The selling volatility strategy is basically a volatility index imputed variance swap return (following Daniel and Moskowitz, 2016). The active returns of the total, equity, and fixed-income portfolios are all significantly correlated with this strategy, meaning that the Fund tends to perform better in less-volatile times, whereas the benchmark tends to perform better in more volatile times.

Panel B reports the partial correlations with the term and credit risk factors considered by Ang et al. (2014). Although all of these factors are based on US data, they nevertheless complement the global fixed-income factors in the two-factor model. There is a significant negative correlation between the term risk factor and the fixed-income and total portfolios.

This suggests that the global term factor in the seven-factor model does not capture all duration risk. Moreover, there are positive correlations between the credit risk factors and the fixed-income portfolio. We noted earlier that the two-factor model did not capture all the credit risks in the fixed-income portfolio. The inclusion of the five equity factors to create the seven-factor model helped, but there still seems to be some credit risk exposure that warrants further exploration. Panel B also reports the partial correlation with the carry and dollar-carry factors. None of the correlations for these foreign-exchange factors is significant.

Panel C reports the partial correlations with the returns of five lookback straddles (i.e., on bonds, currencies, commodities, short-term interest rates, and stock indices) as in Fung and Hsieh (2001). These lookback straddles are of interest as they capture trend-following strategies and have been used extensively as performance benchmarks for hedge funds. We find significant negative correlations between the active return and the trend-following strategy for short-term interest rates and a positive correlation between the active return on the equity portfolio and the trend-following strategy for currencies. This suggests that the total portfolio performs worse than its benchmark when fixed-income markets experience negative and positive trends, whereas the equity portfolio performs better than its benchmark when the currency markets experience trends.

Panel D reports the partial correlations with various liquidity and funding factors. These factors are known to capture crisis periods and can provide further insights into the sensitivity of the active return to crisis scenarios. There are only weak correlations between the active return and the traded and non-traded liquidity factors of Pástor and Stambaugh (2003). The implied volatility of the S&P 500 index (VIX) and the three-month USD Libor minus the three-month US T-bill rate (i.e., TED spread) are often used as proxies for volatility and funding risks, respectively. The correlation between the active return and the change in the TED spread is negative and statistically significant. This correlation indicates that the Fund is more exposed to funding risks than is the benchmark. Changes in VIX are negatively correlated with the equity portfolio and positively

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correlated with the fixed-income portfolio, so the overall correlation is close to zero for the total portfolio. The remaining three factors in Panel D are liquidity measures, as constructed by Nagel (2016). We find small correlations with changes in the spread between the interest rate on three-month general collateral repurchase agreements (effectively an interbank loan collateralized by Treasuries) and the three-month US T-bill rate. However, the spread between the three-month certificate of deposit (CD) rate and the T-bill rate exhibits a significant negative correlation with the equity portfolio, which carries over to the total portfolio, providing consistent and complementary evidence regarding the TED spread. Finally, the correlation between the fixed-income portfolio and the spread between on-the-run and off-the-run two-year T-notes is significantly negative. As this on-the-run, off-the run spread can be interpreted as a liquidity premium, this suggests that the fixed-income portfolio does better than does its benchmark in times of lower liquidity.

In addition to the partial correlations, we have considered the increase in adjusted R^2 value when adding an alternative factor (untabulated results). The largest increase occurs for the factor representing the strategy of selling volatility. For the total and fixed-income portfolios, the adjusted R^2 value increases by about four percentage points when this factor is added. Other notable increases in the adjusted R^2 value occur when adding the change in the TED spread and the change in the CD spread (yielding three-percentage-point increases for the total portfolio return). For the equity portfolio return, the increases are six percentage points for the change in the CD spread and three percentage points for the momentum factor.

To sum up, we find some statistically significant partial correlations, most notably for the selling-volatility factor for all portfolios, and the credit and liquidity factors for the fixed-income portfolio. While the correlations in this analysis are sometimes significant, we do not view them as extreme. This does not come as a big surprise. Recall that we use the seven-factor model to adjust for the return difference between the Fund and its actual benchmark. This means that the partial correlation with alternative factors examined in this section is always for the Fund relative to its actual benchmark controlling for

Table 12 Partial correlations for alternative factors.

	Total	Equity	Fixed income
Panel A: Equity factors			
Momentum	0.06	0.23***	−0.11*
Short-term reversals	−0.01	−0.12*	0.07
Long-term reversals	0.04	0.10	0.00
Emerging markets	−0.15**	−0.03	−0.17**
Quality-minus-junk	0.08	−0.01	−0.06
Betting-against-beta	0.11*	0.00	0.25***
Selling volatility	0.30***	0.14**	0.27***
Panel B: Fixed-income and foreign-exchange factors			
Term	−0.13**	−0.02	−0.11*
Credit Aa	0.06	0.02	0.04
Credit Baa	0.03	−0.10	0.13**
Credit HY	0.07	−0.11*	0.17**
Carry	−0.08	−0.06	−0.04
Dollar carry	0.05	0.07	0.01
Panel C: Trend-following factors			
Bonds	0.05	0.06	0.01
Currencies	0.07	0.13**	0.00
Commodities	−0.06	−0.06	−0.02
Short-term interest rates	−0.17***	−0.12*	−0.07
Stock indices	0.08	0.02	0.09
Panel D: Liquidity and funding factors			
Liquidity (nontraded)	−0.03	0.02	−0.03
Liquidity (traded)	−0.05	0.02	−0.09
ΔVIX	0.03	−0.13*	0.12*
ΔTED	−0.25***	−0.30***	−0.06
ΔRepo	0.03	0.04**	−0.00
ΔCD	−0.25***	−0.32***	−0.05
ΔOn/off	−0.11	0.02	−0.18***

The table presents partial correlations for alternative factors for the 1998–2017 sample period. Each partial correlation measures the correlation between the active return and the factor after controlling for the factors in the seven-factor model. The alternative factors are grouped in four panels: Panel A reports equity factors, Panel B fixed-income and foreign-exchange factors, Panel C trend-following factors, and Panel D liquidity and funding factors. All factors are expressed in the Fund's currency basket. See the main text for a discussion of the factors and Appendix E for a more detailed description of their construction and sources. Standard errors of the correlations, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

the seven-factor model. In addition, it may be that both the Fund and its benchmark are sensitive to a factor, but without a significant difference between their sensitivities. We measure the relative, not absolute, factor exposure. However, from a performance-evaluation perspective, even a seemingly small difference in exposure to a factor may matter for the alpha. Furthermore, gauging the effects of additional factors on the alpha requires both estimates of the factor exposures and factor returns when representing the investability of the Fund. For many of the alternative factors, taking investability into account is tricky, and sometimes the factors are not even traded.

7 Evaluating the performance using value added

We have so far evaluated the Fund's performance using the mean active return and the alpha from the seven-factor model. These measures capture the additional risk-adjusted return the Fund has generated, before and after costs and expressed in % per year. Also of interest is the value added, i.e., the total value in NOK that the Fund extracts from the capital markets. Below, we follow the arguments of Berk and Green (2004) and implement the value-added measure in a manner similar to that of Berk and van Binsbergen (2015).

7.1 Methodology

The mean active return and the alpha as performance measures do not explicitly take into account the size of the Fund. As discussed in Section 3, recent evidence suggests that the return performance of a fund or industry deteriorates with growth in size (see Pastor et al. 2015, 2017, and references therein). To account for the Fund's size, we multiply the active return or the alpha by the Fund's AUM to obtain the total value that the Fund adds. In other words, we now take into account that small returns earned on a large asset base may be more valuable than large returns earned on a small asset base.

Let AUM_t denote the Fund's AUM at time t and let the risk-adjusted return from $t-1$ to t be captured by the active return, $R_t - R_t^b$. The value added between $t-1$ and t is then:

$$V_t = \text{AUM}_{t-1}(R_t - R_t^b). \tag{6}$$

We construct the cumulative sum of the monthly value added, $V = \sum_{t=1}^{T} V_t$, to measure the total amount the Fund has extracted from the capital markets over the 1998–2017 and 2013–2017 sample periods. We consider this value-added measure before and after costs. Following the arguments of Berk and van Binsbergen (2015), the before-cost measure can be viewed as the value the Fund extracts from the capital markets and the after-cost measure as the value the Fund provides to its asset owner. The value-added measure certainly depends on the benchmark against which the Fund is evaluated. In addition

to the active return considered above, we consider as a benchmark the beta-adjusted benchmark and the seven-factor model (discussed and analyzed above). We conduct the benchmark analysis in the CB and then convert it to NOK—the currency in which we measure the AUM. We consider the value added for the total portfolio as well as for the equity and fixed-income portfolios.

We emphasize that the value-added measure used here is not precisely estimated. Above, we discussed the imprecision in mean returns and alphas. That imprecision carries over to the value-added measure via the risk-adjusted return and is magnified by the AUM. While we are interested in the Fund's value added to the asset owners, Berk and van Binsbergen (2015) were interested in measuring the managerial skill of the entire mutual fund industry. They argued that the average value added before costs captures managerial skill and that, by considering cross-section averages of individual mutual funds' added values, they could assess their estimates with greater precision.

7.2   Results

Table 13 presents the value-added measures before and after costs for the 1998–2017 and 2013–2017 sample periods. The equity and fixed-income value-added measures do not exactly sum up to the total value added because (i) the Fund's returns include real estate as of 2017 and (ii) the value-weighted average of abnormal returns of the equity and fixed-income portfolios are not necessarily equal to the abnormal returns of the total fund because of different benchmarks and possible asset class tilting.

Panel A reports the value added using the return difference between the Fund and the actual benchmark (i.e., the active return). In total, the Fund has extracted NOK 111.7 billion from capital markets relative to its benchmark since 1998, of which NOK 75.4 billion can be transferred to its asset owner. The lion's share of the value added comes from the Fund's equity portfolio. After costs, the equity portfolio has added NOK 72.7 billion in value, whereas the Fund's fixed-income portfolio has not added any value over its benchmark. In the more recent sample period, the Fund has extracted NOK 65.1 billion

Table 13 Value added by active management (in NOK billion).

	1998–2017		2013–2017	
	Before costs	After costs	Before costs	After costs
Panel A: Active return				
Total	111.7	75.4	65.1	49.7
Equity	99.3	72.7	63.0	51.6
Fixed income	7.7	−0.9	−3.6	−6.6
Panel B: Beta-adjusted active return				
Total	34.8	−1.5	46.9	31.5
Equity	68.8	42.2	39.8	28.4
Fixed income	−5.8	−14.3	−2.2	−5.2
Panel C: Seven-factor model				
Total	−10.2	−46.4	48.0	32.5
Equity	49.4	22.8	42.7	31.2
Fixed income	−59.8	−68.3	−0.8	−3.8

The table presents the value added by active management (in NOK billion) before and after costs for the 1998–2017 and 2013–2017 sample periods. The value added is the cumulative value that the Fund accrues before and after its costs are taken into account. Panel A reports the value added using the return difference between the Fund and the actual benchmark (i.e., the active return) as a measure of performance; Panel B reports the value added using the beta-adjusted active return; Panel C reports the value added using the seven-factor model as the benchmark. Note that costs are for managing the Fund and do not take into account the costs of passively managing the benchmark or the costs of replicating the factors. Hence, the after-cost value added can be seen as a lower estimate of the true performance.

from the capital markets relative to its benchmark. Again, the main source of the value added is the Fund's equity portfolio. Panel B reports the value-added measures using the active return when we have beta-adjusted the benchmark. As the beta of the Fund relative to its benchmark is above one, the value added is now lower. In the full sample period, the value added after costs is close to zero for the total portfolio (the equity portfolio has added NOK 42.2 billion in value, whereas the fixed-income portfolio has a negative value added of NOK 14.3 billion). In the more recent sample period, the total portfolio's added value after costs is NOK 31.5 billion and again it can be attributed to the equity portfolio.

Panel C reports the value-added measures by risk-adjusting by the seven-factor model, showing that the factor exposures do matter. The cumulative value-added measures for the total fund are now negative, i.e., NOK –10.2 billion before costs and NOK –46.4 billion after costs. Again, the Fund's equity portfolio adds value, whereas the fixed-income portfolio in this case has destroyed value relative to its benchmark. In the 2013–2017 period, the value-added measures are positive, both before and after costs. These estimates are lower than the estimates using the Fund's active return, but still economically important.

We point out two caveats regarding the value-added measures for the seven-factor model. First, we have found that the betas have varied over time, thereby affecting the alpha measures, especially in the 1998–2017 sample period. We report the results for completeness but are not confident that the seven-factor model accurately captures the true alpha. Second, an important takeaway from the preceding discussion is that factor risk adjustments can be useful in explaining how the active return of the Fund comes about (i.e., whether the active return is due to exposures to various risk factors). However, the discussion also generates a warning regarding how performance measures based on factor risk adjustments should be interpreted. Suppose a particular factor performs well and that the Fund benefits from exposure to it. One might argue that the Fund should be credited for having chosen exposure to this factor. However, once the alpha measure is adjusted for the exposure to the factor, the positive performance due to the desired factor exposure would not raise the Fund's alpha. Moreover, recall that NBIM (2017c) estimated the costs

of a passive benchmark strategy to be of the order of 0.08% (0.04%) per year for the full (recent) sample period, costs that in principle could be added to the active returns of the Fund when calculating the value-added measures.

8 Evaluating the equity performance using holdings

In this section, we evaluate and attribute the performance of the equity portfolio, using some additional information relative to previous reviews, namely, the portfolio weights of the Fund's active positions along various dimensions. We group the stocks available for investment by the Fund according to their countries of origin and product markets. We consider investments in 69 countries and in product markets according to the Industry Classification Benchmark (ICB), the industry classification used by FTSE. The ICB uses a system of 10 industries subdivided into 41 sectors.

NBIM has provided us with monthly observations of the returns and portfolio weights of the Fund and its actual benchmarks for each of these categories for the 2013–2017 period. Table 14 lists the 69 countries, 10 industries, and 41 sectors for which we have monthly weight data.

The weight data allow us to characterize and analyze the Fund's portfolio over and above a performance analysis based on returns and/or factors. Any active allocation involves deviations between the actual Fund weights and the benchmark weights. Analyzing the weights can thus give us complementary information about the Fund's sources of returns.

