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The Performance of Norwegian Investment Grade Bond Funds

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Abstract

The following thesis examines the performance of Norwegian investment grade bond mutual funds in the period from January 2011 to January 2016. In this study we address two important issues. Firstly, by applying a CAPM model framework, we examine whether funds are able to outperform passive portfolios. Due to the lack of appropriate benchmarks for evaluation in the Norwegian market, we construct and include a bond index in our analysis. Across several different model specifications, we cannot detect a single fund exhibiting significantly positive performance relative to passive portfolios. Secondly, we extend the CAPM framework and analyze whether Norwegian bond funds generate abnormal returns[1] when controlling for the term and credit risk premium introduced by Fama and French (1993). We account for the risk factors by applying return-based style analysis. When controlling for the risk factors, we do not detect any significantly positive performance among the bond funds in our sample. Our results are important for investors, as attempts to select attractive securities or timing the market typically contributes to higher management fees compared to bets on risk factors. Thus, investors seem better off without funds seeking to harvest returns from market timing and security selection.

[1] Abnormal returns, refers to returns in excess of a relevant benchmark. Excess returns, refers to returns in excess of the risk-free rate.

Acknowledgements

This thesis marks the end of our MSc in Economics and Business Administration at the Norwegian School of Economics, and we look back at an inspiring and rewarding process. We would like to thank our supervisor Trond Døskeland for his guidance and constructive feedback. We would also like to thank Stamdata for providing us with reference data on bonds in the Norwegian market. Finally, our families deserve praise for giving us their valuable and unconditional support.

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1 Introduction

This thesis examines the investment performance of Norwegian investment grade bond mutual funds in the period from January 2011 to January 2016. We find this research to be particularly important for two specific reasons. Firstly, bond funds handle large sums of private wealth and pension liabilities. At the end of 2015 the value of bond funds climbed to NOK 298 billion, amounting to approximately 30% of the total mutual fund market (SSB 2016). Due to the magnitude and popularity of bond funds, information regarding performance is vital for investors. Secondly, we believe the current portrayal of Norwegian bond fund performance is misleading and imprecise for investors. All funds examined in this thesis uses government bond indices as their benchmarks, due to the lack of better alternatives, even though they invest in bonds with credit risk. Basic financial theory states that investors are rewarded for bearing credit risk,[2] thus exceeding the returns of government indices should not be a daunting task.

Most international papers on bond fund performance report on either under- or non-superior performance, net of expenses. To our knowledge, Gjerde and Sættem (1996) is the only paper providing evidence from the Norwegian market. Compared to the BRIX-index,[3] they conclude on non-superior performance for Norwegian corporate bond funds. In general, active bond fund management does not seem add value to the investor. These results are in line with the efficient market hypothesis, presented by Fama (1970). He claims that any attempts to outperform the market will be fruitless beyond occasional luck, as current prices reflect all available information. Grossman and Stiglitz´s (1980) do, however, not rule out that outperformance may occur, as markets cannot be fully efficient at all time. Through a CAPM framework we want to analyze abnormal returns for Norwegian bond funds. Due to the lack of appropriate benchmarks for evaluation in the Norwegian bond market, we construct and include a bond index in our analysis following the methodology of Barclays (2016) and Citigroup (2016). We form the following research question:

1) Do Norwegian bond funds outperform passive portfolios, net of expenses?

[2] Ilmanen (2012) expresses that US investors have historically been rewarded, relative to US Treasury portfolios, for bearing credit risk.
[3] The BRIX-index is no longer marketed by Oslo Børs.

Extending the CAPM framework, we want to analyze whether Norwegian bond funds deliver abnormal returns when controlling for the bond risk factors introduced by Fama and French (1993). This is vital, as attempts to identify attractive securities typically is costlier than betting on risk factors (French 2008). The Norwegian Government Pension Fund Global[4], recently reported on non-superior performance when controlling for Fama and French´s risk factors (NBIM 2016: 97). Although referring to an international fixed income portfolio, similar concerns can be directed towards bond funds operating in the Norwegian market. We account for the bond risk factors by applying return-based style analysis (RBSA)[5], or simply style analysis, as presented by Dopfel (2004). RBSA controls for risk factors by identifying managers' investment style. Based on the discussion in this section, we form a second research question:

2) Do Norwegian bond funds generate abnormal returns when accounting for risk factors in the Norwegian bond market?

Our thesis makes two main contributions to the existing literature. First, we are able to improve the current evaluation of Norwegian bond funds by constructing a bond index accounting for credit risk. Second, we are the first to analyze abnormal returns and controlling for risk-factors by applying RBSA. And, at least to our knowledge, this research is the first to examine the performance of Norwegian bond mutual funds in over twenty years.

The reminder of this thesis is organized as follows. Section 2 provides a literature review of academic papers examining topics covered in this thesis, while Section 3 outlines the theoretical framework of our analysis. Section 4 outlines a description of the data retrieval, and section 5 addresses the methodology of the bond index construction along with the choice of evaluation models. Section 6 outlines the empirical results, while the concluding remarks are presented in Section 7.

[4] The fund managing Norway's petroleum wealth.

[5] A descriptive and formal presentation of style analysis is presented in section 3.3.2.

2 Literature review

In this section, we review previous literature on the performance of bond mutual funds. We address the first research question by presenting studies on bond fund performance relative to passive portfolios in several bond markets. Second, we review studies RBSA to analyze bond fund performance.

2.1 Bond fund performance and passive portfolios

The investment performance of bond mutual funds has seen some scrutiny in international financial literature, and the results are consistent. Most papers report on either under- or non-superior performance. Bond funds consistently fail to outperform passive portfolios, as reflected through benchmarks consisting of relevant bond indices.

The first comprehensive study evaluating bond fund performance were conducted by Blake, Elton and Gruber in 1993. They investigated the performance of bond mutual funds in the US market in a 10-year period from 1979 to end of 1988, using single-index and multi-index models. The models are extended by imposing constraints on the estimated coefficients, and in doing so, they are kept consistent with fund investment policies including restrictions on short selling and leveraging. The results suggest that all bond funds underperform relative to their matched index in the sample period, with the results being robust across all models. The only exception is for high-yield bond funds, where some funds exhibit positive risk-adjusted returns. The authors explain this particular finding with the lack of a relevant high-yield benchmarks.

In a more recent study, Dietze et al. (2009) evaluates the performance of investment grade corporate bond funds in the European market. The focus is merely on the investment grade market, as they argue that the high yield market is poorly developed. They follow Blake, Elton and Gruber (1993) and apply similar index models, with specifications restricting funds from short selling and leveraging. More precisely, they apply both letter-rating-based and maturity-based indices in evaluating bond funds (Dietze et al. 2009: 192).[6] The findings of Dietze et al. (2009) are consistent with the previously presented studies, bond fund managers are not able

[6] We elaborate on both maturity-based and letter-rating-based indices in Section 3.2.

to outperform passive portfolios post expenses. The authors conclude that the underperformance in the European market is mainly due to expenses, and therefore advice investors to choose bond funds with low management fees.

The evidence regarding bond fund performance reviewed so far is based on empirical studies applying unconditional models. The unconditional approach fails to account for funds changing their portfolio weights over time. On the contrary, the conditional models allow for the dynamic investing behavior of managers. Gallagher and Jarnecic (2002) address the performance of actively managed Australian bond funds by applying both unconditional and conditional models. Regardless of the model applied, Gallagher and Jarnecic (2002) conclude that no funds are able to outperform passive portfolios. Their results are robust before and after accounting for expenses. Silva, Cortez and Armada (2003) uses an equivalent approach in the evaluation of European bond funds, and conclude on the inability of fund managers to generate abnormal returns.

While a significant amount of research has been conducted on the performance of Norwegian equity funds, the number of studies on bond funds are limited. To our knowledge, the only contribution is Gjerde and Sættem´s (1996) study of Norwegian bond mutual funds´ between 1992 and 1995. Using both single- and multi-index models, they conclude that corporate bond funds do not earn a positive abnormal return. The research of Gjerde and Sættem (1996) was based on the BRIX index, but this is no longer marketed by Oslo Børs.

2.2 Bond fund performance and return-based style analysis

The following section addresses studies applying style analysis to identify and adjust for funds exposure to risk factors when evaluating performance. William Sharpe introduced style analysis in 1992, trying to identify fund exposure to various indices in the equity market. Sharpe (1992) interprets the estimated exposures as historical portfolio weights determining the fund´s investment style. Based on these portfolio weights, he evaluates fund performance relative to a style-adjusted benchmark based on each fund´s investment style.[7] The use of

[7] Horst et al. (2004) provides an excellent overview of RBSA and its general application in constructing performance benchmarks. We elaborate on style-adjusted benchmarks in Section 3.3.2.

style analysis in the fixed-income market is presented and explained by Dopfel (2004). According to Dopfel (2004), style analysis amounts to measuring fund manager´s historical exposures to risk factors. Thus, using style analysis, it is possible to control for the risk factors presented by Fama and French (1993).

Kahn and Rudd (1995) applies style analysis on a selection of actively managed equity and fixed-income funds in the US between 1986 and 1993. They construct and assign each fund with a style-adjusted benchmark and analyze abnormal returns using a single-index model. By taking into account the specific investment style of managers, they eliminate historical bets on risk factors from the performance analysis. The authors conclude that investors are better off by funds not pursuing strategies trying harvest returns from identifying attractive securities or timing the market. In another study, Bosse et al. (2013) examines drivers of the performance differences between US active fixed income funds and their benchmarks, in the period from 1998 to 2012. In this study, skill is defined as the generation of returns generated from either successful market timing or security selection. Bosse et al. (2013) limit the analysis to funds benchmarked to the Barclays U.S. Aggregate Bond Index, due to its popularity among fund managers. The authors find that historical bets on risk factors seemed to be the primary driver of returns in the sample period, not successful market timing or security selection.

A recent report, evaluating the performance of the fixed-income portfolio of the Norwegian Government Pension Fund (NBIM 2016: 97), concludes on non-significant alphas when controlling for the bond risk factors presented by Fama and French (1993). The report does not apply style analysis, but creates two separate factors to adjust for the term and credit risk premium.[8] The overall results show non-significant alphas from 1998 to 2015, both before and after expenses. If the Norwegian Government Pension Fund Global is not able to generate returns in excess of risk factors, the Norwegian electorates are better without pursuing market timing and security selection.

[8] The report creates two factors accounting for the term and credit risk premium, we elaborate on these factors in section 3.3.1. The term premium factor is defined as the difference between the returns from Barclays Global Aggregate Treasury 10+Y index and Barclays Global Aggregate Treasury 1-3Y index. The credit risk premium factor is defined as the difference between the Barclays US Aggregate Corporate Long index and the US Aggregate US Treasury Long index (NBIM 2016: 83).

The research discussed in Section 2.1 and 2.2 is essential for understanding the performance of bond mutual funds. Undeniably, academics find no evidence of the ability of bond funds to either outperform passive portfolios or generating returns when accounting for risk factors. This thesis will identify whether similar conclusions can be drawn based on the Norwegian bond market.

3 Theoretical framework

In this section, we start by introducing the basic concepts of bonds and characteristics of the Norwegian market. This is essential, combined with the elaboration on bond indices, for understanding the constructed bond index in Section 4. The bond index is essential for conducting and understanding the analysis in Section 6, and will be applied to address both research questions presented in the introduction. Finally, we present the preferred performance evaluation models and the use of these in the modelling of abnormal returns.

3.1 Bonds and the Norwegian market

Bodie, Kane and Marcus (2014) define a bond as a security issued in connection with a borrowing agreement. The issuer is obligated to make quantified payment(s) to the bondholder on specified dates, depending on the terms of the bond. The payments are called coupons, and denote the (fixed) stream of payments made to owners during the life of the bond (Fabozzi 2011). Coupon-paying bonds could have either a fixed or floating rate coupon, meaning that the payment made to bondholders each period is respectively fixed by a contract or settled and updated periodically based on an underlying interest rate plus a fixed premium (Bjerksund and Stensland 2014). Coupon payments are typically made in fixed intervals, e.g. annually, semiannually, quarterly or monthly. The principal is specified in the indenture, and states the amount that the borrower must repay to the lender at maturity, also called the face or par value (Morningstar 2013).

The time-to-maturity of a bond represent the number of years in which the debt will cease (Fabozzi 2011). Bonds have a maturity of more than one year, while certificates have a maturity of less than a year. The price of a bond is dependent on the (fixed) stream of income an investor can expect to receive over the horizon of his investment. The cash flows consist of the coupon payments plus the payment of par value at maturity, and are discounted by an appropriate discount rate (Bodie, Marcus and Kane 2014: 452).[9] Formally the price of a bond is defined as:

[9] For a thorough analysis of bond pricing and discount rates we recommend chapter 14 in Bodie, Marcus and Kane (2014).

$$Bond\ price = \sum_{t=1}^{T} \frac{Coupon}{(1+r)^t} + \frac{Par\ value}{(1+r)^T}$$

where r is the discount rate and T is the time to maturity. The bond price is inversely related to the discount rate, meaning that the bond price increases if the discount rate decreases. If a bond is purchased between coupon dates, the buyer has to compensate the seller for the accrued interest. The accrued interest refers to the part of the coupon in which the seller is entitled to receive if he or she chooses to sell the bond between coupon dates (Bodie, Marcus and Kane 2014: 447). The sales price, including accrued interest, is often referred to as the *dirty price*. The price excluding accrued interest is referred to as the *clean price*. A bond´s sensitivity to interest rate changes is measured by the duration, a weighted average of future coupon or principal payments (Fabozzi 2011: 137).

Most corporate bonds will be exposed to credit risk, reflecting the chance of the borrower (the issuer of the bond) not being able to meet his obligations (Fabozzi 2011: 25). Credit ratings are a measurement of the credit risk of an issuer. For bonds with higher ratings, the probability that the bondholder will meet its obligations during the lifetime of the bond is higher. In terms of the ratings, bonds with a rating of A are safer than those with a rating of B or below. Bonds with a rating of at least BBB-/Baa3 (see Table 3.1) is characterized as investment grade bonds. Bonds with a rating lower than BBB-/Baa3 are of lower credit quality and are often referred to as junk or high-yield bonds.

Bonds issued by the government are typically considered to be of very high credit quality (i.e. little or no credit risk), hence they are rewarded with a high credit rating. In our dataset, the credit risk classification is made by Stamdata[10], in which we chose to trust, since a large part of the bonds in the Norwegian market does not have a publicly available credit rating. An overview of the implication of different credit ratings is presented in Table 3.1.

[10] Stamdata is the leading provider of reference data on individual bonds in the Norwegian market.