8.1 Active share measures

Above, we noted that the degree of active management of the Fund has declined in recent years, as measured in the risk attribution and by the expected tracking error. We now use the holdings data to document the activity of the Fund relative to its benchmark. One measure of activity is the active share measure introduced by Cremers and Petajisto (2009). The active share measure is defined as the percentage of a fund's holdings that differ from its benchmark. It is computed as:

$$\text{Active Share}_t = \frac{1}{2} \sum_{i=1}^{N_t} |w_{i,t} - w_{i,t}^b|, \tag{7}$$

Table 14 Countries, industries, and sectors.

Country		Industry	Sector
Australia		Oil & Gas	Aerospace & Defense
Austria	Mauritius	Basic Materials	Alternative Energy
Bahrain	Mexico	Industrials	Automobiles & Parts
Bangladesh	Morocco	Consumer Goods	Banks
Belgium	Netherlands	Health Care	Beverages
Botswana	New Zealand	Consumer Services	Chemicals
Brazil	Nigeria	Telecommunications	Construction & Materials
Canada	Oman	Utilities	Electricity
Chile	Pakistan	Financials	Electronic & Electrical Equipment
China	Peru	Technology	Equity Investment Instruments
Colombia	Philippines		Financial Services
Croatia	Poland		Fixed Line Telecommunications
Czech Republic	Portugal		Food & Drug Retailers
Denmark	Qatar		Food Producers
Egypt	Romania		Forestry & Paper
Estonia	Russia		Gas, Water & Multiutilities
Finland	Saudi Arabia		General Industrials
France	Singapore		General Retailers
Germany	Slovenia		Health Care Equipment & Services
Ghana	South Africa		Household Goods
Greece	South Korea		& Home Construction
Hong Kong	Spain		Industrial Engineering
Hungary	Sri Lanka		Industrial Metals & Mining
India	Sweden		Industrial Transportation
Indonesia	Switzerland		Leisure Goods
Ireland	Taiwan		Life Insurance
Israel	Tanzania		Media
Italy	Thailand		Mining
Japan	Tunisia		Mobile Telecommunications
Jordan	Turkey		Nonequity Investment Instruments
Kenya	Ukraine		Nonlife Insurance
Kuwait	United Arab Emirates		Oil & Gas Producers
Latvia	United Kingdom		Oil Equipment, Services
Lithuania	United States		& Distribution
Malaysia	Vietnam		Personal Goods
			Pharmaceuticals & Biotechnology
			Real Estate Investment & Services
			Real Estate Investment Trusts
			Software & Computer Services
			Support Services
			Technology Hardware & Equipment
			Tobacco
			Travel & Leisure

The table lists the 69 countries, 10 industries, and 41 sectors for which we have weight data for the 2013–2017 period.

where $w_{i,t}$ is the weight (i.e., fraction of total investment) of category i at time t in the Fund's portfolio, $w_{i,t}^b$ is the corresponding weight in the benchmark, and N_t is the number of holdings at time t. The measure is intuitive and ranges from zero (i.e., no active management, the Fund being identical to the benchmark) to one (i.e., full active management, the Fund holding no benchmark stocks). Cremers and Petajisto (2009) characterized equity mutual funds by their active share and related it to their tracking error, documenting a strong positive relationship between the two active management measures. They found that the aggregate mutual fund industry has an active share of 30–50%. They also argued that mutual funds with an active share of less than 20% are index funds. Frazzini et al. (2016) emphasized that the active share measure is sensitive to the chosen benchmark. While for this reason it may be difficult to compare the active share measure of mutual funds having different benchmarks, we can use it in assessing the activity of the Fund over time.

Figure 16 Active share for the equity portfolio by country, industry, and sector over time.
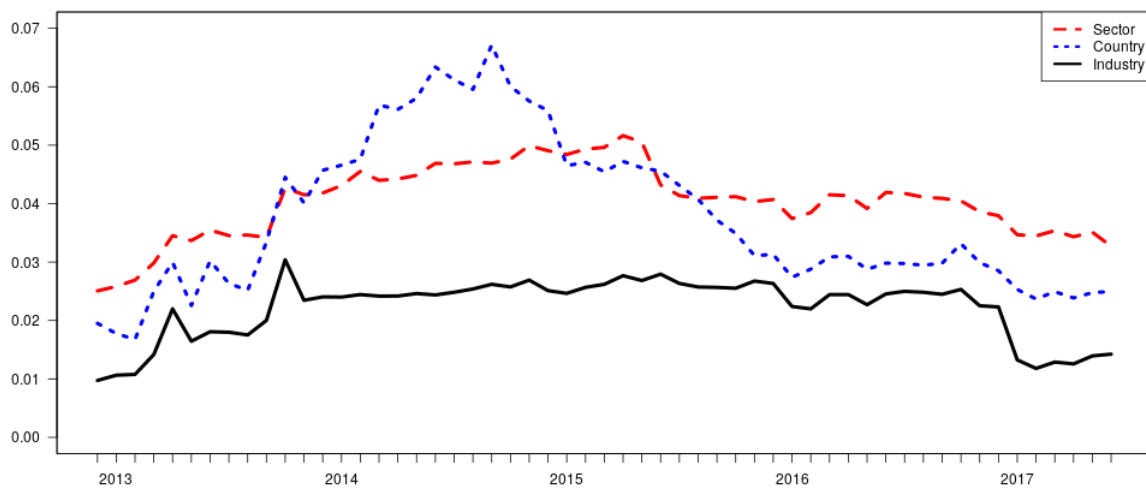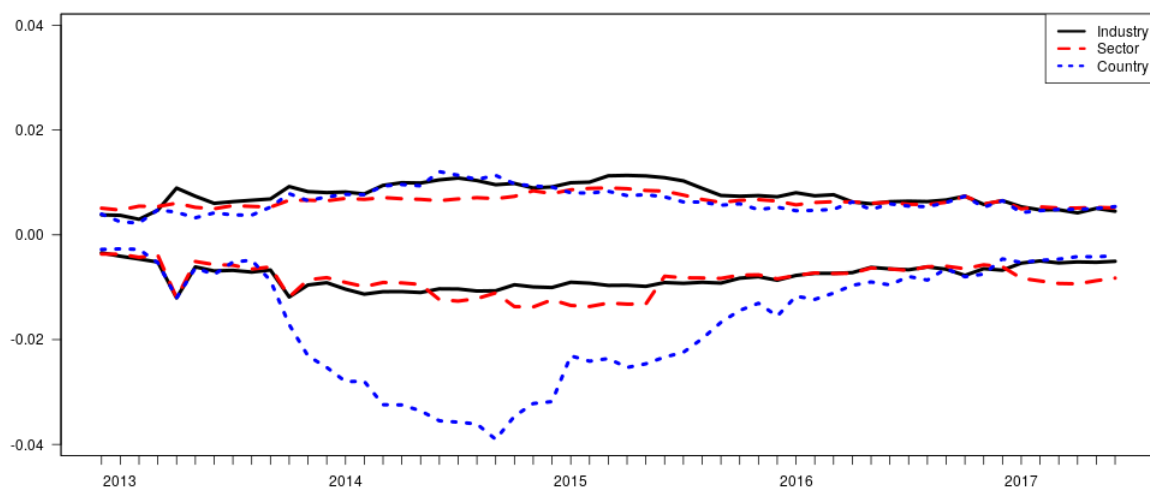

The figure plots time series of the active share measure (Cremers and Petajisto, 2009) for the Fund's equity portfolio by country, industry, and sector (see Table 14). See (7) in the main text for the calculation of the active share measure.

Figure 16 plots the active shares over time calculated by country, industry, and sector,

which range from 1% to 7%. These shares are much smaller than for mutual funds, whose active share measure is based on individual stocks versus our more aggregated measure based on countries, industries, and sectors. Cremers and Petajisto (2009) found a negative relationship between active share and both size (for mutual funds with more than USD 1 billion AUM) and future performance. It is difficult to extrapolate these results to a mega fund, however. Interestingly, we find that the active share was low in 2013, increased in 2014 (which, based on the Fund's performance relative to its benchmark, was a bad year), but has since declined.

**Figure 17** Extreme weight deviations for individual countries, industries, and sectors.

The figure plots time series of the minimum and maximum weight deviations between individual countries, industries, and sectors in the Fund and its benchmark (see Table 14).

The above active share measure is aggregated for the Fund. A complementary measure of active management is to consider weight deviations for individual holdings in given countries, industries, and sectors, which helps us further understand how far the Fund is from its benchmark. Figure 17 plots the largest positive (overweight) and negative (underweight) deviations at each point in time, again by country, industry, and sector. The minimum and maximum weight deviations for individual industries and sectors are around –1% and 1%, respectively (i.e., a range of two percentage points). The minimum

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weight deviation for individual countries is occasionally more extreme, but this can be explained to some extent by the fact that a single stock can be traded in more than one location, leading to larger deviations for the measure by country. We finally note that these minimum and maximum deviations in weights tend to become lower at the end of the period. This is consistent with our general observation that the Fund has become less active over time. However, note that this is for aggregated (by country, industry, and sector) weights. Interestingly, NBIM reports a related measure, the degree of overlap with the benchmark based on individual stocks, with a 100% overlap meaning that the portfolio is exactly the same as the benchmark. The Fund's overlap in the equity portfolio has been in the 80–85% range, which we interpret as an active share measure in the 15–20% range. Figure 18 plots 100% minus NBIM's measure of the overlap and does not reveal any strong trend. Taken together, this suggests a more stable activity level on a stock basis, but less stable activity on a country, industry, or sector basis. We also note that a fund with an active share range of 15–20% would be an index fund, according to the definition of Cremers and Petajisto (2009).

Figure 18 Active share.
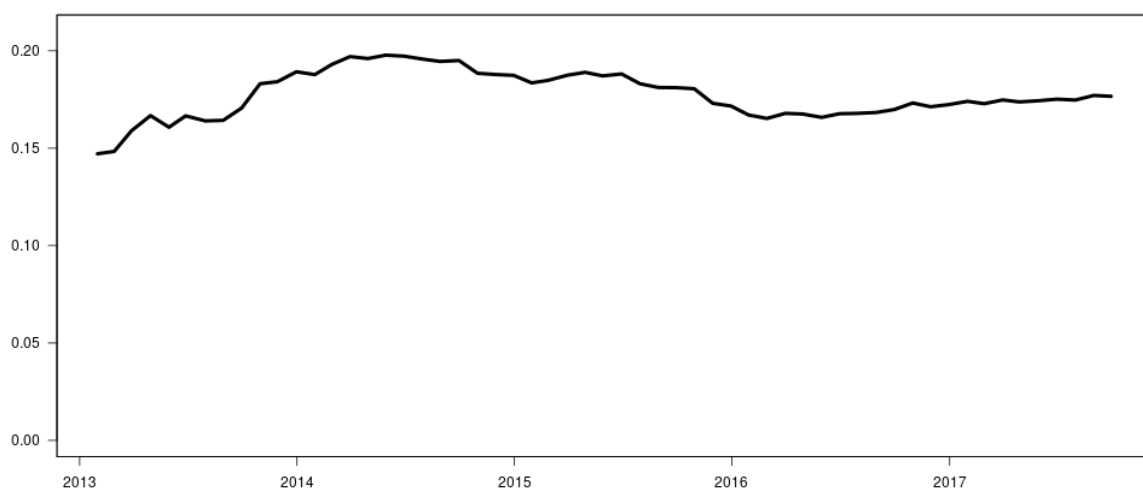
The figure plots a time series of 100% minus NBIM's overlap measure as a proxy for the active share measure of the equity portfolio.

8.2 Return decomposition: policy, selection, and timing

In this section, we decompose the Fund's equity returns into the benchmark (or policy) portfolio, selection component, and timing component. We do this decomposition by country, industry, and sector (see Table 14).

Let index i be a country, industry, or sector. The total returns of the equity portfolio and the benchmark are:

$$R_t = \sum_{i=1}^{N_t} w_{i,t-1} R_{i,t}, \tag{8}$$

$$R_t^b = \sum_{i=1}^{N_t} w_{i,t-1}^b R_{i,t}^b, \tag{9}$$

where $w_{i,t}$ and $w_{i,t}^b$ are the investment weights in i at time t for the Fund and the benchmark, respectively, $R_{i,t}$ and $R_{i,t}^b$ are the returns in i between $t-1$ and t for the Fund and the benchmark, respectively, and N_t is the number of indexed countries, industries, or sectors.

A standard decomposition of the Fund's total return is:

$$R_t = R_t^b + \sum_{i=1}^{N_t} w_{i,t-1}(R_{i,t} - R_{i,t}^b) + \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b) R_{i,t}^b. \tag{10}$$

$$\text{Fund} = \text{Policy} + \text{Selection} + \text{Timing}$$

The selection component measures the excess returns earned by the Fund's tendency to choose stocks within a given country, industry, or sector. The timing component measures the Fund's success at timing investments in the different countries, industries, or sectors. See Appendix F for the derivation and a further discussion of the components of the Fund's total returns. We note that the decomposition is based on the unit exposure of the Fund relative to the benchmark (i.e., the policy portfolio).

Table 15 presents the Fund's equity returns, decomposed into the policy, selection, and timing components as in (10).[7] We find that the return difference between the Fund and its benchmark (i.e., the active return) is positive for the equity portfolio, consistent

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[7]There are some inaccuracies in the weight calculations relative to the Fund's calculated monthly returns. This is due to weights changing during the month and to our simplified treatment of cash (i.e., setting its return to zero).

Table 15 Decomposition into policy, selection, and timing components.