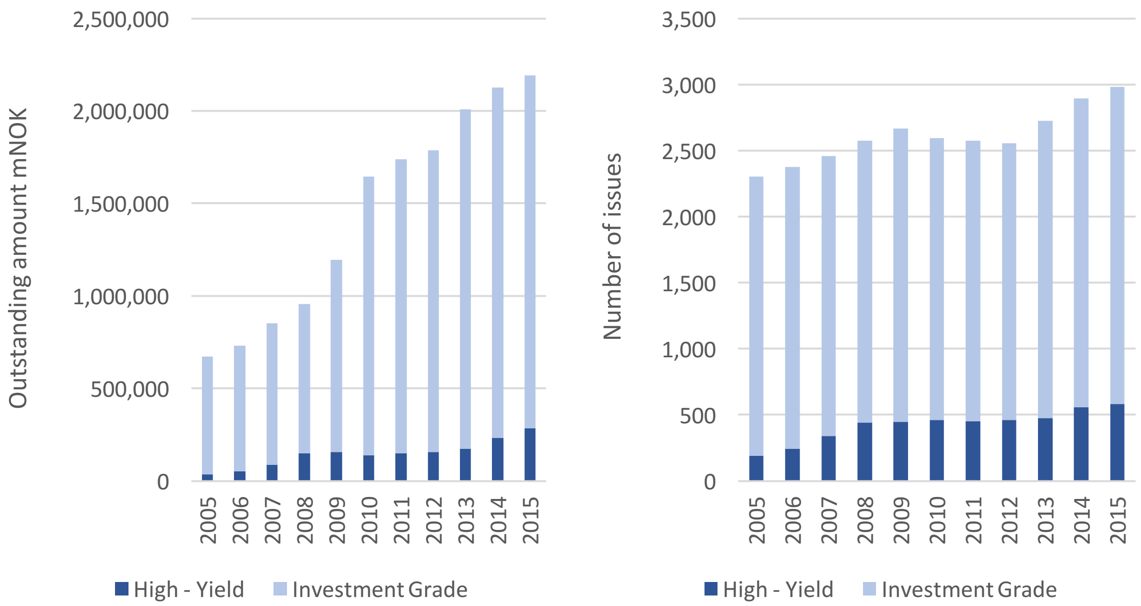
Table 3.1: Credit ratings

Risk Class	Definition	Moody`s	S&P	Fitch
Investment Grade	Premium credit quality	Aaa	AAA	AAA
	Very high credit quality	Aa1	AA+	AA+
		Aa2	AA	AA
		Aa3	AA-	AA-
	Upper medium credit quality	A1	A+	A+
		A2	A	A
		A3	A-	A-
	Lower medium credit quality	Baa1	BBB+	BBB+
		Baa2	BBB	BBB
		Baa3	BBB-	BBB-
High Yield	Speculative	Ba1	BB+	BB+
		Ba2	BB	BB
		Ba3	BB-	BB-
	Highly speculative	B1	B+	B+
		B2	B	B
		B3	B-	B-
	Default a likely option	Caa1	CCC+	CCC+
		Caa2	CCC	CCC
		Caa3	CCC-	CCC-
	Extremely speculative	Ca	CC	CC
	Close to default	C	C+/C/C-	C+/C/C-
	Default		D	D

Source: Bodie, Marcus and Kane (2014)

Figure 3.1 illustrates descriptive statistics comparing the Norwegian investment grade and high-yield market in terms of debt outstanding and issues. Over the last ten years the market has, in terms of debt outstanding, more than doubled in size. In addition, the number of issues have increased since 2005, and reaching approximately 3000 in 2015.

Figure 3.1: The Norwegian high yield and investment grade market



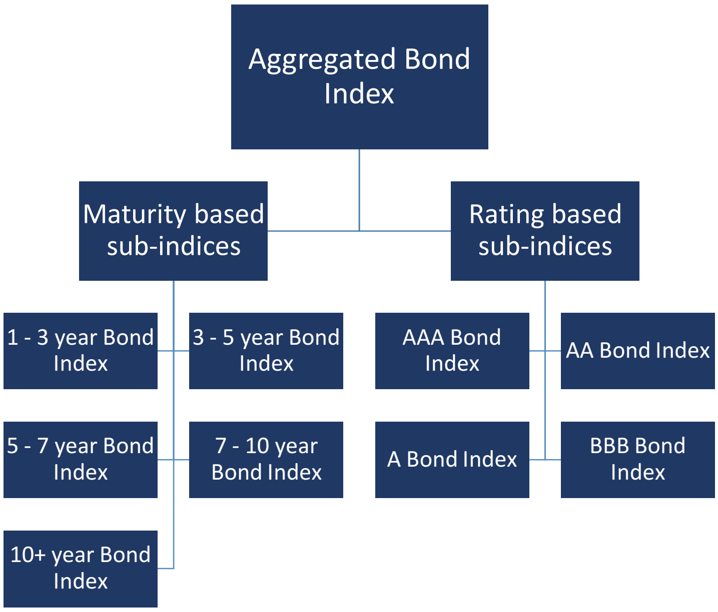
Source: Stamdata

In Norway, newly issued bonds face the opportunity of listing at either Oslo Børs or the Nordic Alternative Bond Market (ABM). The Nordic ABM is a self-regulated marketplace, with a less comprehensive and time-consuming origination process compared to Oslo Børs. On the contrary, Oslo Børs requires a higher degree of transparency and rules concerning accounting standards. However, both markets are useful sources of financing for firms, compared to borrowing from banks.

3.2 Bond indices and bond index construction

A bond index is, just as a equity index, a combination of several underlying securities with the objective to represent the entire or different segments of the market (Bodie, Marcus and Kane 2014: 48). Designing, computing and maintaining bond indices is, however, far more complex than for equity indices. The bond universe includes several issuers varying in terms of credit ratings, maturity and coupon payment structure. Therefore, many bond index providers offer sub-indices to complement the aggregated bond index. An overview of hypothetical sub-indices is presented in Figure 3.2 below. Normally, the sub-indices are divided into letter-based and maturity-based indices, referring to either the credit rating or remaining maturity of the bond.

Figure 3.2: Aggregated bond index and sub-indices



A reliable bond index should include as many different bonds as possible, if reliable prices are available. In this thesis, we use a rules-driven approach to determine the set of bonds to include in our index.[11] A rules-driven index requires the provider to publish a set of rules, and all of the bonds that meet those rules are index eligible (Tucker 2011). If an index is made public, the rules must be transparent and accessible to all investors. Barclays (2016) and Citigroup (2016) uses equivalent approaches when constructing their indices.

First, providers need to determine the minimum credit rating for bonds to be included in the index. An index that mixes investment grade and high yield bonds could complicate the risk structure of the index, thus separate indices are normally created (Barclays 2016). Additionally, providers could face challenges as different rating agencies may assign different ratings to the same security (Barclays 2016).

Second, the bond universe is highly heterogeneous, making it important for an index provider to specify which bond types to include. Some bonds have optionality on earlier payment of principal, while others differ in coupon payment structure (fixed or floating rate payments).

[11] A complete list of rules for the bond index constructed in this thesis is presented under Section 4.1.

For example, Barclays (2016) only include fixed-rate bonds in their index. In addition, providers must distinguish between bonds that have senior claims and those that have subordinated claims in a credit event. E.g. in the case of bankruptcy a senior secured bond will have priority over a senior unsecured bond.

Third, providers need to address the treatment of cash flows generated through coupon payments. The re-investment of coupons will affect the individual bond return, and subsequently the return of the aggregated bond index. If intra-month cash flows are re-invested, this can be done directly back into the bond that generated them, into an overall bond index or in the money market. Alternatively, one can assume that intra-month cash flows are *not* reinvested. After defining what bonds to be included in the index universe and the re-investment strategy, the return of each security will be aggregated to an index level determined by the index weighting scheme.

Finally, providers need to assess if the index should be weighted by the market value of debt or by equal weights. Most bond indices are value-weighted, however there are examples, such as the Dow Jones corporate bond index, in which all issues are weighted equally. Goltz and Campani (2011) emphasizes that value-weighting is the only scheme consistent with a passive investment strategy. If all securities are bought at market-value proportions, portfolio weights will automatically change over time. Hence, investors will not need to update their portfolios.

3.3 Modelling abnormal returns

3.3.1 The Capital Asset Pricing Model

The modelling of abnormal returns in this thesis relies on the Capital Asset Pricing Model (CAPM), an asset-pricing model developed by Sharpe (1964), Lintner (1965) and Mossin (1966). The CAPM is used to predict the risk-return relationship for individual securities. The model is simple and intuitive; it assumes that the (expected) return of an asset is only dependent on the market risk premium and the assets sensitivity to the market. The market should, in theory be the aggregated portfolio of all individual investors (Bodie, Marcus and Kane 2014: 292). However, such a portfolio is virtually impossible to identify and create. Thus, in most research of abnormal returns, the market is reflected through broad indices.

The CAPM is based on several underlying assumptions of both individual behavior and market structure. Investors have to be rational mean-variance optimizers with homogenous expectations, and all assets in the market have to be traded on public exchanges (Bodie, Marcus and Kane 2014: 304). According to the CAPM, investors split their investment between the well-diversified market portfolio, with no idiosyncratic risk, and a risk-free investment. A diversified portfolio implies limiting exposure to only the market risk that cannot be eliminated through diversification (Døskeland 2014: 104). Sources of market risk are typically movements in macroeconomic factors such as inflation, GDP and unemployment. The CAPM is formally defined as:

(1) $$E(r_i) = r_f + \beta_i(E(r_m) - r_f)$$

$E(r_i)$ is the expected return of asset i, r_f is the risk-free rate and $(E(r_m) - r_f)$ is the market risk-premium. β_i represent the systematic risk, and is a quantitative measure of how asset i covary with the market. In theory, investors should only be rewarded with higher expected return when increasing their exposure to market risk. β_i is formally defined as:

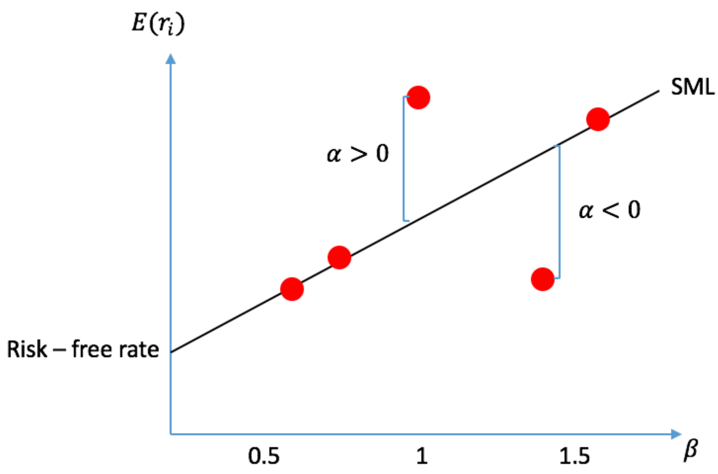
(2) $$\beta_i = \frac{cov(R_i, R_m)}{var(R_m)}$$

where β_i is calculated by taking the covariance between the return of asset i and the return of the market m, divided by the variance of the return of the market m. The size of β_i indicates how much the return of asset i will change as the return of the market changes. If β_i is smaller than 1, the return will increase with *less* than that of the market. Correspondingly, if β_i is larger than 1, the return will increase by *more* than that of the market.

If the formal CAPM model can be used to price all assets, there should exist a linear relationship between the expected return and the beta of an asset. This linear relationship is typically characterized as the security market line (SML). Figure 3.3 illustrates the basic concept of the SML. Assets with returns deviating from the SML has generated, either positive or negative, abnormal returns. Because the formal has accounted for market risk, the abnormal returns can be interpreted as risk-adjusted performance. Alternatively, the general CAPM equation can formulated as a regression model:

(3) $$E(r_i) - r_f = \alpha_i + \beta_i\big(E(r_m) - r_f\big) + \varepsilon_i$$

Figure 3.3: The Security Market Line (SML)



Equation (3) introduces α_i, which is the risk-adjusted performance of asset i. ε_i is the error – term of the model, the part of the return of asset i which is not accounted for by the model. If the market is fully efficient, as implied by model (3), the estimated alphas will neither be positive or negative. When the market return is proxied by the returns from an index, equation (3) can be characterized as a single-index model. Single-index models are specific versions of the CAPM, where historical index data are used to proxy market risk (Bodie, Marcus and Kane 2014: 259). A multi-index model includes additional indices to equation (3), and aims to explain more of the variation in the returns of asset i.

In active management, the fund manager explicitly tries to outperform an index (or a benchmark consisting of several) based on his subjective perceptions of the market (Focardi and Fabozzi 2004). For example, the manager may inherit superior information compared to others or he more effectively exploits available information. By doing so, the manager tries to exploit market inefficiency as measured the market risk implied by the CAPM model. These activities typically come at a higher cost compared to passive management. Passive management makes no attempts to outperform the market and typically invest in broad market indices.

According to the CAPM, the beta of a security is sufficient to determine the expected return of any security. However, Fama and French (1992) famously criticized the CAPM, and thus the index-models, showing that market risk is not the only systematic determinant of stock returns. They introduced a multifactor model, and argued that the relative size and the book-to-market value of companies could contribute to explain variations in returns. Carhart (1997) introduced a fourth factor, controlling for funds tendency to pursue momentum strategies. Accordingly, a manager of an equity fund has several ways in which he can actively make his returns deviate from his benchmark.

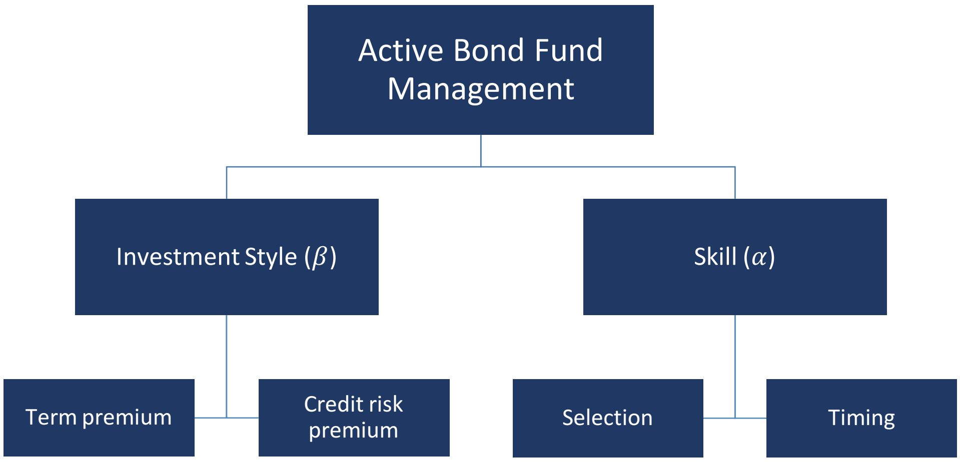
In the bond market, similar factors are not frequently utilized in academic research (Dietze et al 2009: 194). Fama and French (1993) argue for two main factors driving bond returns. Investors are rewarded for their exposure to interest rates, and the longer the average maturity of a bond investment the larger the interest rate risk. Ilmanen (2012) characterizes the return arising from interest rate risk as the *term premium*. Investors are also rewarded for their exposure to default risk when investing in bonds. Ilmanen (2012) characterizes the return arising from default risk as the *credit risk premium*.

According to Dopfel (2004), a bond fund can apply two types of active management to generate returns in excess of their benchmark (illustrated in Figure 3.4 below). Firstly, managers can utilize the risk premiums presented by Fama and French (1993), often referred to as *investment style*. A manager can either increase the duration of his portfolio, trying to exploit the term premium. Alternatively, he can exploit the credit risk premium by increasing the allocation to sectors with higher credit risk.[12] Secondly, returning to Figure 3.4, an investor can exhibit skill by making either *selection* or *timing bets*. Selection bets refer to the selection of specific securities based on active research, and correspondingly changing their initial weight in the portfolio (Dopfel 2004: 34). Timing bets refer to the managers´ ability to predict

[12] Keep in mind that Figure 3.4 represents an extreme simplification of the choices a bond fund manager faces.

the yield curve and credit spreads, and correspondingly changing the duration or credit risk of his portfolio.

Figure 3.4: Active bond fund management



3.3.2 Return-based style analysis

Initially the CAPM only control for the degree of market risk undertaken by a fund. Thus, it is not possible to separate returns generated from skill and investment style. This distinction is important, because returns arising from skill typically entails larger management fees for investors (French 2008). If either timing or selection (i.e. alpha) does not pay off, investors would prefer funds not pursuing these strategies. We account for investment style (i.e. beta), thus isolating the skill component in Figure 3.5, by applying return-based style analysis (RBSA). The investment style of a manager will account for his average bets on both the term and credit risk premium over the sample period.

RBSA was introduced by William Sharpe in 1992, and compares actual fund returns with various style-based indices all meant to represent passive portfolios. Sharpe (1992) interprets the exposure to the indices and interpret as historical portfolio weights, and uses the weights to constructed style-adjusted benchmarks. In general, RBSA estimates the following asset class factor model (ACFM) (Sharpe 1992):

(4) $R_i = [\beta_1 F_1 + \beta_2 F_2 + \cdots + \beta_n F_n] + \varepsilon_i$

R_i denotes the return on asset i, in this study represented by bond fund returns. $F_1 + F_2 + \cdots + F_n$ represents the return of different indices determining fund returns. The factor loadings $\beta_1 + \beta_2 + \cdots + \beta_3$ can be interpreted as portfolio weights determining the fund´s investment style across the included indices. The error term ε_i, can be interpreted as the part of the return in model (4) not explained by the independent variables. The estimated loadings can be used to construct *style-adjusted benchmarks* accounting for historical bets on both the term and credit risk premium. In the CAPM framework, the style-adjusted benchmark replaces the market representative index (or indices). RBSA requires a minimization of the sum of squared residuals, where each error term equals:

(5) $\varepsilon_i = R_i - [\beta_1 F_1 + \beta_2 F_2 + \cdots + \beta_n F_n]$

Mutual funds are typically not allowed to engage in short positions or leveraging the fund, thus the regression coefficients are forced to be nonnegative and sum to one. Constraining the coefficients so that $0 \leq \beta_i \leq 1$ and $\sum \beta_i = 1$, implies running a quadratic optimization procedure. Quadratic programming involves optimizing an objective function, in this case equation (5), with respect to inequality constraints. Quadratic programming is not always necessary in determining the fund´s investment style, which will become evident in Section 6. In some cases, a constrained regression is sufficient, imposing merely the sum-to-one constraint which implicitly satisfies both constraints.

4 Data

This section provides a description of the data used in our study. The data were collected based on two specific purposes. First, in order to construct a bond index, we gathered and filtered data for individual investment grade bonds. Next, we conduct a thorough review of the characteristics of the bond index, due to its importance in evaluating bond funds. The bond index is critical for the assessment of both research questions presented in the introduction. Secondly, in order to evaluate performance, data on a group of relevant mutual funds were collected.

4.1 Bond data

Reference data on individual bonds from the Norwegian investment grade market were obtained from Stamdata. The raw data included information on historical developments in coupon payments, coupon payment frequency, return type, issue and maturity date, seniority, sector and the size of initial debt issues. End-of-month traded clean prices for each individual bond were collected from the Datastream database.[13] If traded prices were not available, Datastream stated either the actual or theoretical bid price at each relevant point in time. In some cases, neither traded or bid prices were available, reducing the total amount of price observations for some bonds. Bonds with no prices available from Datastream were considered ineligible for index inclusion, in line with the methodology of several other European bond indices.[14]

There are several pros and cons associated with using traded and bid prices. Corporate bonds usually trade in a highly illiquid market, possibly reducing the amount of available prices. Furthermore, for the bid prices the actions of one or a small group of investors may be driving the observed prices. However, when the objective is to track market performance, we argue that actual traded prices (or bid prices) are suitable. Even though some bonds do not trade at their fair price, this is still the return an investor would *actually* earn by selling the bond. That is, traded prices (prices including accrued interest), along with coupon payments and interest earned from reinvestments are the only determinants in realized returns for investors. In

[13] Thomson Reuters Datastream provides current and historical time series data on equities, indices, bonds, derivatives and interest rates.
[14] See S&P (2016) and Barclays (2016) for European Bond Indices Methodology.

addition, Goltz and Campani (2011) claims that using observed transaction prices (or bid prices) is a valid when constructing bond indices ex post.

For the individual bond return calculations, we follow the methodology of Morningstar (2013) and Barclays (2016). We calculate the holding period return (HPR) of a bond consisting of price movements, accrued interest and any interest earned by the bond within the calculation period. In this thesis all return calculations are made on monthly return data. The price return is formally defined by:

$$(6) \qquad Price\ return = \frac{Price_{Ending} - Price_{Start}}{Price_{Start} + AccruedInterest_{Start}}$$

In cases were there was no monthly change in the clean price, the gross price still changes as accrued interest accumulate with time. The return from coupon payments is formally defined as:

$$(7) \qquad Coupon\ return = \frac{(AccruedInterest_{Ending} - AccruedInterest_{Start}) + Coupon\ Payment}{Price_{Start} + AccruedInterest_{Start}}$$

The coupon return reflects the change in accrued interest between calculation periods, plus any interest payment made by the bond, as a fraction of the dirty price. The HPR of the bond equals the sum of the price and coupon return. Some bond returns might be calculated on an ex-dividend date with a negative accrued interest, where the holder of the bond is no longer entitled to receive the next coupon payment, and the seller has to compensate the buyer for any interest accrual in this period (Barclays 2016: 61).

The data on individual bonds, with the purpose of constructing an index, were subject to a large amount of filtration. The index construction proved to be extremely tedious and time consuming. A summary of the assumptions made in the construction of the corporate bond investment grade index is presented in Table 4.1. Securities that met the eligibility criteria at the beginning of a given month were retained in the index for purposes of return calculations until the following month-end, when the index was rebalanced (Barclays 2016). From this point, the constructed bond index will be referred to as the *credit index*.[15]

Table 4.1: Main characteristics credit index

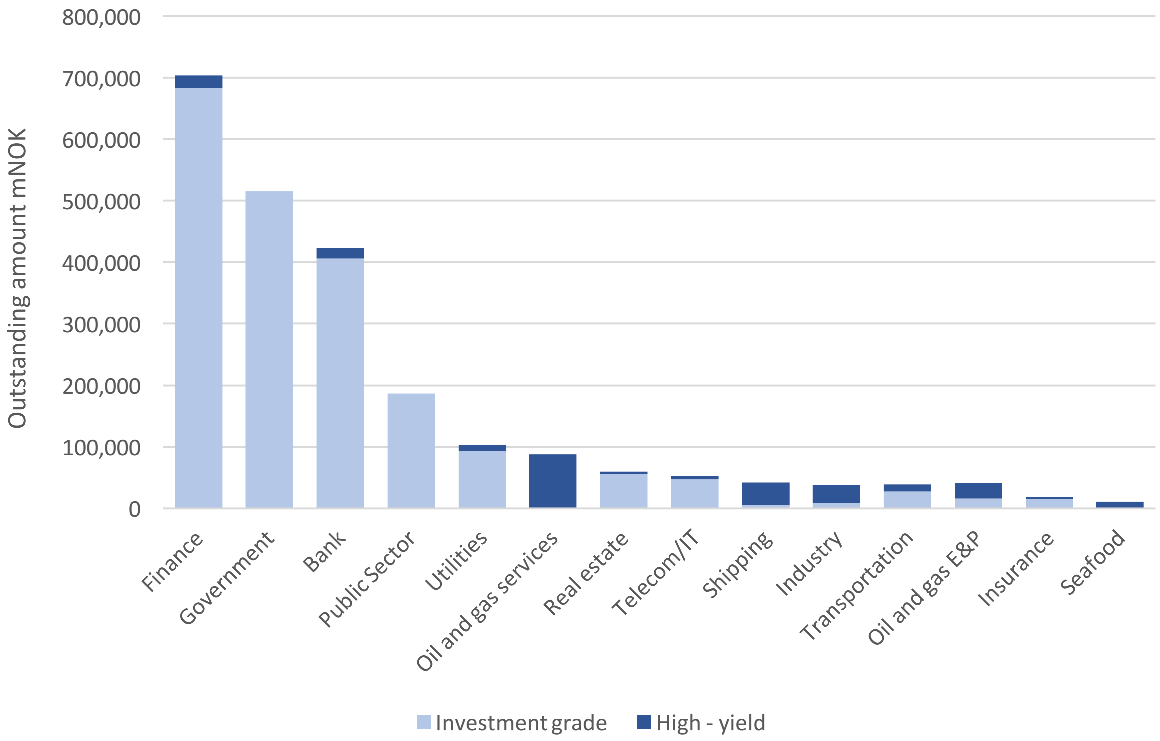
Credit index	
Inclusions	*Listed NOK denominated fixed- and floating rate investment grade bullet bonds*
Exclusions	*Zero-coupon bonds, callable and puttable bonds, serial bonds, bonds with irregular coupons, inflation-linked bonds, linked notes*
Time – to – maturity	*Minimum of 1 year*
Minimum requirements	*Minimum issue size of NOK 100 million*
Reinvestment Assumption	*No reinvestment (cash position until month-end)*
Rebalancing	*End of month*
Matured securities	*Yes*
Currency	*NOK*

The purpose of our thesis is to evaluate Norwegian bond mutual funds investing solely in the Norwegian bond market. Thus, we include only NOK denominated bonds. All bonds *not* listed on either the OSE or the Nordic ABM were excluded from the sample. We restricted the data with respect to covering only investment grade bonds. The choice of a minimum credit rating was based upon the magnitude of the Norwegian investment grade market compared to the high yield market, and the degree of available reference data. The amount of sectors was limited to finance, bank, utilities, public sector and real estate. In total, these sectors represent approximately 92 % (in terms of total nominal value) of the investment grade bond market,

[15] The credit index only include bonds with credit risk, as government bonds are accounted for by indices marketed by Oslo Børs.

as illustrated in Figure 4.1 below. Thus, the preferred sectors should be a valid representation of the Norwegian market.

Figure 4.1: Sectors – the Norwegian corporate bond market



Source: Stamdata

Following the manner in which corporate bond indices are developed by Barclays (2016) and Citigroup (2016), as well as suggegtions by Goltz and Campani (2011), all bonds with peculiar structures were eliminated from our index. We disregard bonds with subordinated seniority, callable and puttable bonds, zero-coupon bonds, serial bonds, inflation-linked bonds, linked notes and bonds with irregular coupon payments. Additionally, all bonds with an issue size smaller than NOK 100 million were eliminated from the sample. Only bonds with a remaining maturity of at least one year are included in the index, following the corporate bond indices developed by Barclays (2016) and Citigroup (2016), and suggestions by Goltz and Campani (2011). Bonds with a maturity exceeding one year and which matures over the horizon of the index, were also included. We assume no re-investment of interim cash flows. If anything, this should understate the return calculations of the aggregated credit index. Figure 4.2 depicts the preliminary sample gathered from Stamdata and Figure 4.3 shows the final sample of bonds eligible for inclusion in the index. Although reducing the preliminary sample, we saw the filtration as necessary in order to analyze