	Fund	Policy	Selection	Timing
Panel A: By country				
2013–2017	12.19***	11.92***	0.38**	−0.11
	(3.72)	(3.61)	(0.18)	(0.13)
2013	23.87	22.83	0.86	0.18
2014	7.73	8.61	−0.09	−0.79
2015	4.62	3.78	0.49	0.35
2016	8.77	8.73	0.36	−0.31
2017	17.22	16.91	0.25	0.07
Panel B: By industry				
2013–2017	12.20***	11.93***	0.33	−0.06
	(3.72)	(3.61)	(0.26)	(0.05)
2013	23.85	22.86	0.97	0.03
2014	7.73	8.62	−0.65	−0.23
2015	4.55	3.79	0.77	−0.01
2016	8.85	8.73	0.22	−0.10
2017	17.28	16.90	0.32	0.06
Panel C: By sector				
2013–2017	12.20***	11.93***	0.27	−0.00
	(3.73)	(3.61)	(0.23)	(0.07)
2013	23.85	22.86	0.84	0.16
2014	7.75	8.62	−0.73	−0.14
2015	4.50	3.79	0.54	0.17
2016	8.86	8.73	0.36	−0.24
2017	17.30	16.91	0.35	0.05

The table presents the mean equity returns of the Fund, decomposed into the policy (benchmark), selection, and timing components. The decomposition is as follows:

$$R_t \quad = \quad R_t^b \quad + \quad \sum_{i=1}^{N_t} w_{i,t-1}(R_{i,t} - R_{i,t}^b) \quad + \quad \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b) R_{i,t}^b.$$

$$\text{Fund} \ = \ \text{Policy} \ + \qquad \text{Selection} \qquad + \qquad \text{Timing}$$

Panel A reports the decomposition by country, Panel B by industry, and Panel C by sector. Each panel reports the means for the 2013–2017 period (57 observations) and year by year (twelve observations per year, except for 2017, for which there are nine observations). The means are expressed in % per year, annualized by multiplying the monthly mean returns by 1200. Standard errors of the means, robust to serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

with our previous analysis of active returns. The positive mean active returns are due to selection. The selection component is positive for all decompositions, and it is statistically significant at the 5% level for the country decomposition. The interpretation is simply that, for a given weight in a country, industry, or sector, the Fund has achieved a higher return than the benchmark. The timing components are all negative but small in magnitude. Finally, we note that the Fund's active return has been positive in all years but 2014. This is also the only year when the selection component was negative.

We conclude that the Fund's positive mean active return is attributable to selection rather than to timing.

9 Evaluating strategies

In this section we consider three of the main strategies (i.e., fund allocation, security selection, and asset management) and certain sub-strategies that the Fund uses in enhancing returns. In the next section, we consider the fourth main strategy: real estate.

We begin by discussing the decentralization of investment decisions and the use of internal benchmarks. We then briefly describe the return of the strategies relative to the corresponding internal benchmarks, and use factor analysis to evaluate how they complement each other. In particular, we evaluate the performance of the Fund's external equity mandates and relate them to the internally managed assets. We close with a discussion.

9.1 Internal benchmarks: scope and value creation

In theory, all investment decisions of the Fund could be made by one central chief investment officer (CIO) acting in the interest of the asset owner. The CIO would decide on the asset mix. In practice, of course, all larger investment organizations decentralize these investment decisions, primarily because gathering information about specific assets to exploit the acquired informational advantage requires great specialization (van Binsbergen et al., 2008). Investment decisions then become a multistage process in which the CIO, in the first step, allocates capital to different managers. Each manager is assigned an investment universe, which can be an asset class or a style of investment within an asset class (e.g., small-cap stocks or emerging markets), and is expected to allocate the given capital to the assets in that universe.

Given this structure, the total return of the investment organization, R_t, can be written as the weighted sum of the returns of each of these managers' portfolio returns:

$$R_t = \sum_{j=1}^{N} w_{j,t-1} R_{j,t}, \tag{11}$$

where $w_{j,t-1}$ is the fraction of AUM allocated to manager j at time $t-1$, $R_{j,t}$ is the return of manager j between $t-1$ and t, and N is the number of managers. As part of this process,

the asset manager is assigned an internal benchmark, which we denote by $R_{j,t}^{ib}$, with ib referring to the internal benchmark. The internal benchmark is typically constructed from a large number of assets in the investment universe of that manager. The compensation of the manager will be a function of the return difference between what the manager achieves and the benchmark, i.e., for manager j, the return difference is $R_{j,t} - R_{j,t}^{ib}$. We also refer to this as the active return versus the strategy's internal benchmark.

Dividing the investment decision into components is the subject of an academic literature on delegated portfolio management. The multistage process of such management may introduce inefficiencies in investment decisions, for several reasons.

- At the *portfolio* level, the optimal solution to the aggregate problem may differ from the solution in which all managers optimize their own portfolios and then aggregate them. In other words, the investor may not achieve optimal diversification. Sharpe (1981) illustrated this in a mean-variance setting.

- At the *manager* level, managers may differ in risk preferences. One manager may be too risk averse relative to the investor's preferences, while another may have a shorter horizon than the investor. If effort is involved in the information production, the effort may be unobservable by the CIO, which adds complexity; see Cuoco and Kaniel (2011) and Basak and Pavlova (2013), and references therein, for recent models of delegated portfolio management.

The theoretical literature on delegated portfolio management also discusses the design of the *internal benchmarks*. For example, van Binsbergen et al. (2008) demonstrated that a properly designed benchmark may alleviate some of the problems of delegated management.

What the theoretical literature refers to as a manager is in our setting a strategy within NBIM (discussed in Section 3). Based on NBIM's own description, the internal benchmarks are customized benchmarks designed to match the scope of each investment strategy, and are used internally for both performance evaluation and funding allocation.

NBIM describes its fund-allocation strategy as an aggregation of internal benchmarks from two sub-strategies (i.e., the internal reference portfolio and allocation decisions) as well as from real estate. Fund allocation is therefore close to the Fund's actual benchmark. The internal reference portfolio is the first benchmark layer in the investment process, acting as the basis for all internal funding decisions. The funding is split between the security-selection strategy and the asset-management strategy. Security selection receives a benchmark, which contains only securities from the investment universe of the portfolio manager, while asset management receives the residual; see NBIM (2014) for a discussion of the benchmark construction of the security-selection strategy.[8]

To see how the return difference, $R_{j,t} - R_{j,t}^{ib}$, affects the total portfolio return, note that the total portfolio in (11) return can also be written as:

$$R_t = \sum_{j=1}^{N} w_{j,t-1} R_{j,t}^{ib} + \sum_{j=1}^{N} w_{j,t-1} (R_{j,t} - R_{j,t}^{ib}). \tag{12}$$

Hence, the return contribution of a given strategy is the return of the strategy's internal benchmark plus the return difference between the strategy and its benchmark. We are interested in the strategies' contributions to the Fund's active return. Subtracting the Fund's actual benchmark from the portfolio returns in (12), we get the active return:

$$
\begin{aligned}
R_t - R_t^b &= \sum_{j=1}^{N} w_{j,t-1} (R_{j,t} - R_t^b) \\
&= \sum_{j=1}^{N} w_{j,t-1} (R_{j,t}^{ib} - R_t^b) + \sum_{j=1}^{N} w_{j,t-1} (R_{j,t} - R_{j,t}^{ib}).
\end{aligned}
\tag{13}
$$

The first line in (13) illustrates how a strategy's return difference from the actual benchmark contributes to the Fund's total active return. This can in turn, as shown in line two, be divided into a choice of an internal benchmark and the implementation of the strategy

---

[8]We note that NBIM's construction of the internal benchmarks relates to the opportunity cost model advocated by Ang et al. (2014). The opportunity cost model uses a set of basis assets to construct a benchmark. For example, a benchmark for real estate can be constructed as a combination of equity and fixed-income investments by choosing weights for the two basis assets equity and fixed income (Ang et al., 2014, Appendix C). NBIM uses the term "funding" of the internal benchmarks, which we interpret as choosing a set of weights on the basis assets that corresponds to the desired risk–return characteristics of a strategy.

relative to the internal benchmark. NBIM uses "scope" when referring to the benchmark choice and "value creation" when referring to the strategy's return over its internal benchmark (i.e., the strategy's active return). We take NBIM's internal benchmarks (i.e., the scope) as given and focus our analysis on the strategies' return differences from their benchmarks (i.e., the value creation).

9.2 Performance relative to internal benchmarks

Table 16 presents summary statistics of returns and active returns for the main strategies and certain sub-strategies of the Fund for the 2013–2017 sample period. Annualized means and standard deviations are reported for the total, equity, and fixed-income portfolios separately. The table also presents annualized information ratios for the active returns.

The grouping of strategies in the table corresponds to that in Figure 4. However, the table does not present return statistics for securities lending under asset management, because for this strategy, NBIM reports contributions to the Fund's relative return (and securities lending is, for our purposes, not comparable to the other strategies). In addition to these strategies, we later consider a rougher grouping of the equity portfolio into external and internal equity portfolios (i.e., splitting equity holdings into those managed through external mandates, and the rest), for which we have data for a longer period, i.e., 1999–2017.

We first note that the Fund's returns and active returns on the total, equity, and fixed-income portfolios (the first line in each of Panels A, B, and C) are the same as previously reported in Tables 1 and 2. For the total portfolio, the fund-allocation strategy has a negative information ratio, –0.27, which seems to stem mainly from the negative relative performance of the fixed-income portfolio. Security selection and asset management have positive information ratios of 0.45 and 2.92, respectively. The positive value for security selection seems to stem from the external equity portfolio and the internal fixed-income portfolio. The positive value for asset management seems to stem from both the equity

Table 16 Summary statistics of returns, main strategies, and sub-strategies.

	Return		Active return		Information ratio
	Mean	Standard deviation	Mean	Standard deviation	
Panel A: Total portfolio					
Fund's total portfolio	8.61	6.29	0.25	0.39	0.64
Fund allocation	8.31	6.25	−0.07	0.25	−0.27
Internal reference portfolio	8.28	6.24	−0.09	0.17	−0.52
Allocation decisions	8.29	6.25	0.02	0.17	0.14
Security selection	9.48	9.23	0.64	1.42	0.45
Internal	9.96	9.49	−0.06	1.76	−0.03
Asset management	8.41	5.82	0.27	0.09	2.92
Asset positioning	8.34	5.82	0.20	0.09	2.27
Panel B: Equity portfolio					
Fund's equity portfolio	12.02	9.69	0.37	0.47	0.79
Fund allocation	11.59	9.62	−0.01	0.29	−0.04
Internal reference portfolio	11.66	9.56	0.01	0.20	0.04
Allocation decisions	11.63	9.59	−0.02	0.16	−0.12
Security selection	11.26	10.65	0.91	1.67	0.54
Internal	12.14	11.36	0.20	2.10	0.10
External	9.12	10.98	2.88	2.02	1.43
Asset management	12.20	9.50	0.28	0.11	2.57
Asset positioning	12.10	9.50	0.18	0.11	1.69
Panel C: Fixed-income portfolio					
Fund's fixed-income portfolio	2.97	2.76	−0.03	0.50	−0.06
Fund allocation	2.77	2.82	−0.25	0.46	−0.54
Internal reference portfolio	2.76	3.09	−0.26	0.34	−0.76
Allocation decisions	2.77	2.82	0.01	0.36	0.03
Security selection	4.43	2.62	0.55	1.09	0.51
Internal	4.43	2.62	0.55	1.09	0.51
Asset management	2.59	2.90	0.27	0.17	1.58
Asset positioning	2.58	2.90	0.25	0.17	1.50

The table presents annualized arithmetic means and standard deviations of returns and active returns on the Fund's strategies. It also presents annualized information ratios for the active returns. Means are annualized by multiplying the monthly mean by 1200; standard deviations are annualized by multiplying the monthly standard deviation by $\sqrt{12} \times 100$; information ratios are annualized by multiplying the monthly information ratio by $\sqrt{12}$. Statistics apply to the sample period January 2013 to June 2017 (54 observations), with the exception of the fixed-income portfolio for security selection, for which the period is October 2014 to June 2017 (33 observations). Statistics for securities lending are not shown under asset management. Panels A, B, and C report the statistics for the total, equity, and fixed-income portfolios, respectively. All returns are expressed in the Fund's currency basket.

and fixed-income portfolios. Note that the table does not present the amount of AUM (or the weight of total AUM) allocated to each strategy, so the contribution of each strategy to the total performance cannot be inferred. However, it becomes clear that in the 2013–2107 period, it is the security-selection and asset-management strategies that positively contribute to the Fund's active return, whereas the fund-allocation strategy contributes negatively. As we have already documented, it is also clear that it is the equity rather than the fixed-income portfolio that contributes to the Fund's active return.

We have observed that for some of the strategies, the median return is substantially above the mean return (untabulated). This is a sign of a skewed distribution, where the mean is lowered due to some large negative returns, and is of interest for risk management and expected shortfall estimates. Recall that the expected shortfall of a strategy is based on the relative return (i.e., relative to the internal benchmark).

We have considered summary statistics of the sub-strategies to the main strategies of fund allocation, security selection, and asset management (and even sub-sub strategies within fund allocation), and do not view them as differing much from the main strategies (untabulated results). We therefore concentrate on the main strategies when investigating how each strategy relates to its internal benchmark. More specifically, we are interested in whether the strategies complement each other. To that end, we perform two analyses.

First, we consider the correlations between the main strategies. Table 17 presents the correlations of the active returns of the Fund with the actual benchmarks set by the Ministry of Finance ($R_t - R_t^b$) and the correlations of the relative returns of the strategies with their internal benchmarks ($R_{j,t} - R_{j,t}^{ib}$). We find that fund allocation is the strategy that has the highest correlation with the Fund (i.e., 0.84, 0.74, and 0.94 for the total, equity, and fixed-income portfolios). Security selection exhibits a high correlation for the equity portfolio, 0.81, but a low correlation for the fixed-income portfolio, –0.30. Asset management exhibits a low overall correlation, 0.27, for the total portfolio. Internally, the correlations are low across the main strategies, ranging from –0.43 to 0.33. Overall, the low correlations indicate that the strategies attempt to generate returns over and above

their internal benchmarks in different ways.

Table 17 Correlations of strategy returns.

Panel A: Total portfolio

	Fund	Fund allocation	Security selection	Asset management
Fund	1.00			
Fund allocation	0.84	1.00		
Security selection	0.74	0.33	1.00	
Asset management	0.27	0.10	0.03	1.00

Panel B: Equity portfolio

	Fund	Fund allocation	Security selection	Asset management
Fund	1.00			
Fund allocation	0.74	1.00		
Security selection	0.81	0.25	1.00	
Asset management	−0.12	−0.18	−0.27	1.00

Panel C: Fixed-income portfolio

	Fund	Fund allocation	Security selection	Asset management
Fund	1.00			
Fund allocation	0.94	1.00		
Security selection	−0.30	−0.43	1.00	
Asset management	0.45	0.22	−0.27	1.00

The table presents correlations between the Fund's active return, $R_t - R^b$, and the returns on the Fund's three main strategies, i.e., fund allocation, security selection, and asset management, over their internal benchmarks, $R_{j,t} - R_{j,t}^{ib}$, for the 2013–2017 sample period. Panels A, B, and C report the statistics for the total, equity, and fixed-income portfolios, respectively. There are 54 observations for all strategies, except the fixed-income portfolio of security selection, for which there are 33 observations. All returns are in the currency basket.