The number of bonds are significantly reduced in the finale sample, however,

Figure 4.2: Preliminary bond sample

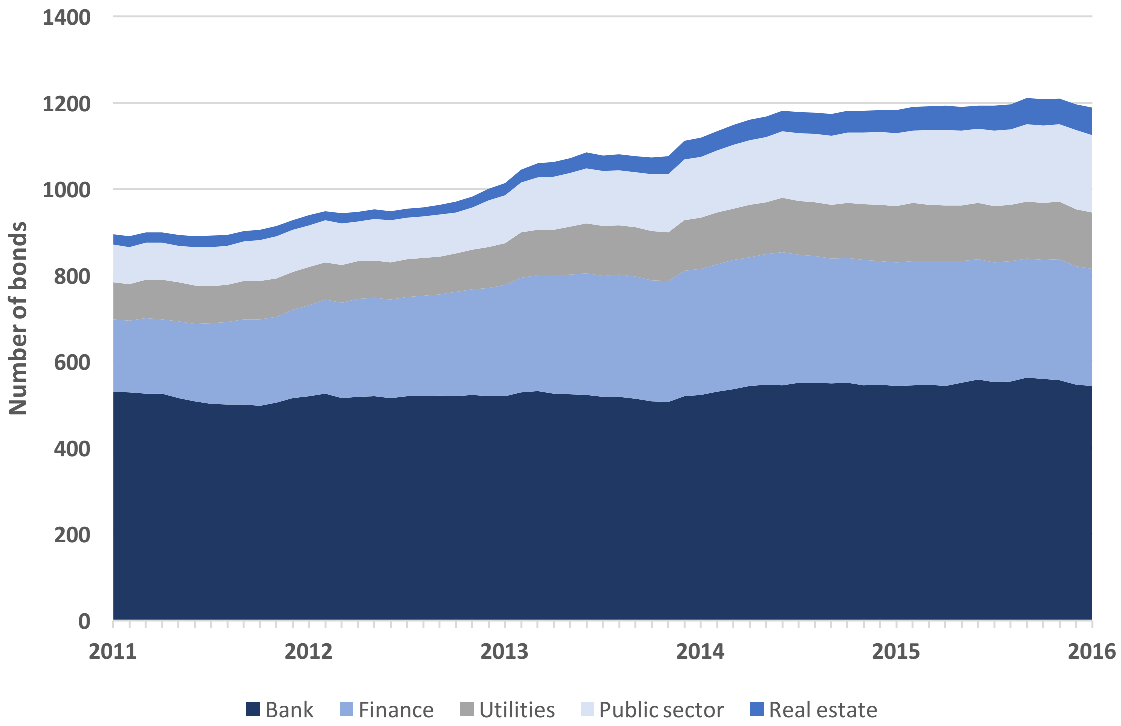


Figure 4.3: Final bond sample

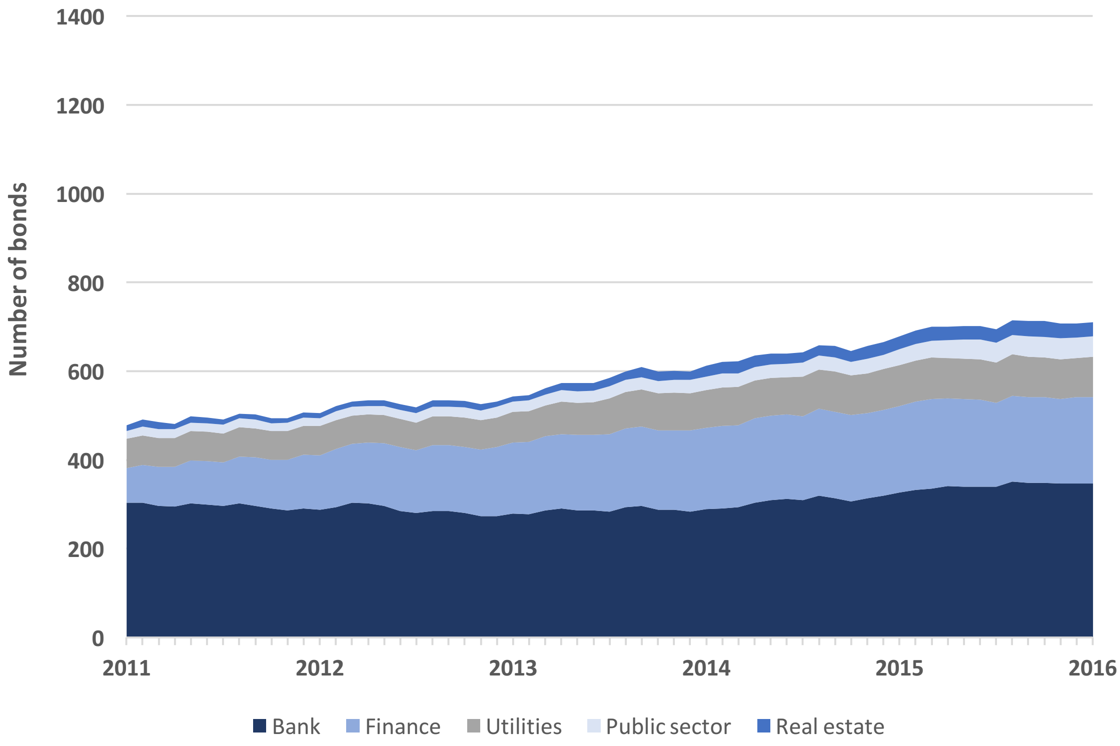


Table 4.2 illustrates the average relative weights of the aggregated credit index and the maturity-based sub indices for the included sectors. All weights are computed based on the aggregated market value of debt. The aggregated credit index is heavily loaded in bonds with a relatively short maturity, an indication that such securities have dominated the bond market based on the size of outstanding debt. This is evident from Figure 4.4, which portrays the historical development in the weights for the aggregated credit index. Bonds with less than five years to maturity accounts for approximately 75% of the sample.

Table 4.2: Sectors, sub-indices and average weights

Maturity cells	***Aggregated credit index***	***Financials***	***Bank***	***Utilities***	***Public Sector***	***Real Estate***
1 – 3 years	*40%*	*33%*	*56%*	*33%*	*34%*	*47%*
3 – 5 years	*35%*	*37%*	*33%*	*31%*	*29%*	*41%*
5 – 7 years	*15%*	*20%*	*7%*	*16%*	*18%*	*7%*
7 – 10 years	*7%*	*6%*	*4%*	*14%*	*18%*	*4%*
10+ years	*3%*	*5%*	*0%*	*6%*	*1%*	*0%*
Total	***100%***	***100%***	***100%***	***100%***	***100%***	***100%***

Figure 4.4: Historical weights credit index

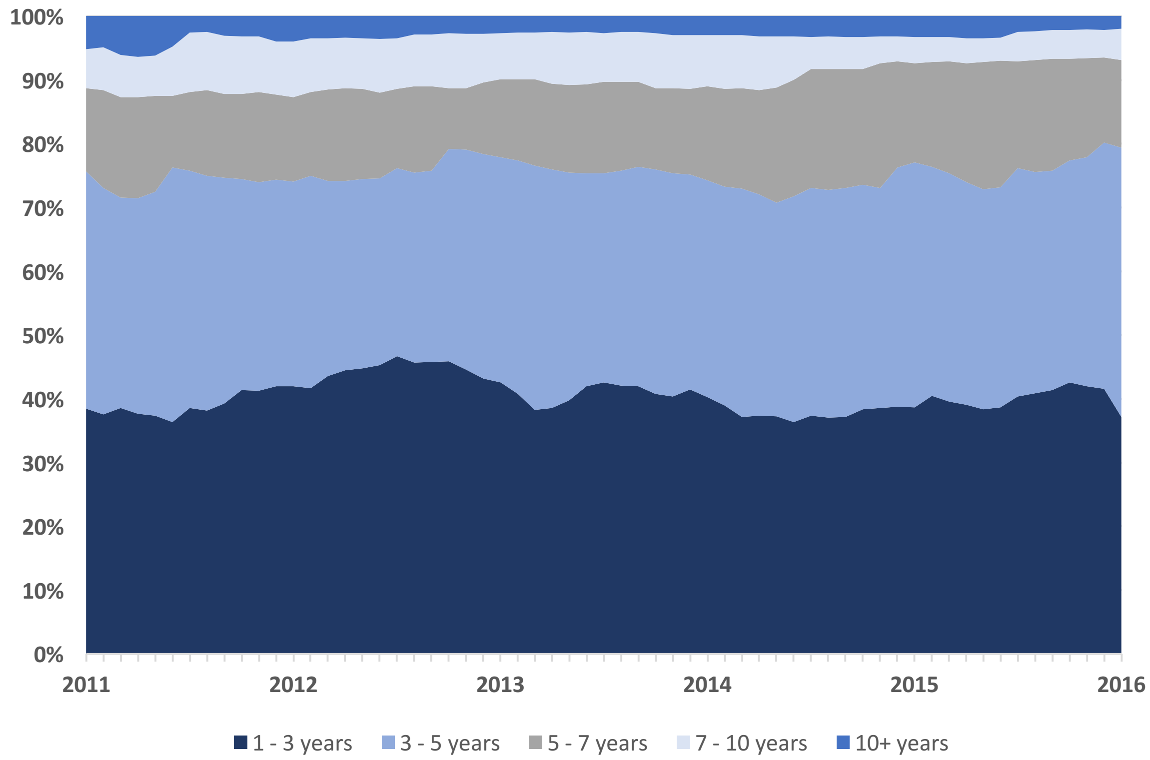


Figure 4.5 compares the returns and index movements of the sub-indices, while Table 4.3 below provides descriptive statistics for all sub-indices. As expected, the sub-indices containing long-term bonds (such as 7-10 years and 10+ years) yields a higher return. Investors holding long-term bonds will carry greater interest rate risk, and thus they are rewarded with a higher return. However, return data in Figure 4.5, shows a significantly higher volatility in the returns of long-term bonds.

Figure 4.5: Index and returns sub-indices

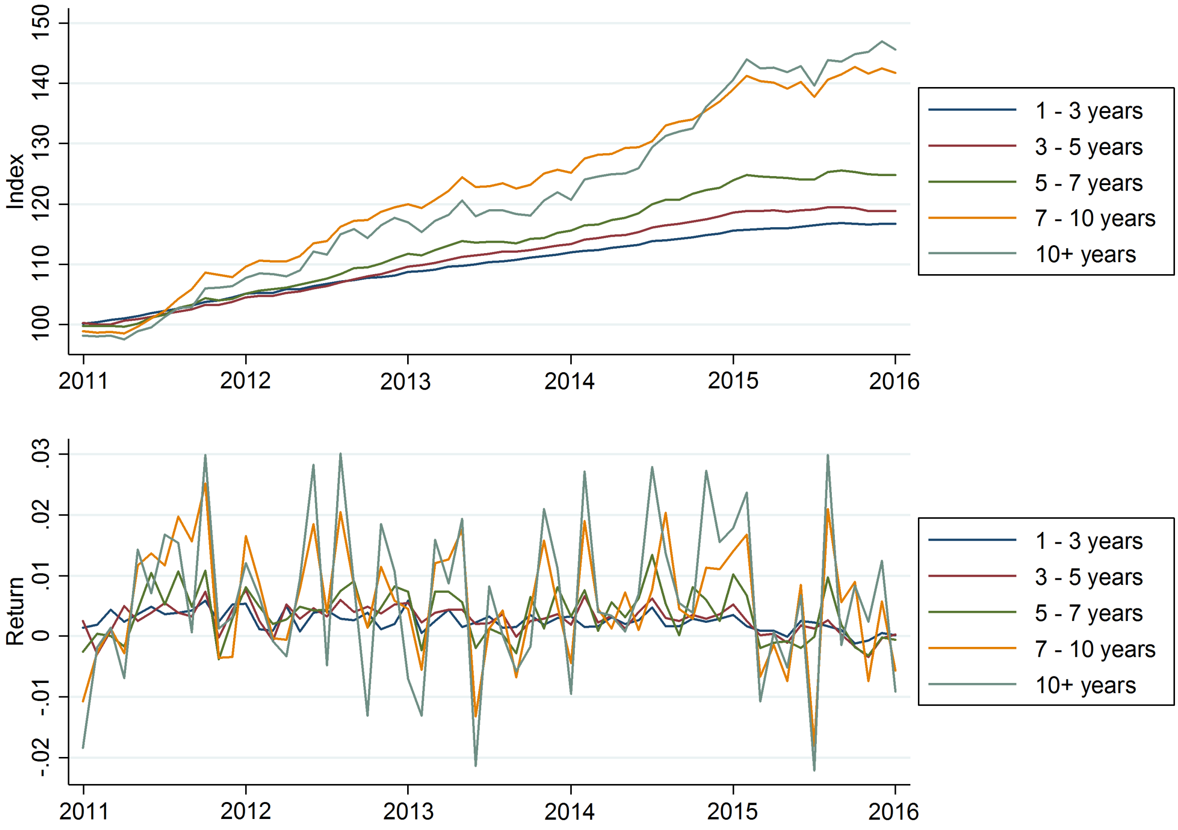


Table 4.3: Descriptive statistics sub-indices

	1 – 3 years	*3 – 5 years*	*5 – 7 years*	*7 – 10 years*	*10+ years*
Average return	*0.251%*	*0.279%*	*0.368%*	*0.591%*	*0.649%*
Average annualized return	*3.102%*	*3.464%*	*4.582%*	*7.454%*	*8.218%*
Standard deviation	*0.159%*	*0.233%*	*0.426%*	*0.945%*	*1.300%*
Minimum	*-0.119%*	*-0.340%*	*-0.373%*	*-1.801%*	*-2.205%*
Maximum	*0.591%*	*0.763%*	*1.346%*	*2.527%*	*3.016%*

All calculations are for monthly data, expect for the annualized return. Returns are geometric averages.

4.2 Bond mutual fund data

End-of-month prices for Norwegian bond mutual funds were collected from the Datastream database, starting in January 2011 and ending in January 2016. We obtained data on all active and liquidated mutual funds after 2000 from Datastream. Additionally, end-of-month prices for each fund were also verified using Bloomberg. Bond fund returns were calculated based on a total return index (TRI). The TRI accounts for changes in the net asset value (NAV) of the fund, while assuming that all income earned either by interest payments or capital gains are re-invested back into the fund (Døskeland 2014: 114). The NAV is calculated by taking the value of all the securities in a fund, subtracting management fees and administration costs, and then dividing by the total number of outstanding shares (Morningstar 2005). The NAV does not account for any sales charges or redemption fees. This is not a major concern, because most of the funds in our sample do not impose sales charges or redemption fees on their investors. Also, this thesis is not analyzing the total return of an investor holding a bond fund over the sample period and therefore we find it appropriate to disregard sales charges and redemption fees. Formally the total return is index is defined as:

(8) $$Total\ return\ index = TRI_t = \frac{TRI_t - TRI_{t-1}}{TRI_{t-1}}$$

Following Dietze et al (2009), in order to be included in the sample, bond funds were required to have a complete time series throughout the sample period. This assumption could lead to the occurrence of the survivorship bias, possibly leading to incorrect performance evaluation results (Gallagher and Jarnecic 2002: 171). However, in the sample period only 2 funds were liquidated, and we believe that this suppresses the effect of the survivorship bias to the extent that it will not alter our results. Also, Blake, Elton and Gruber (1993) claims that survivorship bias is less prominent among bond funds since their performance tend to be less variable than that of equity funds, thus fewer of them are liquidated due to poor past performance.

We restricted the sample to cover only funds investing in the Norwegian bond fund market, with at least 80 % of their capital invested in investment grade bonds, as we seek to evaluate the performance of Norwegian bond mutual funds. In total a number of 22 bond funds were included in the sample. Fund characteristics and descriptive statistics are presented in Table 4.4.

Table 4.4: Fund descriptive statistics

Fund	Average return (%)	Standard deviation (%)	Current Benchmark	Net assets (mNOK)
Alfred Berg Lang Obligasjon	0.484	0.703	ST5X	154
Alfred Berg Obligasjon	0.356	0.398	ST4X	7,170
Alfred Berg Obligasjon 3-5	0.411	0.534	ST4X/ST5X	371
Carnegie Obligasjon	0.363	0.470	ST4X	519
Danske Invest Norsk Obligasjon	0.361	0.427	ST4X	1,771
DNB Kredittobligasjon	0.39	0.409	ST4X	6,868
DNB Lang Obligasjon 20	0.437	0.634	ST5X	547
DNB Obligasjon	0.372	0.404	ST4X	1,678
DNB Obligasjon (III)	0.403	0.408	ST4X	12,236
DNB Obligasjon 20	0.333	0.424	ST4X	238
DNB Obligasjon 20 (II)	0.345	0.423	ST4X	148
DNB Obligasjon 20 (III)	0.357	0.424	ST4X	321
DNB Obligasjon 20 (IV)	0.363	0.426	ST4X	7,283
Eika Obligasjon	0.302	0.344	ST4X	612
Handelsbanken Obligasjon	0.408	0.783	ST5X	1,517
KLP Kredittobligasjon	0.347	0.515	ST4X	1,662
KLP Obligasjon 3 år	0.325	0.395	ST4X	1,018
KLP Obligasjon 5 år	0.468	0.724	ST5X	1,408
Nordea Obligasjon II	0.344	0.423	ST4X	3,162
Nordea Obligasjon III	0.371	0.442	ST4X	3,563
Odin Obligasjon	0.272	0.301	ST4X	1,068
PLUSS Pensjon	0.316	0.321	ST4X	24
Average	**0.362**	**0.470**	**-**	**2,425**
Median	**0.356**	**0.424**	**-**	**1,238**
Maximum	**0.476**	**0.783**	**-**	**12,236**
Minimum	**0.268**	**0.301**	**-**	**24**

Average returns and standard deviations are calculated for monthly data. Returns are geometric averages. ST4X and ST5X are Norwegian government bond indices.

5 Methodology

This section presents the models used in the empirical analysis of this thesis, based on the CAPM framework described and developed in Section 2. We start by addressing the first research question, examining whether bond funds are able to outperform passive portfolios. To answer our second research question, we address the methodology used to separate investment style and skill. We estimate time-series models using the ordinary least squares method (OLS). The regression results rely upon meeting a set of underlying assumptions. These are presented in part A.1 of the appendix. A set of diagnostic tests, investigating potential violations of the OLS assumptions are presented and discussed under Section 5.4.

5.1 Performance and passive portfolios

5.1.1 Single-index model

In the first step of our analysis, we apply a single-index model (SIM) using only government indices as benchmarks. We use the SIM to test whether funds are able to outperform government bonds, portraying the performance currently observable to investors. The SIM is specified in line with suggestions made by Blake, Elton and Gruber (1993), and applied by Gjerde and Sættem (1996), Gallagher and Jarnecic (2002) and Dietze et al (2009):

$$(9) \qquad \left(R_i - r_f\right) = \alpha_i + \beta_{Gov}\left(R_{Gov} - r_f\right) + \varepsilon_i$$

Equation (3) is a linear regression model where $\left(R_i - r_f\right)$ represent the return on bond fund i in excess of the risk-free rate r_f. As a proxy for the risk-free rate we utilize the monthly Norwegian Interbank Offered Rate (NIBOR), also collected from the Datastream database, following Gjerde and Sættem (1996)[16]. β_{Gov} is the sensitivity of bond fund i to the government benchmark[17] and ε_i is the residual return of fund i (i.e the part of the fund return not accounted for by the model). Finally, α_i represents the return fund i is able to generate in excess given the risk implied by the government index. The shortcoming of model (9) is its failure to properly account for total market risk, as it disregards bonds with credit risk.

[16] Dietze et al (2009) uses the 1-month Euribor as a proxy for the risk-free rate.

[17] The government benchmark of each fund equates to the government indices presented in Table 4.4.

5.1.2 Multi-index models and the asset class factor model

Extending model (9) we apply multi-index models (MIMs), where the benchmark is a combination of a government index *and* credit index.[18] Consequently, the combination of a government and credit index should correctly proxy the market risk in the Norwegian investment grade bond market. The first MIM, named MIM-1, is specified as:

$$(10) \quad (R_i - r_f) = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \beta_{Credit}(R_{Credit} - r_f) + \varepsilon_i$$

Model (10) includes $(R_{Credit} - r_f)$, representing the return of the constructed credit index in excess of the risk-free rate. β_{Credit} measures the sensitivity of bond fund i to the credit index. The objective of model (10) is to correctly account for the total bond market risk. α_i is the risk-adjusted performance of fund i. If α_i is positive and significant, the fund manager has succeeded in delivering a return higher than the risk implied by model (10). The error term ε_i represents the return not account for by the model.

In addition to model (10), we want to examine the impact of fund preferences towards long or short term bonds. That is, model (10) does not properly account for the different target durations among bond funds (Dietze et al 2009: 196). Accordingly, we modify model (10) and replace the aggregated credit index with the specific sub-indices. The second MIM, named MIM-2, is specified as:

$$(11) \quad R_i = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \beta_{13}(R_{13} - r_f) + \beta_{35}(R_{35} - r_f) + \beta_{57}(R_{57} - r_f) + \beta_{710}(R_{710} - r_f) + \beta_{10+}(R_{10+} - r_f) + \varepsilon_i$$

where $(R_{13} - r_f) + \cdots + (R_{10+} - r_f)$ represent the returns of each of the five maturity sub-indices in excess of the risk-free rate. The sub-indices are all components of the aggregated credit index used in model (10). β_{Gov} measures the sensitivity of bond fund i to the government index, while $\beta_{13} + \cdots + \beta_{10+}$ are the sensitivities related to the sub-indices.

[18] The construction of the credit index was elaborated on in Section 4.1. The credit index *excludes* government bonds, as these are accounted for in the government index.

α_i measures the risk-adjusted performance, while ε_i is the error term.

According to Blake, Elton and Gruber (1993), models such as (10) and (11) fail to account for fund restrictions with respect to short sales and leverage, by not restricting the estimated coefficients from being non-negative and exceeding unity. This could lead to a misconception of the estimated performance. Following Dietze et al (2009) we modify model (11) and impose restrictions on the estimated coefficients, such that $0 \leq \beta_i \leq 1$ and $\sum_{i=1}^{n} \beta_i = 1$. We classify this model as an ACFM (due to the restrictions), formally defined as:

(12) $$R_i = \alpha_i + \beta_{Gov}\left(R_{Gov} - r_f\right) + \beta_{13}(R_{13} - r_f) + \beta_{35}(R_{35} - r_f) + \beta_{57}(R_{57} - r_f) + \beta_{710}(R_{710} - r_f) + \beta_{10+}(R_{10+} - r_f) + \varepsilon_i$$

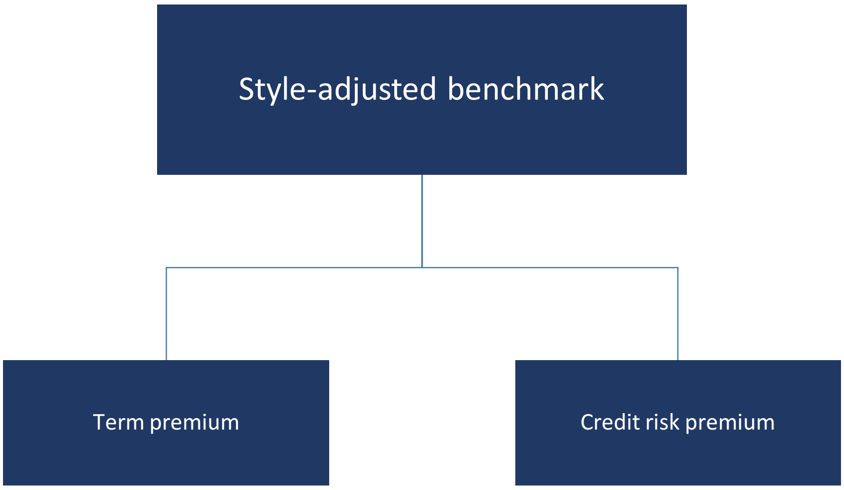
subject to $0 \leq \beta_i \leq 1$ and $\sum_{i=1}^{n} \beta_i = 1$.

If model (11) does not imply a violation of the restrictions, the estimated results of (11) and (12) will not differ. We use model (10) through (12) to test whether the bond funds in our sample are able to outperform passive portfolios. Applying these models should help us to address our first research question.

5.2 Separating investment style and skill – the style-adjusted model

Extending the CAPM framework, we analyze whether Norwegian bond funds deliver positive abnormal returns when controlling for the term and credit risk premium introduced by Fama and French (1993). We address this by applying return-based style analysis, as suggested by Sharpe (1988, 1992). RBSA enables us to account for historical bets on both the term and credit risk premium through identifying fund manager's investment style. Based on the estimations using RBSA, we construct a style-adjusted benchmark unique for each fund in the sample. Figure 5.1 summarizes the components of the style-adjusted benchmark.

Figure 5.1: Constructing style-adjusted benchmarks



We establish two proxies to account for both the term and credit risk premium. *First*, bets on the term premium is proxied by fund´s historical exposure to each of the five maturity-based sub-indices of the constructed credit index. Intuitively, funds with higher target durations can be expected to load more heavily in long-term bonds. On the other hand, funds with lower target durations can be expected to load more heavily in shorter term bonds. The representative government index for each fund has a fixed duration, and we assume that bets across government bonds does not generate a duration diverging from this. Therefore, for simplicity, we disregard bets on the term premium for government bonds.

Second, bets on the credit risk premium is proxied by fund exposure to bonds with credit risk, defined as the allocation between the credit and government index. Intuitively, funds investing in bonds with higher levels of credit risk can be expected to load more heavily in the credit index. We apply the following ACFM to determine both bets on the term and credit risk premium:

(13) $$R_i = \alpha_i + \beta_{Gov}R_{Gov} + \beta_{13}R_{13} + \beta_{35}R_{35} + \beta_{57}R_{57} + \beta_{710}R_{710} + \beta_{10+}R_{10+} + \varepsilon_i$$

where R_i determines the return of fund i, while R_{13}, R_{35}, R_{57}, R_{710} and R_{10+} are the returns of the constructed bond index for all five sub-indices of the aggregated credit index. For example, R_{13} represent the aggregated return of all individual bonds with a remaining maturity between 1 and 3 years. R_{Gov} represents the return of the government index. Model (13) differs from model (12) in Section 5.1 by using returns, not excess returns, in the estimation procedure. Following Sharpe (1992), all slope coefficients are non-negative, $0 \leq \beta_i \leq 1$, and does not exceed unity, $\sum_{i=1}^{n} \beta_i = 1$. We run model (13) for each fund, and interpret the estimated coefficients as the fund´s historical investment style accounting for bets on both the term and credit risk premium (Sharpe 1992: 10). Next, the estimated coefficients are applied to assign each individual fund with a style-adjusted benchmark. To determine whether bond funds exhibit superior skill (i.e. from market timing or security selection) we regress fund excess returns on the style-adjusted benchmarks, specified by the following model:

$$(14) \quad \left(R_i - r_f\right) = \alpha_i + \beta_{Style}\left(R_{Style} - r_f\right) + \varepsilon_i$$

where $(R_i - r_f)$ still refers to the return of fund i in excess of the risk-free rate, and $\left(R_{Style} - r_f\right)$ represents the return of the style-adjusted benchmark in excess of the risk-free rate. β_{Style} measures the sensitivity of bond fund i to the style-adjusted benchmark. In this case, α_i measure the abnormal return (relative to the style-adjusted benchmark) generated via market timing or security selection. The different measures of performance are summarized in Table 5.1.

Table 5.1: Model specifications

Name	Model specification	Constraints	Benchmark
SIM	$(R_i - r_f) = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \varepsilon_i$	No	Government index
MIM-1	$(R_i - r_f) = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \beta_{Credit}(R_{Credit} - r_f) + \varepsilon_i$	No	Government index Aggregated credit index
MIM-2	$(R_i - r_f) = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \beta_{13}(R_{13} - r_f) + \beta_{35}(R_{35} - r_f) + \beta_{57}(R_{57} - r_f) + \beta_{710}(R_{710} - r_f) + \beta_{10+}(R_{10+} - r_f) + \varepsilon_i$	No	Government index Credit index 1-3 Credit index 3-5 Credit index 5-7 Credit index 7-10 Credit index 10+
ACFM	$(R_i - r_f) = \alpha_i + \beta_{Gov}(R_{Gov} - r_f) + \beta_{13}(R_{13} - r_f) + \beta_{35}(R_{35} - r_f) + \beta_{57}(R_{57} - r_f) + \beta_{710}(R_{710} - r_f) + \beta_{10+}(R_{10+} - r_f) + \varepsilon_i$	$0 \leq \beta_i \leq 0$ and $\sum_{i=1}^{n} \beta_i = 1$	Government index Credit index 1-3 Credit index 3-5 Credit index 5-7 Credit index 7-10 Credit index 10+
STYLE	$(R_i - r_f) = \alpha_i + \beta_{Style}(R_{Style} - r_f) + \varepsilon_i$	No	Style-adjusted

5.3 Diagnostic tests

A large variety of diagnostic tests were conducted to investigate potential violations of the sample properties of OLS[19] in models MIM-1, MIM-2 and STYLE. Tests were run in Stata for estimations of MIM-1, MIM-2 and STYLE.

The zero conditional mean assumption of OLS assumes no correlation between explanatory variables and the error term. If they are correlated, this could be due to wrongly specified explanatory variables. In such instances squaring or log-transforming the relevant variable might be more suitable. Correlation between explanatory variables and error terms may also result from omitting a relevant explanatory factor from the equation (Woolridge 2009: 87).

[19] A detailed description of the econometric analysis is presented in part A.2 of the appendix.

Misspecifications of the functional form are identified using the Ramsey´s specification error test (RESET). We observed some cases of misspecification across both the MIMs and the STYLE model. The RESET test does not reveal the optimal model specification, and we can only remain cautious in claiming that the model specifications applied in this thesis are correctly defined.

Heteroscedasticity is assessed using the Breusch-Pagan test. We observe heteroscedastic features across both the MIMs and the STYLE model.[20] To detect autocorrelation we perform a test for AR(1) serial correlation without strictly exogenous regressors. Neither heteroscedasticity nor autocorrelation leads to biased estimators, but they can lead to incorrect t-statistics and standard errors. To account for heteroscedasticity, we simply run heteroscedastic-robust regressions (Woolridge 2009: 267). To correct for autocorrelation, we apply the Prais-Winston procedure. This method will lower t-statistics and significance levels, but it will also eliminate the problem of autocorrelation in the error terms. The corrections of both heteroscedasticity and autocorrelation did not alter the conclusions in terms of risk-adjusted performance.