Second, we consider whether the return differences between the main strategies and the corresponding internal benchmarks are exposed to the common factors in the seven-factor model. We therefore use the return difference between a strategy and its internal benchmark, $R_{j,t} - R_{j,t}^{ib}$, as the dependent variable and regress it on the factors. Heterogeneity in factor exposures across strategies may indicate that specialization of the strategies helps generate different factor exposures.

Tables 18 and 19 present the results of the factor regressions for fund allocation,

security selection, and asset management for the 2013–2017 sample period: Table 18 reports results for the equity portfolio, and Table 19 for the fixed-income portfolio.

Table 18 Factor regressions for strategies, equity portfolio.

	Fund allocation	Security selection	Asset management
Constant	−0.009	0.053	0.024***
	(0.013)	(0.071)	(0.005)
MKT	0.011***	0.043**	−0.003**
	(0.003)	(0.019)	(0.001)
SMB	0.010	0.092**	−0.002
	(0.008)	(0.044)	(0.003)
HML	0.021**	−0.117**	−0.000
	(0.009)	(0.050)	(0.004)
RMW	0.000	−0.052	0.007
	(0.014)	(0.085)	(0.006)
CMA	−0.026	0.093	0.018***
	(0.018)	(0.083)	(0.007)
TERM	0.004	−0.133***	−0.003
	(0.008)	(0.042)	(0.003)
DEF	−0.009	0.079***	0.006**
	(0.006)	(0.028)	(0.002)
Adjusted R^2	0.23	0.41	0.29
Observations	54	54	54

The table presents factor regressions for the equity portfolios of the main strategies: fund allocation, security selection, and asset management. We run the following regression:

$$R_{j,t} - R_{j,t}^{ib} = a + b_{MKT}\text{MKT}_t + b_{SMB}\text{SMB}_t + b_{HML}\text{HML}_t + b_{RMW}\text{RMW}_t + b_{CMA}\text{CMA}_t + b_{TERM}\text{TERM}_t + b_{DEF}\text{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_{j,t} - R_{j,t}^{ib}$, is the return of the sub-strategy minus the internal benchmark and the right-hand variables are all the factor returns (described in Appendix E). All returns are expressed in % and in the Fund's currency basket. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. The sample period is 2013–2017.

For equity, the most economically and statistically significant exposures are for security selection. There are significant exposures to the equity factors MKT, SMB, and HML, as well as to the fixed-income factors TERM and DEF. This regression is also the one with the highest adjusted R^2 value of 41%. The fund-allocation strategy has a significant exposure to the factors MKT and HML. We also note that the asset-management strategy for equity

has significant exposure to `CMA` as well as to the fixed-income factor `TERM`.

Some of the results for the equity security selection can be linked back to how the internal benchmark for this strategy is constructed. The internal benchmark for security selection is tilted away from market-cap weights. We therefore expect the security-selection strategy to have a significant, and large, exposure to `SMB`, which is what we find.

For the fixed-income portfolios, all the strategies are exposed to the fixed-income factor `TERM`, but only the asset-management strategy is exposed to `DEF`. Security selection has the most significant exposures to equity factors, likely due to the investments in corporate bonds. The adjusted R^2 values for the fixed-income regression for security selection are as high as 65%. The other strategies have R^2 values comparable to those of the equity regressions.

To conclude, we find that the main strategies' active returns are far from perfectly correlated among themselves and with the Fund's active return relative to the actual benchmark. We also find that the main strategies have different factor exposures, consistent with the strategies specializing in certain styles, captured by the factors. The low internal correlations among the main strategies are also reassuring in the sense that it seems less likely that the internal strategies are directly competing for the same profit opportunities.

9.3   Internal and external equity mandates

We now consider the internal and external equity mandates, for which we have returns data beginning in 1999. According to the NBIM website, the Fund had about 4.5% of its capital under external management at the end of 2016. A total of 91 mandates were managed externally, of which 65 were country-specific mandates for investments in emerging and frontier equity markets and 15 were country-specific mandates for investments in small-capitalization companies in developed equity markets. (The other external mandates were seven mandates for environment-related investments and four mandates for global emerging market debt.) For mandates like the country mandates, NBIM told us that the external manager is typically evaluated relative to a given country index. The

Table 19 Factor regressions for strategies, fixed-income portfolio.

	Fund allocation	Security selection	Asset management
Constant	−0.024	0.062***	0.021***
	(0.016)	(0.019)	(0.004)
MKT	0.009	−0.054***	0.007**
	(0.007)	(0.008)	(0.003)
SMB	0.018	0.049***	0.003
	(0.012)	(0.018)	(0.004)
HML	0.005	−0.024	0.006
	(0.012)	(0.020)	(0.004)
RMW	0.042	0.095***	0.003
	(0.027)	(0.034)	(0.010)
CMA	0.017	0.091	−0.004
	(0.026)	(0.064)	(0.007)
TERM	−0.049***	−0.043**	−0.009*
	(0.012)	(0.019)	(0.005)
DEF	0.012	−0.011	−0.009**
	(0.014)	(0.017)	(0.004)
Adjusted R^2	0.32	0.65	0.24
Observations	54	33	54

The table presents factor regressions for the fixed-income portfolios of the main strategies: fund allocation, security selection, and asset management. We run the following regression:

$$R_{j,t} - R_{j,t}^{ib} = a + b_{MKT}\mathrm{MKT}_t + b_{SMB}\mathrm{SMB}_t + b_{HML}\mathrm{HML}_t + b_{RMW}\mathrm{RMW}_t + b_{CMA}\mathrm{CMA}_t + b_{TERM}\mathrm{TERM}_t + b_{DEF}\mathrm{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_{j,t} - R_{j,t}^{ib}$, is the return of the sub-strategy minus the internal benchmark and the right-hand variables are all the factor returns (described in Appendix E). All returns are expressed in % and in the Fund's currency basket. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. The sample period is 2013–2017.

"internal benchmark" for such a mandate is thus a well-defined, observable index that satisfies the requirements of being unambiguous, measurable, and specified in advance (as discussed in Section 3.1). We are therefore comfortable undertaking an alpha-type analysis of the external equity mandate. We begin, however, with a brief comparison of the returns on the internal and external equity portfolios.

Table 20 presents summary statistics of the internal and external equity portfolios. For the 1999–2017 sample period, the mean returns are similar for both the internal and external equity portfolios, i.e., 6.71% and 6.40% per year, respectively. However, the portfolios have two very different internal benchmarks due to their different scopes. The mean active returns (i.e., the returns on the mandates relative to their internal benchmarks) are 0.28% and 2.09% per year for the internal and external equity portfolios, respectively. While the mean active return is much larger for the external equity portfolio, it also has a much larger standard deviation, so the information ratios for the internal and external equity portfolios are 0.48 and 0.81, respectively. The information ratios indicate strong relative performance, especially for the external equity portfolio. In the 2013–2017 sample period, the internal equity portfolio still outperformed its internal benchmark, now with an information ratio of 0.43. The external equity portfolio had an even better performance, now with an information ratio of 1.47. Next, we analyze the external equity portfolio's performance using factor regressions and undertake an alpha analysis.

Table 21 presents factor regressions and alpha analyses for the 1999–2017 and 2013–2017 sample periods. Columns 1 and 3 in Panel A report results of the seven-factor model. In the full sample period, the external equity managers (relative to their internal benchmark) are positively exposed to the SMB factor and negatively exposed to the HML factor; that is, the external managers seem to tilt their portfolios toward small, growth stocks. The external managers are also exposed to the fixed-income factors TERM and DEF, indicating a relative tilt toward lower duration risk and higher credit risk relative to the internal benchmark. In the more recent sample period, the external managers are still exposed to growth stocks and now also to firms with relatively weak profits (as captured

Table 20 Summary statistics of returns, internal and external equity portfolios.

	Return		Active return		Information ratio
	Mean	Standard deviation	Mean	Standard deviation	
1999–2017					
Internal	6.71	14.55	0.28	0.58	0.48
External	6.40	14.50	2.09	2.58	0.81
2013–2017					
Internal	12.17	9.75	0.21	0.49	0.43
External	9.60	10.60	2.70	1.83	1.47

The table presents annualized arithmetic means and standard deviations of the returns and active returns on the internal and external equity portfolios for the 1999–2017 and 2013–2017 sample periods. It also presents annualized information ratios for the active returns. Means are annualized by multiplying the monthly mean by 1200; standard deviations are annualized by multiplying the monthly standard deviation by $\sqrt{12} \times 100$; information ratios are annualized by multiplying the monthly information ratio by $\sqrt{12}$. All returns are expressed in the Fund's currency basket.

by the negative exposure to the RMW factor).

A main use of the external mandate in the recent period is to make investments in emerging markets, which entered the strategic benchmark in 2008. We therefore add an emerging market factor, EM, which is the return difference between an emerging stock market index and a world stock market index (see Appendix E for the details). The results of adding this factor to the seven-factor model are reported in columns 2 and 4. There are significant exposures to the EM factor, especially in the more recent sample period, when its inclusion increased the adjusted R^2 value from 21% to 30%.

The most striking result, however, relates to the alphas of the external mandates, reported in Panel B. The gross alphas for the two sample periods are in the range of 2.39–3.28% per year. These alphas can be compared with the mean return differences of 2.09% and 2.70% per year in Table 20. The alphas higher than the means are mainly due to the exposures to HML and TERM in the full sample period and to exposure to RMW in the more recent period. Since the external equity portfolio (relative to its benchmark) is negatively exposed to these factors and the factor returns are positive, more of the portfolio's return (relative to the benchmark) is attributed to outperformance (a higher

Table 21 Factor regressions and alpha analyses for external equity portfolios.

	1999–2017		2013–2017	
	(1)	(2)	(3)	(4)
Panel A: Regression analysis				
Constant	0.294***	0.209***	0.273***	0.199***
	(0.054)	(0.053)	(0.067)	(0.067)
MKT	0.005	0.010	−0.011	−0.005
	(0.012)	(0.011)	(0.018)	(0.018)
SMB	0.117***	0.137***	−0.037	0.018
	(0.022)	(0.025)	(0.061)	(0.058)
HML	−0.143***	−0.138***	−0.210***	−0.119**
	(0.036)	(0.037)	(0.056)	(0.052)
RMW	0.020	0.029	−0.245***	−0.122
	(0.036)	(0.035)	(0.076)	(0.090)
CMA	−0.034	−0.050	0.014	−0.066
	(0.035)	(0.034)	(0.082)	(0.062)
TERM	−0.049**	−0.048**	−0.038	−0.016
	(0.021)	(0.022)	(0.031)	(0.027)
DEF	0.037**	0.036*	0.022	0.005
	(0.019)	(0.019)	(0.040)	(0.037)
EM		−0.027**		−0.066***
		(0.013)		(0.022)
Adjusted R^2	0.43	0.44	0.21	0.30
Observations	222	222	54	54
Panel B: Alpha analysis				
Gross alpha	2.45	2.50	3.28	2.39
Costs	0.34	0.34	0.44	0.44
Net alpha	2.11	2.16	2.84	1.95

The table presents factor regressions in Panel A and alpha analyses in Panel B. In columns 1 and 3, we report the following regression:

$$R_{j,t} - R^{ib}_{j,t} = a + b_{MKT}\,\mathrm{MKT}_t + b_{SMB}\,\mathrm{SMB}_t + b_{HML}\,\mathrm{HML}_t + b_{RMW}\,\mathrm{RMW}_t + b_{CMA}\,\mathrm{CMA}_t + b_{TERM}\,\mathrm{TERM}_t + b_{DEF}\,\mathrm{DEF}_t + \varepsilon_t,$$

where the left-hand variable, $R_{j,t} - R^{ib}_{j,t}$, is the return difference between the external equity portfolio and its benchmark and the right-hand variables are all the factor returns (described in Appendix E). Columns 2 and 4 report regressions with an added emerging market (EM) factor, which is the difference between the MSCI Emerging Market Index and the MSCI World Index. All returns are expressed in % and in the Fund's currency basket. Standard errors of the parameters, robust to conditional heteroscedasticity and serial correlation with an optimal lag length using a Bartlett kernel as in Newey and West (1987), are shown in parentheses. *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. "Observations" refers to the number of observations in the regressions. "Gross alpha" is the constant expressed in % per year (i.e., the constant multiplied by 12). "Costs" are the annual costs for managing the Fund. The cost estimates are available for the years 2003–2016 (see Figure 15). We use the costs in 2003 to estimate costs in 1999–2002, and the costs in 2016 to estimate the costs in 2017. "Net alpha" is the gross alpha minus the costs. Note that costs do not take into account the costs of passively managing the benchmark or the costs of replicating the factors. Hence, the net alpha can be seen as a lower estimate of the true performance.

alpha). Trading equities in emerging markets is more expensive than trading equities in developed markets, and external managers are also more costly than internal managers. The Fund's returns are adjusted for the direct trading costs, but we need to subtract the management costs of the external managers, as shown in Figure 15. These costs are indeed larger than those of the internally managed equities and also vary more due to performance-based fees. We subtract the estimated costs from the gross alpha to get an estimate of the net alpha, which is in the range of 1.95–2.84% per year. The alphas are highly economically and statistically significant.

We find substantial contributions to the Fund's active return from the external mandate. It may be helpful to make a back-of-the-envelope calculation. Consider the 2013–2017 conservative estimate of the net alpha of 1.95%. How much added value does this correspond to? At the beginning of 2016, the assets under external management were NOK 297 billion, which means that the 1.95% alpha corresponds to NOK 5.8 billion. For 2016, the Fund had an active return of 0.15%. The value of the Fund at the beginning of 2016 was NOK 7.475 trillion. The total active return of the Fund was thus about NOK 11.2 billion. According to this calculation, more than 50% of the 2016 value added was due to external security selection.

To conclude, we find that the external mandates contribute substantially to the Fund's active return and value added. This is consistent with the presence of skill at several levels. First, the external managers show skill in their stock selection within their emerging market universes. Second, NBIM shows skill in selecting those managers that outperform.

9.4 Concluding comments

From the perspective of the asset owner wanting to evaluate the internal decisions of the Fund, two decisions are particularly important:

1. How much capital should be allocated to each strategy?

2. How should the benchmarks be determined for each strategy?

These decisions correspond to similar insights into the Fund itself: By far the most important decision of the Fund concerns the benchmarks used for equity and fixed income and the weights of these asset classes.

We have considered how the Fund implements its main strategies and asked whether these strategies seem conducive to the goal of delivering active returns. We have found some evidence consistent with specialization among the main strategies, with the strategies' returns relative to their internal benchmarks seeming fairly uncorrelated and providing different factor exposures.