The analysis is based on return data and we expected stationarity for the dependent and independent variables. An augmented Dickey – Fuller test confirmed our initial beliefs. Thus, we continue with the assumption that none of our regressions results are spurious.

The Shapiro-Wilk test was computed to test for normally distributed residuals. The majority of the residuals, across all models, do not fulfill the criteria of normality. Zuur et al (2010) addresses normality in statistical analysis and claims that the power of normality tests is low for small samples, and our sample is relatively small, containing five years of monthly returns (equaling 60 observations for each fund). Furthermore, Fitzmaurice et al (2004) shows that even though linear regressions assume normality, they are pretty robust against violations of the assumption. Thus, we believe that non-normally distributed residuals will not affect our results.

[20] Formally presented in part A.1 of the appendix.

Finally, the problem of multicollinearity has to be addressed.[21] The indices with maturities close in range are highly correlated, ranging from 0.1614 to 0.8614. The main objective in this thesis is to measure performance by observing the size of α, which in general is not affected by multicollinearity. High correlations are, however, more challenging for the application of style analysis. Some academics, such as Buetow et al. (2000), criticize the use of style analysis for mutual funds, claiming that the estimations of investment style are invalid if cross-correlations are too high. A way to examine multicollinearity is to calculate the variance inflation factor (VIF) for all estimated models. The VIF is based on the proportion of the variance shared between independent variables in a model (O´Brien 2007: 684). According to Kennedy (2003), a VIF smaller than 5 should indicate that multicollinearity is not problematic in a model with multiple explanatory variables. In our case, the VIF was smaller than 5 for all estimated models. Thus, we proceed with the assumption that multi-collinearity does not bias our estimated results, especially in the case of style analysis.

[21] Section A.3 in the appendix presents the cross-correlations between all independent variables used in our analysis.

6 Empirical results

6.1 Current portrayal of performance

First, we run the SIM to portray the performance currently observable to investors, by comparing fund returns to their stated government benchmark. The α coefficient of each fund is presented in the first column of Table 6.1 below. Our results show that all funds in the sample significantly outperformed their government benchmark at a one percent significance level. The worst performing fund in the sample did on average outperform the government benchmark by 0.0916 % on a monthly basis. Presumably, investors might interpret these results as an indication of superior performance among the funds examined in this paper. However, we stress the importance of treating the alpha estimates from the SIM model with great caution. The estimates only represent the ability to outperform a government index, *not* the ability to outperform an appropriate passive portfolio including credit risk.

6.2 Do Norwegian bond funds generate returns in excess of passive portfolios?

6.2.2 Multi-index models and the asset class factor model

Second, we apply MIM-1 and MIM-2, by including the constructed credit index in addition to the government index, with the purpose of correctly reflecting market risk. MIM-1 includes the aggregated credit index, while MIM-2 substitutes the credit index with its sub-indices. In doing so, MIM-2 accounts for the possibility that funds might load differently in either shorter or long-term bonds.

The α coefficients for MIM-1 and MIM-2 are presented in the second and third column in Table 6.1, respectively. We cannot detect any bond funds managing to outperform passive portfolios, net of expenses. That is, the observed performance when running the SIM is not persistent when the credit index is included. For both MIM-1 and MIM-2 there is one fund, Handelsbanken Obligasjon, exhibiting a statistically significant negative alpha. Handelsbanken Obligasjon is an actively managed fund (Handelsbanken 2016), however in this sample period, the active management significantly failed in providing superior returns.

A comparison of MIM-1 and MIM-2 shows that substituting the credit index with the sub-indices in MIM-2, increases the explanatory power for most funds. Thus, the ability of MIM-2 to capture different preferences with respect to short and longer term bonds yielded a superior fit. The results for MIM-1 and MIM-2 are in alignment with the findings of Gjerde and Sættem (1996), Norwegian bond funds are not able to deliver abnormal returns relative to passive portfolios.

Next, we apply the AFCM by adding constraints to the estimated coefficients compared to MIM-2, as presented in model (12) above. According to Blake, Elton and Gruber (1993) and Dietze et al (2009) such a model should be included to account for restrictions on short-selling and leveraging. We primarily run this regression to see if it yields similar results as MIM-1 and MIM-2. The fourth column in Table 6.1 shows no significant alphas, either positive or negative, when applying the ACFM. Thus, introducing restrictions in line with fund management does not alter the conclusion drawn from MIM-1 and MIM-2. Dietze et al (2009) provides similar results when applying ACFM in the European market.

Based on the results presented and discussed in this section we can conclude that Norwegian bond funds were not able to outperform passive portfolios in the period from January 2011 to January 2016. The conclusion is robust across a different set of models, both with and without restrictions on the estimated coefficients. The results imply that if fund managers actually outperform passive portfolios pre expenses, the performance is deteriorated by fees.

Table 6.1: Monthly alphas SIM, MIM-1, MIM-2 and ACFM

	SIM		**MIM-1**		**MIM-2**		**ACFM**	
	Alpha	R^2	Alpha	R^2	Alpha	R^2	Alpha	R^2
Alfred Berg Lang Obligasjon	0.213%*** (3.52)	0.567	-0.0094% (-0.18)	0.777	0.0171% (0.32)	0.809	0.0396% (0.87)	0.789
Alfred Berg Obligasjon	0.166%*** (3.86)	0.34	0.0154% (0.37)	0.583	0.0393% (0.89)	0.61	0.0281% (0.77)	0.606
Alfred Berg Obligasjon 3-5	0.184%*** (3.51)	0.436	-0.00773% (-0.16)	0.697	0.0214% (0.46)	0.752	0.000904% (0.02)	0.724
Carnegie Obligasjon	0.160%*** (3.28)	0.345	-0.0271% (-0.60)	0.697	-0.00797% (-0.14)	0.642	0.00148% (0.04)	0.693
Danske Invest Norsk Obligasjon	0.173%*** (3.53)	0.193	-0.0154% (-0.33)	0.631	0.0175% (0.29)	0.663	0.00994% (0.26)	0.653
DNB Kredittobligasjon	0.199%*** (4.49)	0.282	0.0268% (0.51)	0.639	0.0465% (0.75)	0.66	0.0445% (1.05)	0.66
DNB Lang Obligasjon 20	0.174%*** (3.14)	0.55	-0.0323% (-0.67)	0.774	-0.017% (-0.31)	0.831	0.00359% (0.09)	0.794
DNB Obligasjon	0.182%*** (4.07)	0.257	0.0182% (0.34)	0.585	0.0394% (0.61)	0.609	0.0324% (0.72)	0.608
DNB Obligasjon (III)	0.213%*** (4.72)	0.252	0.048% (0.88)	0.582	0.0702% (1.58)	0.607	0.0629% (1.39)	0.606
DNB Obligasjon 20	0.143%*** (2.98)	0.223	-0.0254% (-0.41)	0.538	0.000859% (0.02)	0.671	-0.0215% (-0.51)	0.656
DNB Obligasjon 20 (II)	0.155%*** (3.24)	0.223	-0.0125% (-0.20)	0.536	0.0137% (0.23)	0.67	-0.00864% (-0.20)	0.655
DNB Obligasjon 20 (III)	0.168%*** (3.49)	0.221	-0.00037% (-0.01)	0.535	0.0261% (0.44)	0.669	0.00342% (0.08)	0.654
DNB Obligasjon 20 (IV)	0.173%*** (3.59)	0.225	0.00315% (0.05)	0.541	0.0295% (0.5)	0.672	0.00785% (0.18)	0.657
Eika Obligasjon	0.106%*** (3.39)	0.483	-0.0226% (-0.74)	0.794	-0.0204% (-0.69)	0.752	-0.0208% (-0.69)	0.748
Handelsbanken Obligasjon	0.0976%** (2.01)	0.775	-0.0749%* (-1.70)	0.877	-0.0750%* (-1.89)	0.915	-0.0474% (-1.33)	0.911
KLP Kredittobligasjon	0.119%*** (3.05)	0.65	-0.0334% (-0.97)	0.826	-0.0185% (-0.65)	0.877	-0.0164% (-0.77)	0.874
KLP Obligasjon 3år	0.116%*** (3.73)	0.618	-0.0101% (-0.45)	0.84	-0.00397% (-0.1)	0.838	-0.00753% (-0.29)	0.835
KLP Obligasjon 5år	0.176%*** (3.35)	0.69	-0.0331% (-0.78)	0.866	-0.0246% (-0.49)	0.896	0.0176% (0.51)	0.884
Nordea Obligasjon II	0.137%*** (3.62)	0.51	-0.0128% (-0.39)	0.762	0.004% (0.12)	0.792	-0.00381% (-0.14)	0.788
Nordea Obligasjon III	0.168%*** (3.86)	0.409	-0.00802% (-0.21)	0.765	0.00873% (0.18)	0.777	0.0166% (0.57)	0.763
ODIN Obligasjon	0.0916%*** (2.78)	0.255	-0.0109% (-0.34)	0.493	-0.00262% (-0.05)	0.489	-0.017% (-0.41)	0.478
PLUSS Pensjon	0.135%*** (3.78)	0.273	0.000141% (0.00)	0.633	0.0126% 0.24	0.578	0.00951% (0.24)	0.577

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.3 Do bond funds generate abnormal returns when accounting for bond risk factors?

6.3.1 The style-adjusted model

In this section, we exclusively focus on the skill component presented in Figure 3.5, possibly arising from either market timing or selection. The intuition is simple, all value added beyond the investment style should be due to the skill component. Evaluating performance beyond historical bets on risk premiums is important for investors, because such returns tends to come at a higher cost (French 2008). Accordingly, investors should expect funds to deliver returns justifying these costs.

Investment styles are identified by analytically applying the methodology presented in Section 5.2. We establish proxies for the term and credit risk premium, using RBSA, by running model (13) for each individual fund in the sample.[22] Initially we perform a constrained regression, were the slope coefficients are forced to sum to one, accounting for the leveraging restriction. In this case, many of the funds automatically fulfill both the short-selling and leveraging constraint. However, several funds did not meet the short-selling criteria (i.e. some estimations came out negative), as highlighted in panel A of Table 6.2 below.[23] For the funds that did not meet the non-negative criteria we applied the quadratic programming procedure, offsetting the initial short positions.[24]

The interpretation of the results posted in Table 6.2 is essential. The regression results only portray the average historical investment style of the investigated funds based on a set of indices, not their actual historical portfolio holdings. For example, the fund Alfred Berg Lang Obligasjon on average allocated approximately 19% of their funds to government bonds, and the remainder in bonds with credit risk (presented in the first row in Panel B). In addition, they are slightly tilted towards long-term bonds. More precisely, our calculations suggest an allocation of more than 50% in bonds with at least five years to maturity.

[22] Model (13) from section 5.2.1 estimates $R_i = \alpha_i + \beta_{Gov}R_{Gov} + \beta_{13}R_{13} + \beta_{35}R_{35} + \beta_{57}R_{57} + \beta_{710}R_{710} + \beta_{10+}R_{10+} + \varepsilon_i$

[23] We identify the investment style for each of the 22 funds in the sample, but only the funds violating the short-selling constraint are presented in Table 6.2.

[24] Sharpe (1992) applies a similar approach to deal with short positions in determining fund exposure.

Table 6.2: Determining the investment style – correcting for short positions

Panel A: Constrained regression							
	β_{Gov}	β_{13}	β_{35}	β_{57}	β_{710}	β_{10+}	Total
Alfred Berg Lang Obligasjon	0.193	**-0.490**	0.672	0.362	0.193	0.070	1
Alfred Berg Obligasjon	0.111	**-0.074**	0.642	0.250	0.048	0.022	1
Alfred Berg Obligasjon 3-5	0.116	**-0.283**	0.740	0.214	0.128	0.086	1
Carnegie Obligasjon	0.126	**-0.036**	0.513	0.251	0.095	0.050	1
Danske Invest Norsk Obligasjon	**-0.003**	0.019	0.565	0.308	0.100	0.012	1
DNB Lang Obligasjon 20	0.141	**-0.244**	0.432	0.421	0.203	0.046	1
DNB Obligasjon 20	0.035	**-0.121**	0.692	0.305	0.055	0.035	1
DNB Obligasjon 20 (II)	0.036	**-0.121**	0.693	0.305	0.052	0.036	1
DNB Obligasjon 20 (III)	0.034	**-0.123**	0.696	0.303	0.055	0.035	1
DNB Obligasjon 20 (IV)	0.036	**-0.129**	0.697	0.306	0.054	0.035	1
KLP Obligasjon 5år	0.241	**-0.138**	0.183	0.389	0.283	0.041	1
Panel B: Quadratic programming							
Alfred Berg Lang Obligasjon	0.172	**0.000**	0.187	0.328	0.223	0.090	1
Alfred Berg Obligasjon	0.101	**0.000**	0.573	0.248	0.053	0.025	1
Alfred Berg Obligasjon 3-5	0.107	**0.000**	0.421	0.215	0.158	0.099	1
Carnegie Obligasjon	0.122	**0.000**	0.480	0.250	0.097	0.051	1
Danske Invest Norsk Obligasjon	**0.000**	0.016	0.568	0.306	0.098	0.012	1
DNB Lang Obligasjon 20	0.131	**0.000**	0.191	0.404	0.218	0.057	1
DNB Obligasjon 20	0.018	**0.000**	0.579	0.301	0.062	0.040	1
DNB Obligasjon 20 (II)	0.019	**0.000**	0.580	0.301	0.059	0.041	1
DNB Obligasjon 20 (III)	0.017	**0.000**	0.581	0.300	0.062	0.041	1
DNB Obligasjon 20 (IV)	0.019	**0.000**	0.576	0.302	0.062	0.041	1
KLP Obligasjon 5år	0.235	**0.000**	0.046	0.380	0.292	0.047	1

Based on the estimations when running model (13), we assign each fund with a style-adjusted benchmark. The estimations in Panel B of table 6.2 above are example of style-adjusted benchmarks**.** The style-adjusted benchmarks are included as the only explanatory factor in model (14) and accounts for investment style. The results from the STYLE model are presented in Table 6.3 below. The alpha-values can be interpreted as the returns generated beyond historical bets on the term and credit risk premium, as defined in Section 5.2. We find no evidence of abnormal returns among the bond funds in our sample when running model (14). More specifically, all funds exhibit alphas *insignificantly* different from zero. Although none are statistically significant, there were eight funds showing negative alphas (in a sample of 22 fund). Our results suggest that the examined funds have failed in generating returns beyond their bets on the term and credit risk premium. Thus, investors are better off by funds *not* seeking to harvest returns from either market timing or security selection.

Table 6.3: Monthly alphas STYLE-model

	STYLE	
	Alpha	R^2
Alfred Berg Lang Obligasjon	0.0406% (0.9)	0.794
Alfred Berg Obligasjon	0.0295% (0.81)	0.608
Alfred Berg Obligasjon 3-5	0.0218% (0.56)	0.744
Carnegie Obligasjon	0.00401% (0.11)	0.697
Danske Invest Norsk Obligasjon	0.0101% (0.26)	0.653
DNB Kredittobligasjon	0.0459% (1.08)	0.66
DNB Lang Obligasjon 20	0.00409% (0.1)	0.798
DNB Obligasjon	0.0337% (0.75)	0.608
DNB Obligasjon (III)	0.0641% (1.41)	0.606
DNB Obligasjon 20	-0.0216% (-0.51)	0.656
DNB Obligasjon 20 (II)	-0.00875% (-0.21)	0.655
DNB Obligasjon 20 (III)	0.00341% (0.08)	0.654
DNB Obligasjon 20 (IV)	0.0078% (0.18)	0.657
Eika Obligasjon	-0.0194 (-0.64)	0.752
Handelsbanken Obligasjon	-0.0463% (-1.31)	0.912
KLP Kredittobligasjon	-0.0129% (-0.61)	0.876
KLP Obligasjon 3år	-0.00646% (-0.25)	0.837
KLP Obligasjon 5år	0.0103% (0.28)	0.889
Nordea Obligasjon II	-0.00116% (-0.04)	0.792
Nordea Obligasjon III	0.0203% (0.71)	0.769
ODIN Obligasjon	-0.0156% (-0.38)	0.476
PLUSS Pensjon	0.0112% (0.28)	0.578

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6.4 Limitations and further research

Before concluding, a couple of remarks on the limitations of our study, and guidelines for future efforts are in place. First, based on the bond data obtained from Stamdata, we could not distinguish between credit rating within the investment grade classification. The absence of official credit ratings barred us from constructing letter-based indices. And as noted by Dietze et al. (2009), letter-based-indices yielded a superior fit in modelling abnormal returns, indicating a clear shortcoming with applying only maturity-based indices. If letter-based-indices should become available, we suggest including these in future research on Norwegian bond fund performance.

Second, in our analysis we could not distinguish between performance pre and post expenses. We were not able to test pre-expense performance, as we only utilized bond funds NAV, were management fees and administration costs are already accounted for. Literature from the European market, such as Dietze et al. (2009), has suggested that underperformance is mainly due to expenses. This information could be of interest for both academics and investors. However, it is not vital information, as investors only receive returns post expenses. Additionally, although we conclude on non-superior performance of Norwegian bond funds in this sample, estimations are based on historical data and we cannot rule out any future outperformance.

7 Conclusion

This paper examines the performance of Norwegian investment grade bond mutual funds, using a dataset of 22 Norwegian investment grade mutual funds between January 2011 and January 2016. Through a CAPM framework we analyze fund performance relative to appropriate passive portfolios. Extending the CAPM framework, we analyze whether Norwegian bond funds generate abnormal returns when controlling for the term and credit risk premium introduced by Fama and French (1993).

Our analysis leads us to make two distinct conclusions. Firstly, Norwegian investment grade bond funds were not able to outperform passive benchmark portfolios consisting of both government bonds and bonds with credit risk. That is, there was not a single fund showing significant positive performance. The results are net of costs, and implies that if fund managers actually possess the ability to outperform passive portfolios, the performance is deteriorated by fees. The results are consistent with the general consensus in the existing literature on the performance of bond mutual funds, managers are not able to generate positively significant abnormal returns. Our findings differ from what is currently observable to investors, where bond funds outperform government bond indices. This way of portraying performance is both imprecise and misleading for investors.

Secondly, when controlling for the term and credit risk premium presented by Fama and French (1993) using return-based style analysis, we do not detect any significantly positive performance among the bond funds in our sample. Thus, investors seem better off without funds seeking to harvest returns from market timing and security selection. Our results are important for investors, as attempts to select attractive securities or timing the market typically contributes to higher management fees compared to bets on risk factors. Correspondingly, investors should pick low cost funds not trying to generate returns beyond bets on the term and credit risk premium.

8 References

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A Appendix

A.1 Econometric analysis

Sample properties of OLS under classical assumptions

All sample properties have been directly gathered from Woolridge (2009).

1. *Linear in parameters*

   The stochastic process $\{(x_{t1}, x_{t2}, \dots., x_{tk}, y_t): t = 1, 2, \dots, n\}$ *follows the linear model*

   $$y_t = \beta_0 + \beta_0 x_{1,t} + \beta_1 x_{1,t} + \dots + \beta_k x_{k,t} + u_t$$

   where $\{u_t: t = 1, 2, \dots, n\}$ *is the sequence of errors or disturbances.*

2. *No perfect collinearity*

   In the sample, no independent variable is constant nor a perfect linear combination of the others.

3. *Zero Conditional Mean*

   At each point in time t, the expected value of the error u_t*, given the explanatory variables for all time periods, is zero.*

   $$E(u_t|\boldsymbol{X}) = 0, t = 1,2, \dots, n$$

4. *Homoscedasticity*

   Conditional on $\boldsymbol{X}$*, the variance of* u_t *is the same for all t:* $Var(u_t|\boldsymbol{X}) = Var(u_t) = \sigma^2, t = 1,2, \dots, n.$

5. *No serial correlation*

   Conditional on $\boldsymbol{X}$*, the errors in two different time periods are uncorrelated:* $Corr(u_t, u_s|\boldsymbol{X}) = 0,$ *for all* $t \neq s$

6. *Normality*

   The errors u_t *are independent of* $\boldsymbol{X}$ *and are independently and identically distributed as Normal*$(0, \sigma^2)$

A.2 Further description of diagnostic tests

Ramsey´s regression specification error test (RESET)

The RESET – test is a general test to detect potential misspecifications of the functional form. The general idea is to investigate whether the original model, such as model (3) in this thesis, is correctly specified. That is, no nonlinear functions of the independent variable should be significant when added to the single-index model (Woolridge 2009: 304). However, misspecification is detected, the RESET – test does not provide any advice on how to proceed. Formally one can hypothesize:

H_o: *The model is correctly specified*

H_1: *The model suffers from misspecification*

If the null hypothesis is rejected, one can conclude that the model is not correctly specified. Potential sources of misspecification can be that the explanatory variables are wrongly specified, and therefore they should be included in a squared form. Also, if misspecification is detected, this could be an indication of omitted variables.

Breusch – Pagan test for heteroscedasticity

As is evident from the assumptions of the OLS – method, the variance term conditional on the explanatory variable(s) should be constant for all *t* if the model is to be homoscedastic. If a model suffers from heteroscedasticity the error term from the estimated model will typically follow a clear pattern, either positive or negative, leading to invalid variance – formulas (Woolridge 2009: 273). The Breusch – Pagan test is run using the Stata post – estimation command *hettest*. Formally one can hypothesize:

H_o: *Constant variance*

H_1: *Non – constant variance*

A rejection of the null hypothesis indicates a problem of heteroscedasticity. In general, one can easily correct for heteroscedasticity by simply running a regression using robust standard errors. With robust standard errors the error-terms will no longer follow a clear pattern, they have a constant variance, and are homoscedastic.

Several of the variables are affected by heteroscedasticity, but this is simply solved by running robust regressions. And, for the purpose of identifying risk – adjusted returns among different bond mutual funds, correcting for heteroscedasticity does not alter the results.

AR (1) t test for serial correlation

If a time-series suffers from serial correlation, a violation of assumption 5 is present, and OLS is no longer the best linear unbiased estimator (BLUE). Serial correlation indicates that error terms over the sample period are correlated, possibly leading to wrongly estimated standard errors and t-statistics (Woolridge 2009: 412). Autocorrelation can be detected by obtaining the predicted residuals from a regression, and testing whether these are dependent on a lagged version of itself. Thus, if autocorrelation is detected one has to treat estimation results with great caution. Formally, one can hypothesize:

H_o: *No autocorrelation*

H_1: *Autocorrelation*

A rejection of the null hypothesis could indicate a problem of autocorrelation. However, there are different ways to correct for serial correlation depending on whether the structure of the autocorrelation problem is known (Woolridge 2009: 412). If the regressors are not strictly exogenous, which is assumed in this thesis (because we simply cannot conclude that they are strictly exogenous), a Cochrane – Orcutt estimation can be performed. This estimation transforms the data and adjusts for the significant lagged error coefficient, and then re-estimates OLS with the adjusted variables (Woolridge 2009: 422).

Augmented Dickey Fuller test for stationary variables

In the empirical analysis of time series, non-stationary variables may lead to so-called spurious regression results. That is, significant relationships between variables may be detected mainly due to the fact that both variables have a drift (or a unit-root process). With an augmented Dickey Fuller test one investigates whether the lagged version of the dependent variable significantly affects the dependent variable, thus controlling for potentially autocorrelated error terms (Woolridge 2009: 633). Formally, one can hypothesize:

H_o: *Unit – root process*

H_1: *Stationary process*

In financial analysis, the problem of non-stationary is addressed by using returns (price differentials) rather than raw price data.

Shapiro – Wilk test for normality

If an estimated regression model suffers from non-normality, the error terms are not normally distributed (Woolridge 2009: 351), violating the sixth assumption of OLS. Shapiro and Wilk (1965) introduced the test as a statistical procedure for detecting normality in a sample. The null hypothesis states that the error terms are normally distributed, while the alternative hypothesis states the opposite. A rejection of the null hypothesis, a low p-value, indicates non-normally distributed residuals.

H_o: *Normally distributed residuals*

H_1: *Non- normally distributed residuals*

Table A.1: Diagnostic tests MIM-1

	RESET - test	Breusch - Pagan test	AR(1) test for autocorrelation	Shapiro - Wilk test
Alfred Berg Lang Obligasjon	Rejected*	Not rejected	Not rejected	Not rejected
Alfred Berg Obligasjon	Rejected*	Not rejected	Not rejected	Rejected*
Alfred Berg Obligasjon 3-5	Rejected**	Not rejected	Not rejected	Not rejected
Carnegie Obligasjon	Not rejected	Rejected*	Rejected**	Rejected**
Danske Invest Norsk Obligasjon	Rejected**	Rejected***	Rejected**	Rejected**
DNB Kredittobligasjon	Rejected**	Rejected**	Not rejected	Rejected**
DNB Lang Obligasjon 20	Not rejected	Not rejected	Not rejected	Not rejected
DNB Obligasjon	Rejected*	Rejected**	Not rejected	Rejected**
DNB Obligasjon (III)	Rejected*	Rejected**	Not rejected	Rejected**
DNB Obligasjon 20	Rejected**	Rejected***	Not rejected	Rejected***
DNB Obligasjon 20 (II)	Rejected**	Rejected***	Not rejected	Rejected***
DNB Obligasjon 20 (III)	Rejected**	Rejected***	Not rejected	Rejected***
DNB Obligasjon 20 (IV)	Rejected**	Rejected***	Not rejected	Rejected***
Eika Obligasjon	Rejected*	Rejected**	Rejected**	Not rejected
Handelsbanken Obligasjon	Not rejected	Not rejected	Not rejected	Not rejected
KLP Kredittobligasjon	Not rejected	Not rejected	Rejected**	Rejected**
KLP Obligasjon 3år	Not rejected	Rejected*	Not rejected	Rejected*
KLP Obligasjon 5år	Not rejected	Not rejected	Not rejected	Not rejected
Nordea Obligasjon II	Not rejected	Not rejected	Not rejected	Not rejected
Nordea Obligasjon III	Rejected**	Rejected*	Rejected***	Rejected*
ODIN Obligasjon	Not rejected	Rejected**	Not rejected	Not rejected
PLUSS Pensjon	Rejected**	Rejected***	Not rejected	Rejected***

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Ramsay RESET test for misspecification. H0: No omitted variables H1: Omitted variables

Breusch - Pagan test for heteroskedasticity. H0: Homoscedasticity H1: Heteroskedasticity

AR(1) test for autocorrelation. H0: No autocorrelation H1: Autocorrelation

Augmented Dickey-Fuller test for unit roots. H0: Unit root H1: Stationary process

Shapiro - Wilk test for normality. H0: Normally distributed residuals H1: Non-normally distributed residuals

Table A.2: Diagnostic tests MIM-2

	RESET - test	Breusch - Pagan test	AR(1) test for autocorrelation	Shapiro - Wilk test
Alfred Berg Lang Obligasjon	Not rejected	Not rejected	Not rejected	Not rejected
Alfred Berg Obligasjon	Not rejected	Not rejected	Not rejected	Rejected**
Alfred Berg Obligasjon 3-5	Not rejected	Not rejected	Not rejected	Not rejected
Carnegie Obligasjon	Not rejected	Rejected*	Rejected**	Rejected***
Danske Invest Norsk Obligasjon	Rejected**	Rejected***	Rejected***	Rejected***
DNB Kredittobligasjon	Rejected*	Rejected***	Not rejected	Rejected***
DNB Lang Obligasjon 20	Not rejected	Rejected*	Rejected*	Not rejected
DNB Obligasjon	Not rejected	Rejected***	Not rejected	Rejected***
DNB Obligasjon (III)	Not rejected	Rejected***	Not rejected	Rejected***
DNB Obligasjon 20	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (II)	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (III)	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (IV)	Rejected***	Rejected***	Rejected*	Rejected***
Eika Obligasjon	Rejected*	Rejected***	Rejected*	Rejected**
Handelsbanken Obligasjon	Not rejected	Not rejected	Not rejected	Not rejected
KLP Kredittobligasjon	Not rejected	Not rejected	Rejected**	Not rejected
KLP Obligasjon 3år	Not rejected	Rejected**	Not rejected	Not rejected
KLP Obligasjon 5år	Not rejected	Rejected*	Not rejected	Not rejected
Nordea Obligasjon II	Not rejected	Not rejected	Not rejected	Not rejected
Nordea Obligasjon III	Not rejected	Rejected**	Rejected***	Rejected***
ODIN Obligasjon	Not rejected	Rejected***	Not rejected	Rejected**
PLUSS Pensjon	Rejected**	Rejected***	Not rejected	Rejected***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Ramsay RESET test for misspecification. H0: No omitted variables H1: Omitted variables

Breusch - Pagan test for heteroskedasticity. H0: Homoscedasticity H1: Heteroskedasticity

AR(1) test for autocorrelation. H0: No autocorrelation H1:Autocorrelation

Augmented Dickey-Fuller test for unit roots. H0:Unit root H1:Stationary process

Shapiro - Wilk test for normality. H0: Normally distributed residuals H1: Non-normally distributed residuals