We have also considered the possibility of isolating the contributions of the various strategies. We found this difficult because the strategies are interrelated in various ways. One issue relates to the internal benchmarks and their potential effects on incentives. We would like to better understand the process of choosing and implementing internal benchmarks. Another issue relates to the costs attributed to the different strategies: while costs are recorded in one place, the services provided are not limited to that strategy. The clearest example concerns the need to collect and analyze information about individual companies, which is located within the security-selection strategy. This information (e.g., company-level information critical for the Fund as a whole to be a responsible investor) is collected in a database and made available throughout the Fund, not only to security selection.

10 Evaluating real estate

10.1 Mandate

The real estate mandate was introduced in 2010. The Fund was to build a global real estate portfolio, financed by the fixed-income portfolio. As of March 2017, unlisted real estate represented 2.5% of the Fund's value. The accumulation of real estate in the Fund has been gradual. The first investment was made in London in 2011, when the Fund entered into a partnership with the Crown Estate and bought a 150-year long lease on a 25% stake in Regent Street. This investment is typical of the Fund's real estate investments, having a strategy of buying commercial properties in major cities worldwide. On average, 0.5% of the Fund's value has been invested in real estate annually since the introduction.

The Fund's real estate mandate has changed since its introduction. The mandate introduced in 2010 gave an upper limit of 5% of the Fund's value to be invested in real estate. The real estate investments would reduce the fixed-income portfolio from 40% to 35% if fully utilized. Initially, the real estate investments were to be measured against a broad global real estate index, the IPD Global Property Index (exclusive of Norway), similarly to how the strategic benchmarks are used for the equity and fixed-income portfolios. Due to the undiversified nature of the Fund's actual real estate investments, when compared with the diversified global index, this way of measuring performance was viewed as unsatisfactory.

At the beginning of 2017, the mandate was changed by the Ministry of Finance. Real estate was removed as a separate asset class in the Fund's strategic benchmark. The new mandate requires the real estate investments to be measured as part of the Fund's total portfolio, against a strategic benchmark with weights of 67.5% in equity and 32.5% in fixed income. Both the scale and composition of real estate investments in the Fund are determined by Norges Bank. The fraction of unlisted real estate investments is left to the Bank, with an upper limit of 7% of the Fund's assets. The Ministry of Finance stated that the limit would allow for an unlisted real estate share of up to 5% over time, given the need

to have a buffer in the event of a sharp drop in the valuation of listed markets. The return on real estate investments is to be measured against an actual benchmark consisting of listed equities and bonds.

10.2   Organization and comparative advantages

Real estate is organized as a separate unit, NBREM, inside NBIM. Investments in real estate have a much higher demand for "boots on the ground" than financial investments such as bonds and equities. NBREM has therefore grown quickly, and by the end of 2016, it had 139 employees in six offices in Oslo, London, Luxembourg, New York, Singapore, and Tokyo. Given that the Fund's total number of employees was 568, NBREM employed almost a quarter of the Fund's personnel, while the real estate portfolio constituted only 2.5% of the Fund's value. The strategic positioning in real estate has entailed the balancing of costs, diversification, and the need for local expertise. These considerations have led NBREM to a strategy of concentrating on investments in commercial properties in large cities and global logistic properties. (Arguably, as the Fund is currently building its real estate portfolio, it faces undiversified real estate risks in the short term but not necessarily in the long term.) The cities are chosen using criteria such as scale, growth, and supply situation. NBREM mainly invests jointly with local partners. At the end of 2016, 79% of the real estate assets were jointly owned with partners, while the remaining 21% were wholly owned by NBREM.

NBREM argues that it has several comparative advantages relative to the typical real estate investor, due to the long-term nature of the Fund. A long-term investor, with capital available even in falling markets, is attractive as a counterpart, partner, and landlord. The backing of a large investment organization such as NBIM ensures high-quality systems and governance. Also, knowledge attained by managing the equity and fixed-income portfolios can be utilized in the real estate investments.

10.3 Asset values and costs

We have received summary data on the Fund's real estate investments, including asset values, returns, and costs. The data cover the real estate investments in four countries: the UK, France, Germany, and the USA (in order of first investment). Note that there are some smaller investments outside these four countries. There is a Swiss building and a pan-European logistics investment, and very recently the Fund has also invested in Japan. These investments are not included in our analysis. Below, we briefly comment on the asset values and the costs. We later discuss returns and the Fund's performance.

Figure 19 shows the total net asset value (NAV) in NOK billion, broken down by the four countries. The initial investments were in Europe. The US investments entered the portfolio only in 2013. However, in the following years these investments were substantial, and have now grown to be the largest portion of the Fund's real estate portfolio.

Figure 19 Real estate NAVs by country
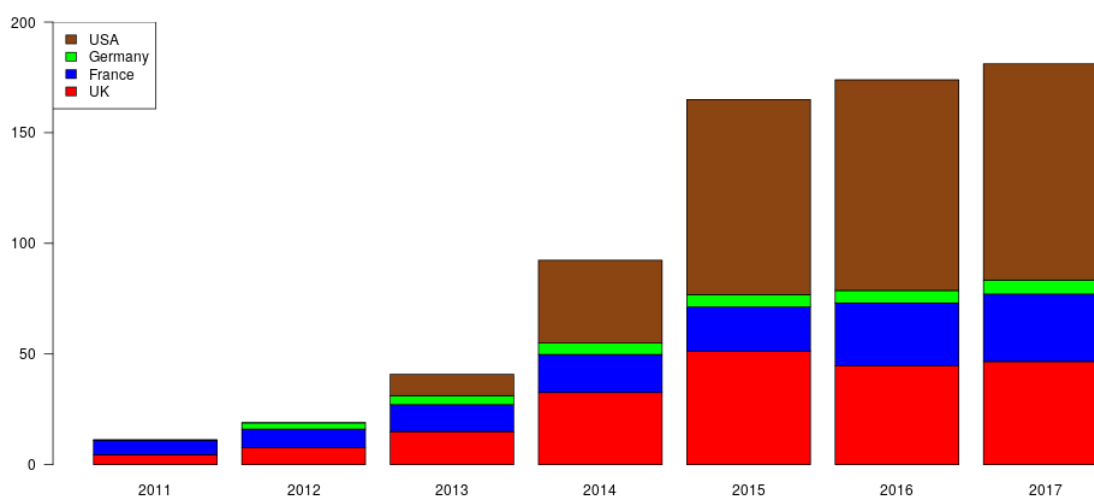
The figure shows NAVs for real estate investments in NOK billion. The NAVs are end-of-year values translated into NOK, using exchange rates from Norges Bank. The NAVs for 2017 are per June 30, 2017. The NAVs are by country of investment: the UK, France, Germany, and the USA. Data source: NBIM.

Figure 20 shows the portion of the Fund's management costs assigned to real estate (costs in the Fund, which do not include costs in real estate subsidiaries). Panel A reports

the costs as a percentage of the real estate assets. These relative costs have decreased; however, that is partially driven by the increase in the assets, as Panel B shows an increase in total costs. As many of the costs are fixed, this may indicate that economies of scale are starting to take effect, although some of the leveling off may be explained by the real estate investments in 2016 being lower than in earlier years.

10.4   Returns and performance

Investments in real estate are illiquid and involve large transaction costs, making it tricky to estimate short-term returns; see Geltner (1991, 1993) and Ross and Zisler (1991) for early treatments, and Ilmanen (2011) and Van Nieuwerburgh et al. (2015) for more recent discussions of this matter. As property values are appraisal based, real estate returns are excessively smoothed, which leads to an underestimation of the volatility. Smoothing also leads to underestimation of correlations and factor exposures (see, e.g., Getmansky et al., 2004). For these reasons, Van Nieuwerburgh et al. (2015) conclude that a five-year moving average of returns may be better for evaluating the performance of the Fund's real estate portfolio. We have approximately five years of real estate data—that is, *one* such moving average return.

We consider real estate investments on a country-by-country basis and in the currency of each country. We take the choice of country as given and consider how the investments have performed relative to the IPD benchmark of each country. Note, however, that the IPD indices represent returns on broad real estate portfolios, whereas the NBREM investments are arguably less diversified. Table 22 presents annual mean returns for the Fund and its benchmark. The investments in the UK outperformed their IPD benchmark by approximately 2.5% per year. The investments in Germany and France were similar to their IPD benchmarks. The investments in the USA underperformed relative to the IPD benchmark by approximately 2.7% per year, but note that the US result is based on only three years of returns. The MSCI (2016) report argues that the US underperformance was due to US office and industrial investments.

Figure 20 Annual management costs for real estate.

Panel A: Costs in % of AUM
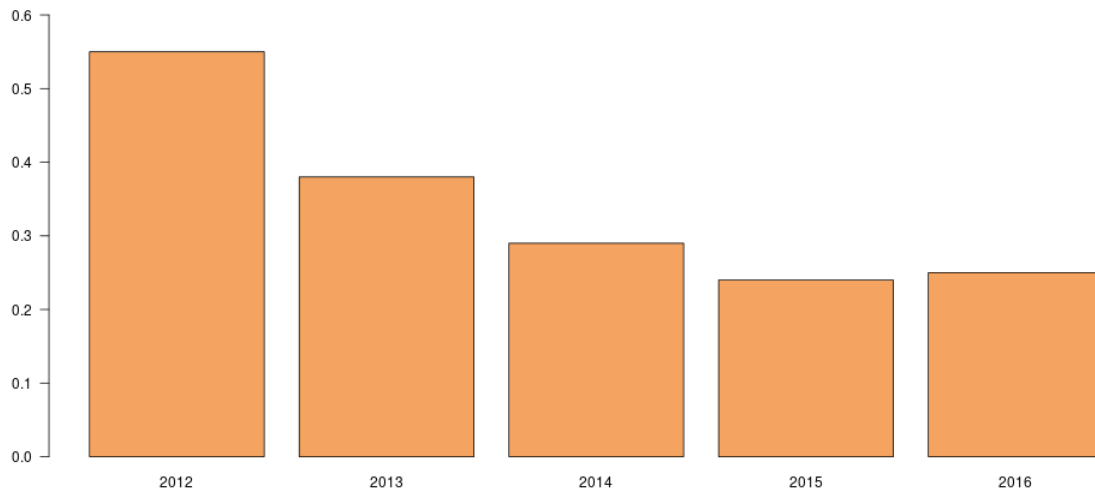
Panel B: Total costs (NOK billion)
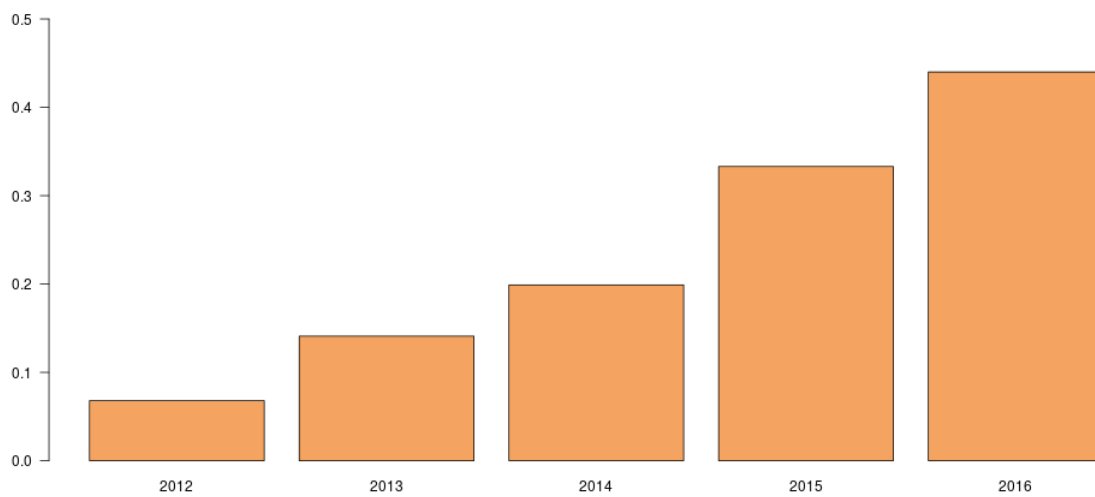
The figure shows annual management costs for real estate. Panel A shows the costs in % of AUM in real estate; Panel B shows the costs in NOK billion. Data source: NBIM.

Table 22 Mean return on real estate by country.

	Fund	IPD	Currency	Years
The UK	12.46	9.98	GBP	5
France	6.95	6.91	EUR	5
Germany	6.28	6.63	EUR	4
The USA	7.73	10.47	USD	3

The table presents arithmetic means of annual returns in % for the Fund and the IPD country indices, showing the currency denomination of the returns and number of observations in years. The calculation only includes years with complete annual returns (i.e., we do not include the partial years of first investments or the first half of 2017). Data source: NBIM.

To complement the annual returns, Figure 21 plots the evolution of the cumulative return for each country. The figure conveys the same message as does Table 22, i.e., that the UK investments perform above average, the French and German investments about average, and the US investments below average.

We have presented the annual performance of the real estate portfolios for the four main countries in which the Fund invests. It is tempting to consider the monthly returns and to aggregate them so as to undertake the same type of factor regressions and alpha analyses as we did for the equity and fixed-income portfolios, but have resisted this temptation.

There are at least two important reasons why we have resisted conducting this type of analysis. The first reason concerns the smoothed real estate returns. We use returns data from the Fund to illustrate this phenomenon. The returns have two components: changes in NAVs (corresponding to capital gains) and rental income (corresponding to dividends). Changing the property value requires a reappraisal (NBREM has all its properties valued externally on a quarterly basis). To illustrate the effect of the appraisals, Figure 22 plots the cumulative returns for each of the four countries. The saw-tooth shapes illustrate how changes come at regular intervals.
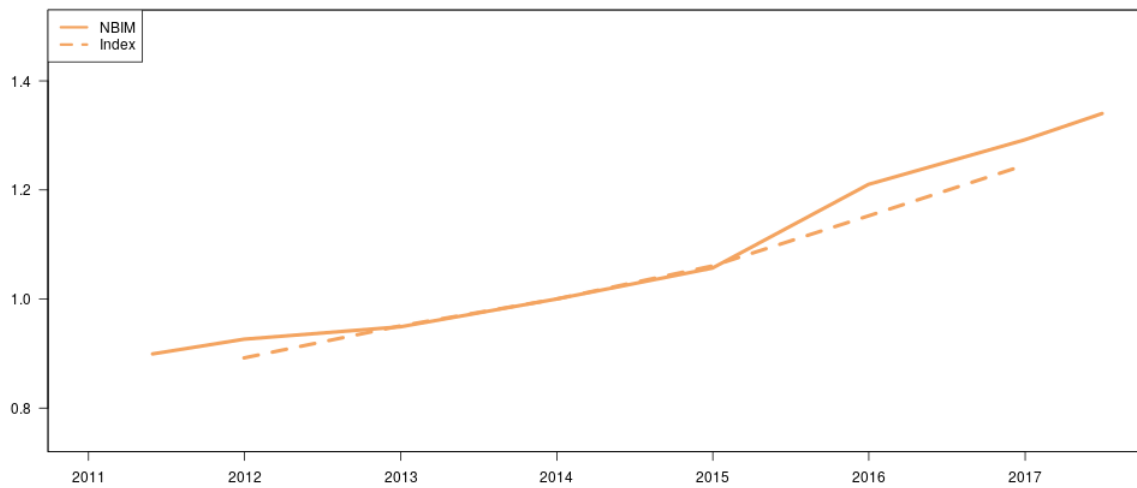
The second reason concerns currency translation. It is still possible to construct monthly returns for the Fund, by taking the returns in Figure 22 and translating them

Figure 21 Cumulative returns for real estate investments by country.
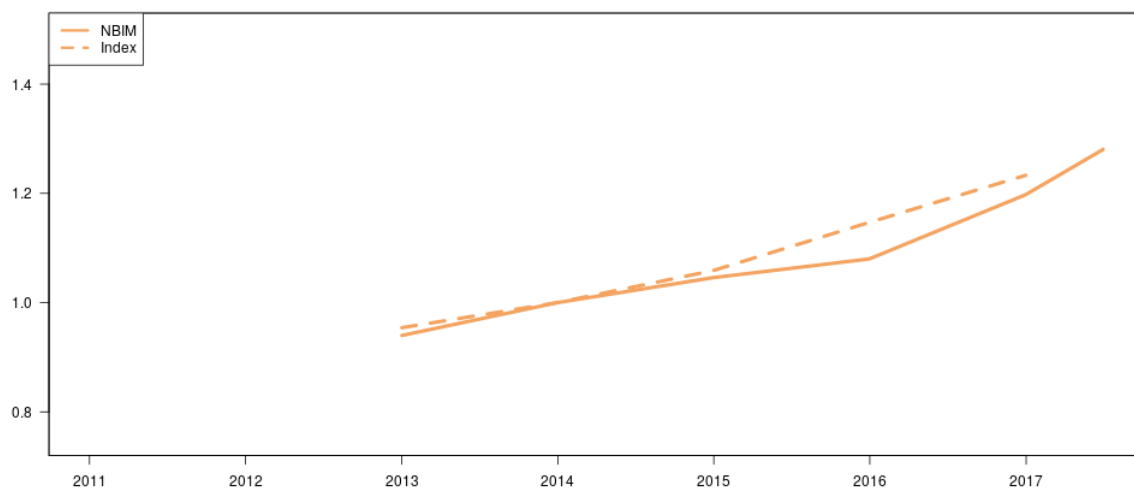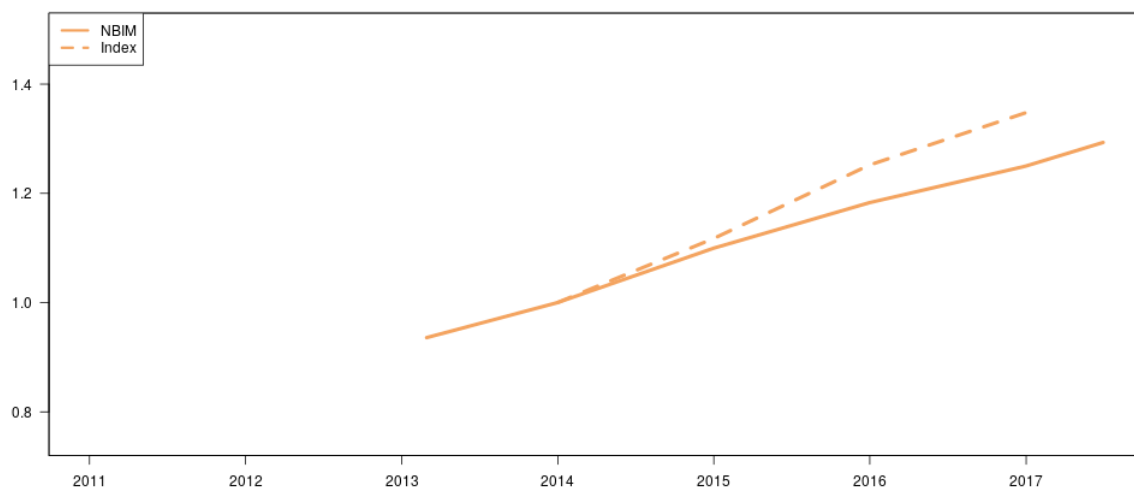
Panel A: The UK

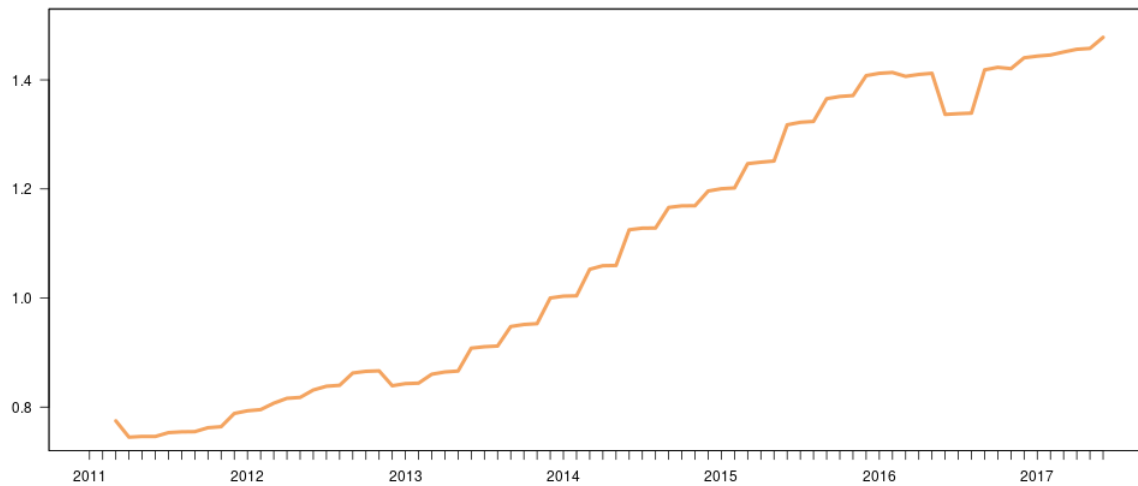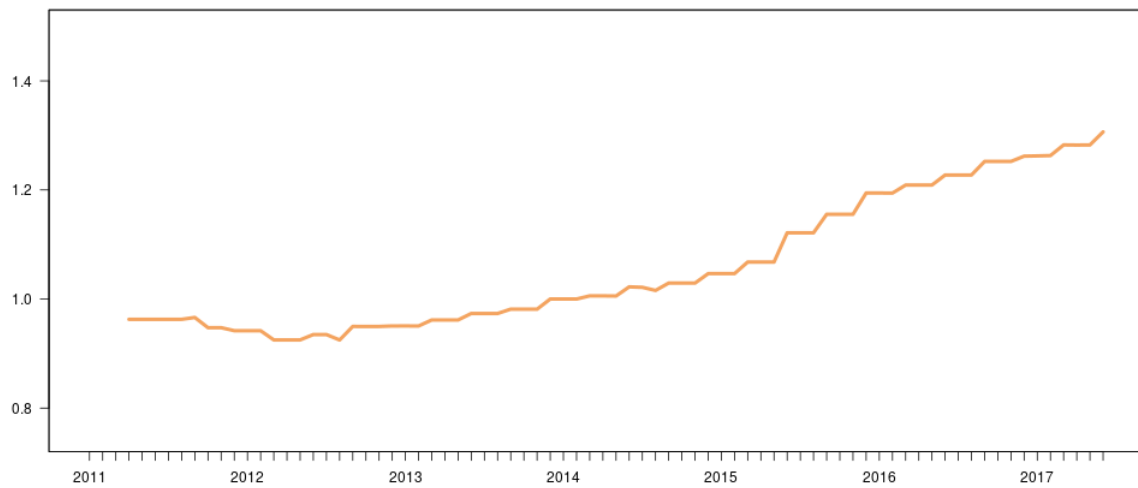Panel B: France

Panel C: Germany

Panel D: The USA

The figure plots the cumulative returns for the Fund's real estate investments in four major markets: the UK (Panel A), France (Panel B), Germany (Panel C), and the USA (Panel D). These returns are normalized by setting the cumulative return equal to one at the beginning of 2014. Returns are expressed in each country's currency. Data source: NBIM.

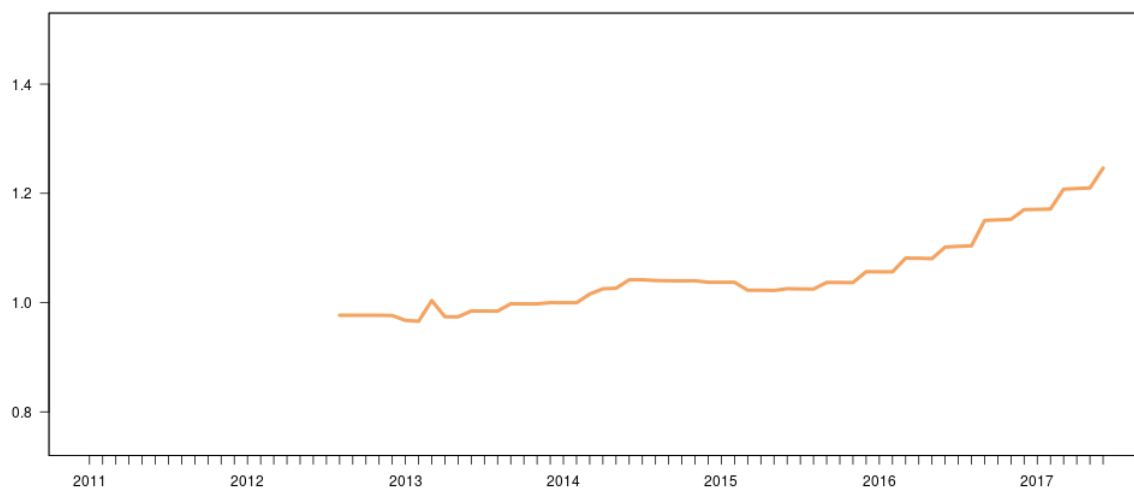**Figure 22** Cumulative changes in real estate NAVs by country.
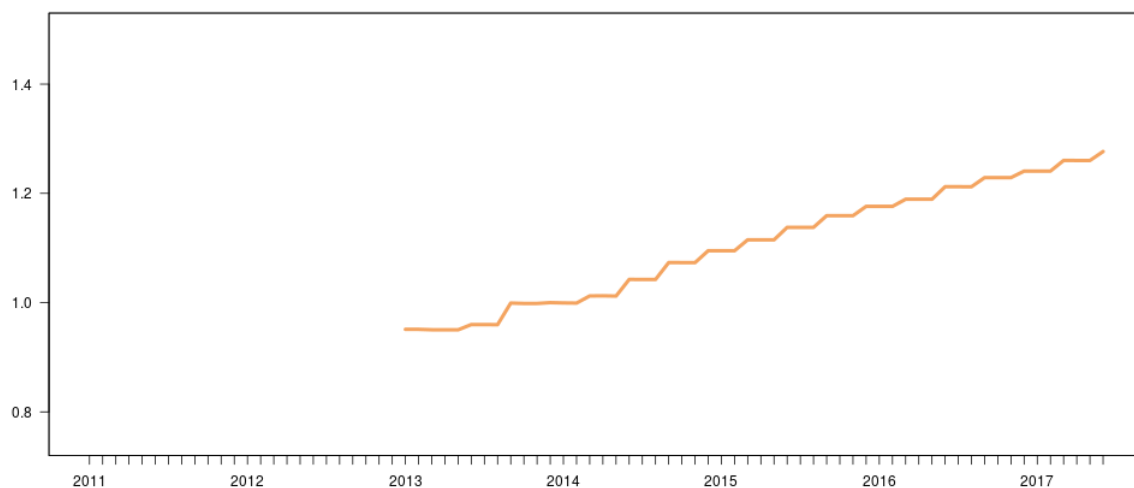
Panel A: The UK

Panel B: France

The figure continues on next page

Panel C: Germany

Panel D: The USA

The figure plots the cumulative returns for the Fund's real estate investments in four major markets: the UK (Panel A), France (Panel B), Germany (Panel C), and the USA (Panel D). These returns are normalized by setting the cumulative return equal to one at the beginning of 2014. Returns are expressed in each country's currency. Data source: NBIM.

to the currency basket of the Fund. Most of the variation in the Fund's monthly real estate returns will then be due to currency fluctuations. Therefore, using the monthly real estate returns in a factor regression will essentially be about explaining the movement of the exchange rates in the currency basket. We view such regressions as irrelevant to understanding the Fund's real estate returns.

We therefore limit ourselves to comparing the cumulative monthly real estate returns over the 2011–2017 period with those of the equity and fixed-income portfolios. Figure 23 shows that the long-term return on real estate lies between those of equity and fixed income. The real estate portfolio returns are much smoother, though, as discussed, that is largely by construction.