Table A.3: Diagnostic tests STYLE

	RESET - test	Breusch - Pagan test	AR(1) test for autocorrelation	Shapiro - Wilk test
Alfred Berg Lang Obligasjon	Not rejected	Not rejected	Not rejected	Not rejected
Alfred Berg Obligasjon	Not rejected	Not rejected	Not rejected	Rejected**
Alfred Berg Obligasjon 3-5	Rejected*	Not rejected	Not rejected	Not rejected
Carnegie Obligasjon	Not rejected	Rejected*	Rejected**	Rejected***
Danske Invest Norsk Obligasjon	Rejected**	Rejected***	Rejected***	Rejected***
DNB Kredittobligasjon	Not rejected	Rejected***	Not rejected	Rejected***
DNB Lang Obligasjon 20	Not rejected	Not rejected	Not rejected	Not rejected
DNB Obligasjon	Not rejected	Rejected**	Not rejected	Rejected***
DNB Obligasjon (III)	Not rejected	Rejected**	Not rejected	Rejected***
DNB Obligasjon 20	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (II)	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (III)	Rejected***	Rejected***	Rejected*	Rejected***
DNB Obligasjon 20 (IV)	Rejected***	Rejected***	Rejected*	Rejected***
Eika Obligasjon	Not rejected	Rejected***	Not rejected	Rejected*
Handelsbanken Obligasjon	Not rejected	Rejected*	Not rejected	Rejected*
KLP Kredittobligasjon	Not rejected	Not rejected	Rejected**	Not rejected
KLP Obligasjon 3år	Not rejected	Rejected**	Not rejected	Not rejected
KLP Obligasjon 5år	Not rejected	Rejected*	Not rejected	Not rejected
Nordea Obligasjon II	Not rejected	Not rejected	Not rejected	Not rejected
Nordea Obligasjon III	Not rejected	Rejected*	Rejected**	Rejected***
ODIN Obligasjon	Not rejected	Rejected**	Not rejected	Not rejected
PLUSS Pensjon	Rejected**	Rejected***	Not rejected	Rejected***

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Ramsay RESET test for misspecification. H0: No omitted variables H1: Omitted variables

Breusch - Pagan test for heteroskedasticity. H0: Homoscedasticity H1: Heteroskedasticity

AR(1) test for autocorrelation. H0: No autocorrelation H1: Autocorrelation

Augmented Dickey-Fuller test for unit roots. H0: Unit root H1: Stationary process

Shapiro - Wilk test for normality. H0: Normally distributed residuals H1: Non-normally distributed residuals

A.3 Correlation between indices

Correlations aggregated credit index

	Credit index
Credit index	1
ST4X	0.6144
ST5X	0.6423
ST4XST5X	0.6401

Correlations sub-indices

	1-3 years	3-5 years	5-7 years	7-10 years	10+ years
1-3 years	1				
3-5 years	0.6345	1			
5-7 years	0.5422	0.6814	1		
7-10 years	0.2702	0.5289	0.6845	1	
10+ years	0.1614	0.4376	0.6379	0.8614	1
ST4X	0.3873	0.3501	0.6201	0.6045	0.5805
ST5X	0.2969	0.3537	0.6649	0.7059	0.6677
ST4XST5X	0.337	0.3568	0.6568	0.6776	0.6441

A.4 Estimated factor sensitivities

	SIM	MIM-1		MIM-2					
	β_{Gov}	β_{Gov}	β_{Credit}	β_{Gov}	β_{13}	β_{35}	β_{57}	β_{710}	β_{10+}
Alfred Berg Lang Obligasjon	0.513***	0.251***	1.715***	0.191***	-0.109	0.713**	0.310*	0.183*	0.0821
	(8.79)	(4.57)	(7.4)	(2.97)	(-0.26)	(2.35)	(1.69)	(1.86)	(1.24)
Alfred Berg Obligasjon	0.368***	0.0916	1.089***	0.113	-0.181	0.631**	0.265*	0.0513	0.0181
	(5.56)	(1.26)	(6.27)	(1.37)	(-0.52)	(2.59)	(1.84)	(0.66)	(0.34)
Alfred Berg Obligasjon 3-5	0.441***	0.156**	1.449***	0.116	-0.243	0.744***	0.209	0.127	0.0872
	(6.75)	(2.49)	(7.08)	(1.66)	(-0.66)	(2,84)	(1.33)	(1.51)	(1.52)
Carnegie Obligasjon	0.467***	0.0965	1.368***	0.0964	0.0781	0.587**	0.246**	0.113	0.0381
	(5.58)	(1.19)	(6.01)	(1.11)	(0.2)	(2.25)	(2.3)	(1.43)	(0.61)
Danske Invest Norsk Obligasjon	0.316***	-0.0568	1.383***	-0.0249	-0.186	0.673***	0.372***	0.112	-0.0138
	(3.75)	(-0.56)	(6.01)	(-0.27)	(-0.43)	(3.08)	(3.03)	(1.22)	(-0.21)
DNB Kredittobligasjon	0.366***	0.0449	1.245***	0.0357	0.0205	0.513**	0.313***	0.057	0.0492
	(4.81)	(0.63)	(5.47)	(0.54)	(0.06)	(2.41)	(2.68)	(0.73)	(0.94)
DNB Lang Obligasjon 20	0.454***	0.211***	1.590***	0.121*	-0.0353	0.502*	0.441***	0.198**	0.0497
	(8.49)	(4.24)	(7.6)	(1.96)	(-0.09)	(1.92)	(2.89)	(2.31)	(0.81)
DNB Obligasjon	0.345***	0.0412	1.179***	0.0369	-0.0576	0.519**	0.312**	0.0581	0.0369
	(4.52)	(0.5)	(4.84)	(0.48)	(-0.15)	(2.4)	(2.48)	(0.70)	(0.68)
DNB Obligasjon (III)	0.345***	0.0377	1.192***	0.0331	-0.076	0.527**	0.316**	0.0612	0.0363
	(4.46)	(0.45)	(4.86)	(0.4)	(-0.21)	(2.13)	(2.17)	(0.78)	(0.67)
DNB Obligasjon 20	0.338***	0.0254	1.215***	0.0458	-0.443	0.774***	0.377**	0.0692	0.00954
	(4.11)	(0.26)	(4.25)	(0.49)	(-1.17)	(2.96)	(2.46)	(0.86)	(0.17)
DNB Obligasjon 20 (II)	0.338***	0.0258	1.210***	0.0471	-0.443	0.775**	0.377***	0.0667	0.00983
	(4.11)	(0.27)	(4.24)	(0.52)	(-0.86)	(2.65)	(2.78)	(0.76)	(0.16)
DNB Obligasjon 20 (III)	0.337***	0.0243	1.214***	0.0443	-0.448	0.774**	0.376***	0.0702	0.00961
	(4.09)	(0.25)	(4.24)	(0.48)	(-0.87)	(2.65)	(2.74)	(0.80)	(0.16)
DNB Obligasjon (IV)	0.342***	0.0259	1.225***	0.0458	-0.434	0.777**	0.377***	0.0686	0.0104
	(4.14)	(0.27)	(4.29)	(0.5)	(-0.84)	(2.66)	(2.76)	(0.79)	(0.17)
Eika Obligasjon	0.399***	0.166***	0.930***	0.148***	0.417*	0.19	0.131	0.121**	0.00739
	(7.43)	(3.16)	(6.49)	(2.68)	(1.77)	(1.15)	(1.35)	(2.34)	(0.20)
Handelsbanken Obligasjon	0.667***	0.464***	1.328***	0.356***	0.363	0.0969	0.189	0.265***	0.0781
	(14.25)	(10.19)	(10.62)	(7.48)	(1.17)	(0.43)	(1.39)	(3.65)	(1.60)
KLP Kredittobligasjon	0.702***	0.418***	1.102***	0.366***	0.133	0.185	0.222**	0.135**	0.0579
	(10.47)	(6.91)	(7.64)	(5.46)	(0.49)	(1.00)	(2.04)	(2.36)	(1.43)
KLP Obligasjon 3år	0.521***	0.289***	0.911***	0.247***	0.252	0.14	0.178**	0.118**	0.0281
	(9.77)	(6.2)	(8.85)	(5.24)	(1.28)	(0.83)	(2.42)	(2.33)	(0.72)
KLP Obligasjon 5år	0.581***	0.335***	1.614***	0.239***	0.325	0.233	0.326***	0.270***	0.0564
	(11.45)	(7.63)	(8.75)	(4.48)	(1.03)	(0.92)	(2.69)	(3.54)	(0.98)
Nordea Obligasjon II	0.509***	0.230***	1.084***	0.192***	0.0221	0.302	0.256**	0.118*	0.0349
	(7.83)	(3.97)	(7.85)	(3.04)	(0.08)	(1.61)	(2.32)	(1.99)	(0.85)
Nordea Obligasjon III	0.477***	0.125	1.292***	0.114	0.0997	0.479***	0.312***	0.0892	0.0364
	(6.40)	(1.53)	(6.13)	(1.47)	(0.28)	(2.87)	(3.05)	(1.14)	(0.70)
ODIN Obligasjon	0.254***	0.0591	0.743***	0.0583	0.153	0.203	0.234**	0.0361	0.0113
	(4.50)	(0.97)	(5.25)	(0.98)	(0.49)	(0.91)	(2.29)	(0.58)	(0.24)
PLUSS Pensjon	0.281***	0.0187	0.981***	0.0593	0.313	0.384**	0.153	0.0234	0.0387
	(4.71)	(0.23)	(4.52)	(0.69)	(1.01)	(2.03)	(1.66)	(0.33)	(0.77)

t statistics in parentheses
* p<0.10, ** p<0.05, *** p<0.01

	ACFM						STYLE
	β_{Gov}	β_{13}	β_{35}	β_{57}	β_{710}	β_{10+}	β_{STYLE}
Alfred Berg Lang Obligasjon	0.172*** (2.65)	0.000*** (3.11)	0.1871 (1.25)	0.3283* (1.82)	0.2231** (2.25)	0.0897 (1.36)	1.053*** (15.08)
Alfred Berg Obligasjon	0.1014 (1.35)	0.000 (0.00)	0.5730*** (5.11)	0.2480* (1.81)	0.0527 (0.71)	0.0249 (0.49)	0.998*** (9.57)
Alfred Berg Obligasjon 3-5	0.1067 (1.31)	0.000*** (5.37)	0.4214*** (3.46)	0.2148 (1.45)	0.1578* (1.95)	0.0993* (1.79)	0.994*** (13.09)
Carnegie Obligasjon	0.1215 (1.45)	0.0000 (0.00)	0.4798*** (3.83)	0.2503 (1.64)	0.0969 (1.17)	0.0514 (0.90)	1.038*** (11.09)
Danske Invest Norsk Obligasjon	0.0000 (0.00)	0.1607 (0.07)	0.5678** (2.14)	0.3061** (2.03)	0.0981 (1.14)	0.012 (0.20)	1.031*** (9.55)
DNB Kredittobligasjon	0.0355 (0.46)	0.0327 (0.15)	0.514** (2.26)	0.312** (2.39)	0.0567 (0.79)	0.0496 (1.00)	0.995*** (9.71)
DNB Lang Obligasjon 20	0.1305** (2.27)	0.000** (2.37)	0.1909 (1.44)	0.4042** (2.52)	0.2179** (2.48)	0.05646 (0.97)	1.033*** (15.25)
DNB Obligasjon	0.0356 (0.44)	0.0413 (0.18)	0.529** (2.20)	0.298** (2.15)	0.0554 (0.72)	0.0401 (0.76)	0.984*** (8.67)
DNB Obligasjon (III)	0.0317 (0.38)	0.0298 (0.13)	0.538** (2.21)	0.302** (2.16)	0.0583 (0.75)	0.0398 (0.75)	0.983*** (8.64)
DNB Obligasjon 20	0.0182 (0.22)	0.000 (0.00)	0.5785*** (4.67)	0.3012** (2.00)	0.0618 (0.75)	0.0403 (0.71)	1.054*** (8.96)
DNB Obligasjon 20 (II)	0.0194 (0.23)	0.000 (0.00)	0.5799*** (4.68)	0.3011** (1.99)	0.0586 (0.71)	0.041 (0.73)	1.054*** (8.91)
DNB Obligasjon 20 (III)	0.017 (0.20)	0.000 (0.00)	0.581*** (4.67)	0.2992** (1.98)	0.0624 (0.76)	0.0405 (0.72)	1.051*** (8.91)
DNB Obligasjon (IV)	0.0188 (0.23)	0.000 (0.00)	0.5762*** (4.64)	0.3023** (2.00)	0.0619 (0.75)	0.0408 (0.72)	1.056*** (9.00)
Eika Obligasjon	0.149*** (2.71)	0.402** (2.64)	0.188 (1.16)	0.133 (1.43)	0.122** (2.38)	0.00689 (0.20)	1.002*** (11.24)
Handelsbanken Obligasjon	0.358*** (7.44)	0.0046 (0.02)	0.0582 (0.26)	0.238* (1.79)	0.275*** (3.76)	0.0664 (1.36)	1.011*** (22.76)
KLP Kredittobligasjon	0.357*** (5.58)	0.0563 (0.32)	0.155 (0.82)	0.236** (2.18)	0.138** (2.31)	0.0568 (1.38)	1.015*** (20.33)
KLP Obligasjon 3år	0.246*** (4.81)	0.289** (2.03)	0.144 (0.95)	0.173* (2.00)	0.117** (2.45)	0.0293 (0.89)	0.997*** (15.68)
KLP Obligasjon 5år	0.0125 (0.23)	0.000 (0.61)	0.5899*** (4.61)	0.2987* (1.93)	0.0589 (0.49)	0.0401 (0.48)	1.026*** (23.03)
Nordea Obligasjon II	0.191*** (3.05)	0.10 (0.58)	0.310* (1.68)	0.245** (2.32)	0.116* (1.98)	0.0375 (0.93)	0.991*** (14.97)
Nordea Obligasjon III	0.150* (1.92)	0.0279 (0.13)	0.399* (1.74)	0.296** (2.24)	0.0894 (1.22)	0.0381 (0.76)	1.027*** (14.38)
ODIN Obligasjon	0.0542 (0.77)	0.470** (2.41)	0.236 (1.14)	0.191 (1.61)	0.0275 (0.42)	0.0217 (0.48)	0.896*** (5.81)
PLUSS Pensjon	0.0589 (0.88)	0.344* (1.85)	0.387* (1.96)	0.148 (1.31)	0.0225 (0.36)	0.0397 (0.92)	0.991*** (7.65)

t statistics in parentheses

* p<0.10, ** p<0.05, *** p<0.01