Figure 23 Cumulative returns for equity, fixed-income, and real estate portfolios
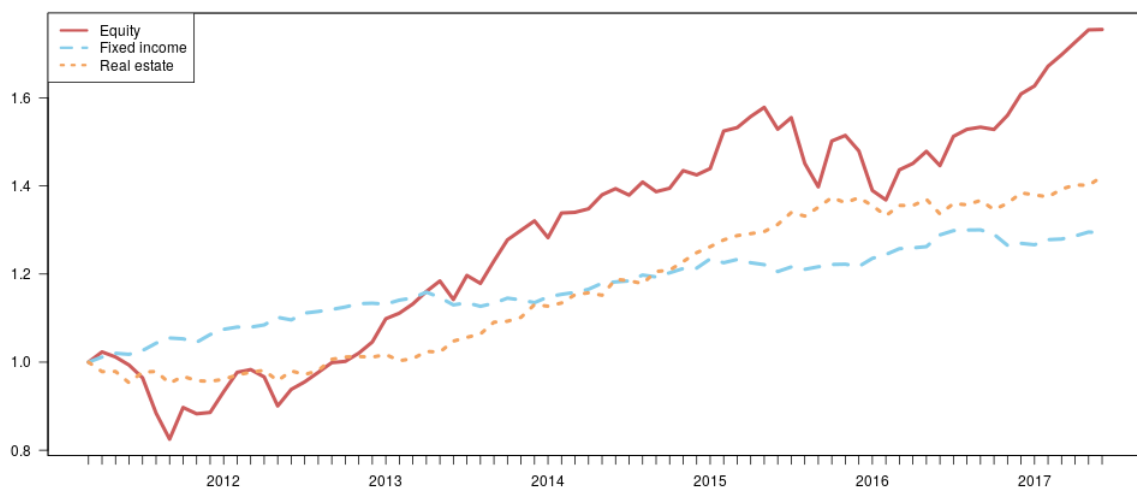
The figure plots the cumulative returns of the Fund's equity (red, solid), fixed-income (blue, dashed), and real estate (orange, dotted) portfolios. The returns are expressed in the Fund's currency basket. Data source: NBIM.

We have compared the real estate returns with the equity and fixed-income returns using simple counterfactual analyses. For example, we have compared two scenarios: (1) the Fund did not invest in real estate in 2011, instead keeping the original 60/40 equity/fixed income mix; and (2) the Fund immediately went to a 60/35/05 equity/fixed income/real

estate mix. In both scenarios, we maintained the fixed weights each month and calculate the monthly cumulative return of the two scenarios. Note that this is highly simplified as we abstract from time-varying weights due to return differences, sophisticated rebalancing, and differences in risks. In this simple experiment, the difference between the cumulative returns in (1) and (2) at the end of the period is 0.73 per 100 units of CB invested in 2011, with the real estate investments adding value. Obviously, this is a simple experiment assuming an initial investment in real estate of 5% at no cost. This analysis can be refined and extended by carefully taking into account the exact timing and purchases of real estate and the management costs. While the mandate before 2017 stated that the Fund's real estate investments should be compared with the IPD benchmarks, we find it worthwhile for NBIM to conduct scenario analyses of the real estate investments similar to those it conducted of its equity/fixed income benchmarks (NBIM, 2017c). It is our understanding that as of 2017, NBIM will measure the return on real estate investments against several benchmarks, including a benchmark based on the equities and fixed-income securities sold to finance these investments.

10.5 Tracking error

We now revisit the Fund's tracking error and the limit set by the Ministry of Finance in the mandate to Norges Bank, matters which we discussed earlier. Real estate was merged into the equity and fixed-income portfolios at the beginning of 2017, and the Fund then started calculating a separate tracking error for the real estate part of the portfolio. Figure 24 shows the tracking error for the real estate portfolio as well as the Fund's total tracking error limit. Note that NBIM uses a risk model for mapping the unlisted real estate investments into market movements to accurately measure the risks. Basically, the risk model maps unlisted real estate investments into listed real estate investments in the form of real estate investment trusts (REITs). It is our understanding that the risk model mitigates the smoothing we discussed earlier. The tracking error is approximately 7.2% per year, which can be compared with the equity and fixed-income tracking errors in the

same time period of 0.4% and 0.5% per year.

Figure 24 Tracking error for the real estate portfolio.
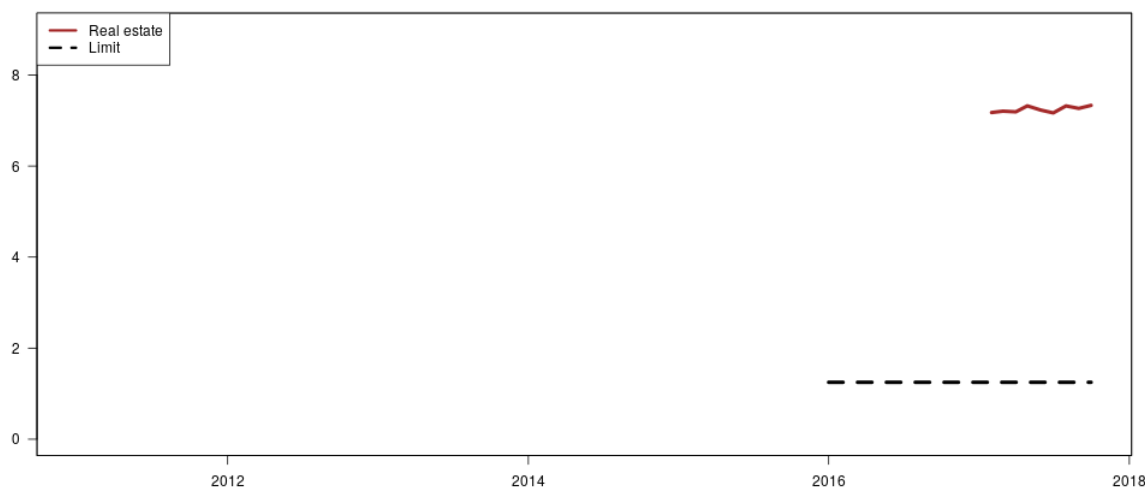
The figure plots the tracking error (i.e., expected relative volatility) expressed in % per year for the real estate portfolio and the limit for the total portfolio set by the Ministry of Finance; see NBIM (2016, p. 50) for calculation details. Data source: NBIM.

In Section 4, we noted a small increase in the tracking error for the total portfolio in January 2017 due to changes in the real estate mandate. While the tracking error for real estate is above the Fund's limit, real estate is still only 2.5% of the Fund's AUM, resulting in a small effect on the total tracking error. Note also that the tracking error limit is set to determine the total scope of active management, including real estate. Hence, if the Fund increases real estate investments from the current 2.5% toward the upper limit of 7%, there may be less scope for active management in the equity and fixed-income portfolios. A larger tracking error limit may then be justified.

10.6 Real estate strategy

Finally, we comment on the Fund's overarching real estate strategy. We limit our comments to the main features of the strategy, the geographical distribution of the real estate investments, and the Fund's targeting of "high-quality" commercial properties in large

cities.

A natural starting point is the CAPM of Sharpe (1964), Lintner (1965), and Mossin (1966), which prescribes that investors should hold the market portfolio. Van Nieuwerburgh et al. (2015) argued that unlisted real estate is about 5% of the global market portfolio. They also pointed out that the largest markets (in decreasing order of value) are the USA, Japan, the UK, Germany, and France. With the Fund's 2017 investments in Japan, the geographical distribution of the Fund's real estate is moving toward that of the global real estate market portfolio. We view this as a sensible way to build a large, global real estate portfolio. We note that the Fund's real estate investments have so far been limited to mature real estate markets. One recommendation of the Van Nieuwerburgh et al. (2015) report was that one should also consider real estate investments in emerging markets, a recommendation we echo, as much of the growth in real estate can be expected there.

Regarding the type of real estate and choice of cities, Ang (2014) argued that real estate investments should be analyzed in terms of urban economics. He emphasized that where people live and work (i.e., housing and office demand and supply) is driven by macroeconomic conditions and geography. The Fund's chosen strategy seems consistent with the strategy recommended by Ang (2014), investing in cities where the supply of housing and office space is restricted either by geography or by regulation. It also seems consistent with the worldwide trend toward urbanization. As we see it, it is an open question how the Fund can use its comparative advantages in doing so.

11 Concluding comments

We have reviewed Norges Bank's active management of the Government Pension Fund Global, referred to simply as the "Fund."

The absolute performance of the Fund is almost entirely determined by the benchmark choice set by the Ministry of Finance (the asset owner) and is dominated by equity risk. In this sense, the Fund can be viewed as a mega index fund. However, the Fund also deviates from its benchmark and pursues active management. These deviations stem from various investment strategies, such as factor investing, internal and external security selection, trading strategies based on opportunities arising from market imperfections and liquidity provisioning, and real estate investments. In this sense, the Fund can be viewed as akin to a mega index fund, enhanced by its active management.

The relative performance of the Fund (i.e., the return difference between the Fund and its benchmark, also referred to as the active return) is 0.20% per year after costs. In terms of the Fund's value added after costs, this corresponds to a transfer to the asset owner (and ultimately the Norwegian people) of NOK 30–50 billion over the 2013–2017 period, depending on how we adjust and credit risk taking. The lion's share of the value added comes from the Fund's equity portfolio. While it is difficult for us to assess each strategy's contribution to the Fund's total performance, a return decomposition suggests that the mean active return is due to security selection rather than market timing and, in particular, that the Fund has been able to choose outperforming external managers that contribute substantially. We also find that activities related to the indexing (e.g., asset positioning and securities lending) contribute to the total return, mitigating the Fund's costs of passively managing the assets.

In line with our mandate, the executive summary highlights the main findings and concludes with recommendations.

A   Mandate

This appendix contains the mandate.

Mandate for the expert group assessing Norges Bank's active management of the Government Pension Fund Global

The group shall prepare a public report reviewing Norges Bank's management of the Government Pension Fund Global (GPFG), by January 5, 2018. The report shall include the following:

1. **An assessment of Norges Bank's current main investment activities in the management of the GPFG, and the most significant investment strategies within each activity for the equity and fixed income portfolios, respectively.**

   Significance should be proportional to the share of relative risk, shortfall risk and cost budgets allocated to the strategy. The assessment shall include discussions of the activities' and strategies'

   - theoretical and empirical foundations,

   - known risk and return characteristics,

   - suitable evaluation horizons,

   - scalability.

2. **An assessment of Norges Bank's active management results for the GPFG since 1998.**

   Emphasis should be put on the most recent years. The assessment shall include quantitative analyses in accordance with leading academic standards using data on, i.a., return, risk and costs, and as a minimum present:

   - Analysis of results for the GPFG ex. real estate, and for the equity and fixed income portfolios separately, relative to the respective benchmarks given in the management mandate from the Ministry of Finance.

   - Analysis of results from each of Norges Bank's main investment activities and most significant investment strategies within each activity for the equity and fixed income portfolios, respectively.

   - A cost-benefit analysis of Norges Bank's main investment activities and significant investment strategies within each activity for the equity and fixed income portfolios, respectively.

3. **An assessment of Norges Bank's management of the real estate portfolio since 2011**.

   Emphasis should be put on the most recent years. The assessment shall include a discussion of the chosen strategy, and a quantitative analysis where the real estate investment results within selected major markets such as the US, UK, Germany and France are evaluated against relevant benchmarks.

4. **An assessment of Norges Bank's possibilities to obtain excess returns in the management of the GPFG relative to the current strategic benchmark**.

5. **Recommendations**. Based on the review of Norges Bank's management of the GPFG, including historical results, strategies and possibilities going forward, should the size of the relative risk budget – or "expected tracking error limit" – be adjusted?

B Chronology

This appendix lists some of the events that have affected the management of the Norwegian Government Pension Fund Global over the years.

1990 Legal basis established for investing oil-related income in international capital markets.

1996 Initial investments solely in developed market government bonds with trading done by Norges Bank, largely because, as the central bank, it had expertise in trading government securities.

1998 Fund established under the name Statens Petroleumsfond (The state petroleum fund); Norges Bank Kapitalforvaltning (later Norges Bank Investment Management) established as a separate division of Norges Bank; equity investments start with initial allocations of 40% equity and 60% fixed income.

2000 NBIM opens office in London, UK.

2001 Introduction of the Handlingsregelen fiscal policy rule limiting the annual amounts that the state can withdraw from the Petroleum Fund.

2002 Non-government bonds added to the fixed-income index.

First exclusion (of Singapore Technologies Engineering) from the Fund's portfolio based on negative screening—landmines.

2004 Ministry sets ethical guidelines for the Fund.

2006 Fund's name changed to Statens pensjonsfond—utland (Government Pension Fund Global).

First exclusion (of Wal-Mart Stores Inc.) from the Fund's portfolio using "ad hoc" evaluation based on record on unionization.

2007 Equity allocation increased to 60%.

Small-cap companies added to equity benchmark.

NBIM opens office in Shanghai.

2008 Emerging markets added to equity benchmark.

2009 First academic evaluation of the Fund's active management (Ang et al., 2009).

2010 Ministry of Finance allows real estate investments in the Fund with an allocation target of 5%.

NBIM opens office in Singapore.

2011 First real estate investment in Europe.

2012 New regional allocation for the Fund portfolio; changes to the sector composition and introduction of emerging market currencies to the fixed-income benchmark.

2013 First real estate investment outside Europe.

2014 Second academic evaluation of the Fund's active management (Ang et al., 2014).

2015 Instruction by the Storting that the Fund should no longer invest in coal-related companies.

Expert group proposes principles for risk adjustment of performance figures (Dahlquist et al., 2015).

Introduction of a separate vice governor in Norges Bank tasked with overseeing the asset allocation arm of the bank.

Academic study of real estate and infrastructure investments (Van Nieuwerburgh et al., 2015).

2016 First NBIM performance and risk report (NBIM, 2016).

Committee appointed by Ministry of Finance proposes equity/fixed-income weights of 70%/30% (Norwegian Ministry of Finance, 2016).

2017 Evaluation of the organization of Norges Bank (Norwegian Ministry of Finance, 2017) recommends creating a separate NBIM outside of Norges Bank, letting the central bank concentrate on monetary policy and overseeing Norwegian financial markets.

Equity/fixed-income weights confirmed to be changed to 70%/30%.

Sources: Skredderberget (2015); Ministry of Finance website; Norwegian Government Policy Papers (NOU/Stortingsmeldinger); various NBIM reports.

C Benchmarks

For reference, the following is the complete text of the regulation of the Fund's two benchmark indices (taken from "Management Mandate for the Government Pension Fund Global").

Section 3-2 Benchmark index for the bond portfolio

(1) The benchmark index for the bond portfolio has fixed weights with monthly rebalancing to the following sub-indices:

    a) Government bonds: 70 per cent.

    b) Corporate bonds: 30 per cent.

(2) The government bond sub-index of the benchmark index for the bond portfolio comprises:

    a) all securities included in the Bloomberg Barclays Global Inflation-Linked (Series-L) Bond Index.

    b) all securities included in the Bloomberg Barclays Global Treasury GDP Weighted by Country Index.

    c) all securities included in the supranational sub-segment (of the government-related segment) of the Bloomberg Barclays Global Aggregate Bond Index.

(3) Bonds issued by supranational organisations are allocated to countries in the government bond sub-index based on the underlying currency denomination. Bonds issued by supranational organisations in euros are allocated to the category "Supranationals (EUR)".

(4) Country weights in the government bond sub-index are calculated on the basis of the rules for the Bloomberg Barclays Global Treasury GDP Weighted by Country Bond Index. GDP weights shall subsequently be adjusted in accordance with the following weighting factors:

    a) Chile, Hong Kong and Russia shall be assigned a factor of 0.25.

    b) Other countries shall be assigned a factor of 1.

All weights in the government bond sub-index shall be standardised (sum of all weights equals 1). In addition, special provisions apply to countries in the eurozone as described in the fifth paragraph.

(5) Country weights shall be adjusted for the allocation to "Supranationals (EUR)" in accordance with the following rules:

    a) Proportion of "Supranationals (EUR)" in the eurozone = X.

    b) Allocation to "Supranationals (EUR)" = X * total GDP weight for countries in the eurozone based on weights calculated using the method specified in the fourth paragraph.

    c) For all countries in the eurozone: Country weight = $(1-X)$ * GDP weight for the country based on weights calculated using the method specified in the fourth paragraph.

X is determined for a period of twelve months effective from the index provider's annual reset of GDP weights as the relationship between the market value of "Supranationals (EUR)" and the market value of all euro-denominated bonds included in the government bond sub-index. The market values are calculated as at the end of October, one month prior to the index provider's annual reset of GDP weights, based on index data published by Bloomberg L.P.

(6) Within each country in the government bond sub-index, the bonds included are weighted using the methodology for the Bloomberg Barclays Global Treasury GDP Weighted by Country Bond Index.

(7) The corporate bond sub-index of the benchmark index for the bond portfolio comprises all securities included in the corporate sub-sector and the covered bond sub-segment (of the securitised segment) of the Bloomberg Barclays Global Aggregate Bond Index. The corporate bond sub-index is restricted to the following approved currencies: USD, CAD, EUR, GBP, SEK, DKK and CHF.

(8) Within the corporate bond sub-index, the bonds are weighted using the methodology for the Bloomberg Barclays Global Aggregate Bond Index.

(9) Securities denominated in Norwegian kroner or classified by Bloomberg L.P. as issued in Norway shall be excluded from the benchmark index for the bond portfolio. The same applies to securities issued by companies excluded by the Bank pursuant to the Guidelines for observation and exclusion from the GPFG. When bonds are excluded from the benchmark index, the remaining bonds in the sub-index in question shall be weighted up. When a company is reincluded under the aforementioned guidelines, the securities shall be reincluded in the benchmark index, cf. section 3-1, third paragraph.

Section 3-3 Benchmark index for the equity portfolio

(1) The benchmark index for the equity portfolio is composed on the basis of the FTSE Global All Cap Index.

(2) The equities in the benchmark index are assigned the following factors based on their country of origin:

    a) European developed markets excluding Norway: 2.5

    b) USA and Canada: 1

    c) Other developed markets: 1.5

    d) Emerging markets: 1.5

The allocation to countries and regions and the distinction between developed and emerging markets are based on the FTSE Global All Cap Index.

(3) Each country is included in the benchmark index with a weight based on the following formula:

$$\frac{\text{market capitalisation}_i \times \text{factor}_i}{\sum_i \text{market capitalisation}_i \times \text{factor}_i}$$

where i represents the countries with the factor in question, cf. section 3-3, second paragraph. The calculation of market capitalisation is based on the methodology for the FTSE Global All Cap Index and adjusted for free float.

(4) The benchmark index is adjusted for the Bank's tax position.

(5) Securities issued by companies excluded by the Bank pursuant to the Guidelines for observation and exclusion from the GPFG shall not be included in the benchmark index for the equity portfolio. When a company is reincluded under the aforementioned guidelines, the securities shall be reincluded in the benchmark index, cf. section 3-1, third paragraph.

D   Currency basket and currency conversions

The currency basket is a weighted basket of international currencies within the benchmark specified for the Fund. This benchmark is the aggregate benchmark of the equity and fixed-income benchmarks (no adjustments are made for real estate). The same currency basket is used to convert the returns of the equity, fixed-income, and real estate portfolios. Table D1 shows the proportions of the 33 currencies in the basket as of January 2015.

We undertake all analyses using returns denoted in the currency basket (CB) of the Fund. However, many factors (e.g., returns, excess returns, and changes in yield spreads) are in USD. Since NBIM provides returns data in both currency-basket and USD terms, we can use the relative returns to infer the currency contributions and translate the factors from USD to the currency basket.

Let R_t^{CB} and R_t^{USD} be the Fund's returns in CB and USD, respectively. The currency depreciation rate, X_t, solves:

$$(1 + R_t^{\text{CB}}) = (1 + X_t)(1 + R_t^{\text{USD}}), \tag{D1}$$

or

$$1 + X_t = \frac{1 + R_t^{\text{CB}}}{1 + R_t^{\text{USD}}}. \tag{D2}$$

Given the currency depreciation rate, we can now translate the returns, R_t^{USD}, and the returns of a long/short portfolio, $R_{L,t}^{\text{USD}} - R_{S,t}^{\text{USD}}$, in USD to the CB as follows:

$$R_t^{\text{CB}} = (1 + R_t^{\text{USD}})(1 + X_t) - 1, \tag{D3}$$

and

$$R_{L,t}^{\text{CB}} - R_{S,t}^{\text{CB}} = (R_{L,t}^{\text{USD}} - R_{S,t}^{\text{USD}})(1 + X_t). \tag{D4}$$

There are minor differences in depreciation rates derived from the total, equity, and fixed-income returns before 2001, but as of 2001 they are exactly the same. We apply the implied depreciation rate from the total returns of the total portfolio, and so on.

Table D1 Currencies and weights in the currency basket.

Currency	Weight
USD	40.35
EUR	20.59
GBP	8.64
JPY	8.06
CHF	3.71
CAD	2.67
AUD	2.39
HKD	2.21
KRW	1.76
SEK	1.58
TWD	1.00
MXN	0.89
DKK	0.83
ZAR	0.70
INR	0.68
BRL	0.56
RUB	0.50
THB	0.48
SGD	0.46
MYR	0.36
PLN	0.35
ILS	0.29
NZD	0.17
IDR	0.17
CLP	0.12
CZK	0.11
PHP	0.09
TRY	0.08
AED	0.06
COP	0.03
QAR	0.03
HUF	0.02
PKR	0.02
EGP	0.02
Aggregate	100.00

The table lists the 34 currencies with weights (%) in the currency basket as of June 2017 (month end).

E Factors

This appendix lists the factors considered in this review. We group the factors by the source of the relevant data. We borrow, sometimes verbatim, from the data sources when describing the factors. The data sources have more detailed information about the factors.

All factors are unhedged and expressed in USD (and then converted to the Fund's currency basket, see Appendix D). Unless stated otherwise, the factors are available from January 1998 to June 2017.

E.1 Data from Kenneth R. French

The data are available through the webpage:

`http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/`.

We use the equity factors in the Fama and French (2017) five-factor model:

`MKT` (market) is the return on a world market portfolio minus the US one-month T-bill rate.

`SMB` (small minus big) is the return on a small stock portfolio minus the return on a big stock portfolio.

`HML` (high minus low) is the return on a value portfolio minus the return on a growth portfolio.

`RMW` (robust minus weak) is the return on a robust-operating-profitability portfolio minus the return on a weak-operating-profitability portfolio.

`CMA` (conservative minus aggressive) is the return on a conservative investment portfolio minus the return on an aggressive investment portfolio.

In addition to these five equity factors, we also consider the international momentum (i.e., winners minus losers) factor, a US short-term reversal factor, and a US long-term reversal factor. Finally, we use the US one-month T-bill rate as a proxy for the risk-free rate.

E.2 Data from NBIM

We obtained several factors from NBIM. These factors are used in NBIM risk and return reports (NBIM, 2016, 2017c) and further described in these reports.

We use two fixed-income factors:

TERM (term premium) is the return on a global Treasury index (containing Treasuries with maturities of more than ten years) minus the return on a global Treasury index (containing Treasuries with maturities of one to three years).

DEF (default premium) is the return on a portfolio of corporate bonds minus the return on a portfolio of Treasury bonds (both with more than ten years to maturity).

These factors are inspired by Fama and French (1993) and the underlying data are from Barclays. To mitigate any duration mismatch in the DEF factor, it is duration adjusted by NBIM (which refers to it as the adjusted default premium factor).

In addition to these fixed-income factors, we also consider NBIM's size-constrained HML, RMW, and CMA factors, which are based on the Fama-French factors but use "big" stocks.

E.3   Data from David Hsieh

The data are available through the webpage:

   `http://faculty.fuqua.duke.edu/~dah7/DataLibrary/.`

These are hedge-fund factors used by Fung and Hsieh (2001). They are returns of look-back straddles for bonds, currencies, commodities, short-term interest rates, and stock indices.

E.4   Data from Ľuboš Pástor

The data are available through the webpage:

   `http://faculty.chicagobooth.edu/lubos.pastor/research/.`

These liquidity factors, used by Pástor and Stambaugh (2003) and updated and available up to December 2016, include one non-traded liquidity factor (based on innovations in aggregated liquidity) and one traded liquidity factor (i.e., the return on a high-liquidity beta portfolio minus the return on a low-liquidity beta portfolio).

E.5   Data from AQR

The data are available through the webpage:

   `https://www.aqr.com/library/data-sets.`

We consider the factors betting against beta (BAB) of Frazzini and Pedersen (2014) and quality minus junk (QMJ) of Asness et al. (2017). BAB is the return on a leveraged

portfolio of low-beta stock minus the return on a portfolio of high-beta stocks in the USA. QMJ is the return on a portfolio of high-quality stocks minus the return on a portfolio of low-quality stocks in the USA.

E.6 Our own factor construction

We construct several factors on our own.

First, we follow Ang et al. (2014) and consider one additional term (duration) factor and three additional default (credit risk) factors. The term factor is the difference in returns between the total-return BarCap US Treasury 20+ yr index and the total-return BarCap US Treasury Bill 1–3-mth index (referred to simply as "term"). The three default factors are: i. the difference in returns between the total-return BarCap US Corporate Aa Long-Maturity index and the total-return BarCap US Treasury 20+ yr index (referred to as Credit Aa); ii. the difference in returns between the total-return US Corporate Baa Long-Maturity index and the total-return BarCap US Corporate Aa Long-Maturity index (Credit Baa); and iii. the difference in returns between the total-return BarCap US Corporate High-Yield Caa index and the total-return BarCap US Corporate Baa Long-Maturity Baa index (Credit HY). The returns for these factors are all obtained from *Morningstar*.

Second, we consider returns in developed markets (MSCI World) and emerging markets (MSCI EM). We construct them either in excess of the risk-free rate (see above) or as an emerging market factor constituting the return on the emerging markets minus the return on the developed markets. These returns are obtained from *Morningstar*.

Third, we consider the return on a variance swap between implied and realized volatility on the S&P500, as computed by Daniel and Moskowitz (2016). We refer to this as the selling-volatility factor.

Fourth, we construct foreign exchange factors. We consider carry and dollar-carry factors in accordance with Lustig et al. (2011, 2014) as constructed by Dahlquist and Hasseltoft (2017) for G10 currencies.

Fifth, we consider several liquidity and funding factors. We consider the change in the VIX (referred to as ∆VIX) and the change in the TED spread (i.e., the three-month USD Libor minus the three-month US T-bill rate, referred to as ∆TED). VIX data are retrieved from the Chicago Board Options Exchange. The TED spread is constructed from data from the *FRED* database at the Federal Reserve Bank of St. Louis. We also consider three liquidity measures, constructed like those of Nagel (2016). The first and second liquidity measures are the change in the spread between the three-month general collateral repurchase agreement rate and the three-month T-bill rate (referred to as ∆Repo) and the spread between the three-month certificate of deposit rate and the three-month T-bill rate (referred to as ∆CD). These series are retrieved from *Bloomberg*. The third

liquidity measure is the spread between the on-the-run two-year Treasury note rate and the off-the-run two-year rate (referred to as ΔOn/off), as constructed by Gürkaynak et al. (2007). The on-the-run rate is retrieved from *Bloomberg* and the off-the-run rate from the Federal Reserve Board webpage:

`https://www.federalreserve.gov/pubs/feds/2006/200628/200628abs.html`.

F Return decomposition

In this appendix, we derive the decomposition of the Fund returns into a policy (or benchmark) return, a selection component, and a timing component.

Recall that the total returns of the Fund and benchmark are:

$$R_t = \sum_{i=1}^{N_t} w_{i,t-1} R_{i,t}, \tag{F1}$$

$$R_t^b = \sum_{i=1}^{N_t} w_{i,t-1}^b R_{i,t}^b, \tag{F2}$$

where $w_{i,t}$ and $w_{i,t}^b$ are the investment weights in i at time t for the Fund and the benchmark, respectively, $R_{i,t}$ and $R_{i,t}^b$ are the returns in i between $t-1$ and t for the Fund and the benchmark, respectively, and N_t is the number of indexed countries, industries, or sectors.

Following Brinson et al. (1986) and Blake et al. (1999), we begin by decomposing the Fund into four components. As an arithmetic identity at each date t:

$$R_t = \sum_{i=1}^{N_t} w_{i,t-1} R_{i,t} \tag{F3}$$

$$= \sum_{i=1}^{N_t} w_{i,t-1}^b R_{i,t}^b + \sum_{i=1}^{N_t} w_{i,t-1}^b (R_{i,t} - R_{i,t}^b) + \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b) R_{i,t}^b$$

$$+ \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b)(R_{i,t} - R_{i,t}^b) \tag{F4}$$

$$= R_t^b + \sum_{i=1}^{N_t} w_{i,t-1}^b (R_{i,t} - R_{i,t}^b) + \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b) R_{i,t}^b$$

$$+ \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b)(R_{i,t} - R_{i,t}^b), \tag{F5}$$

where the first term is the benchmark (or policy) return and the next two terms can be interpreted as the (i) selection and (ii) timing components. The last term is a residual having both selection and timing characteristics. In our setting, the residual term is small compared with the other terms. We therefore follow Daniel et al. (1997) and merge the residual term with the selection term to get (10), as presented earlier in the main text:

$$R_t = R_t^b + \sum_{i=1}^{N_t} w_{i,t-1}(R_{i,t} - R_{i,t}^b) + \sum_{i=1}^{N_t} (w_{i,t-1} - w_{i,t-1}^b) R_{i,t}^b. \tag{F6}$$

That is, we have decomposed the Fund's return into three components: policy, selection, and timing.

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