Factor and risk-adjusted return

Norges Bank Investment Management

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Contents

List of Tables

1 Factor-adjusted returns

1.1 Introduction

The purpose of the first part is to analyse the robustness of alpha estimates and factor exposures through various regression analyses. In the analyses, we consider the total fund performance along with those of the equity and fixed-income management entities. We present results from several factor regressions under both traditional and alternative model specifications, subject to different sample periods. We also investigate the role of management costs through before and after-cost factor regressions.

All relevant data used in the analysis that is not publicly available can be found on our website www.nbim.no. For the publicly available data, the reader is referred to the section on data and methodology.

The outline of this part of the analysis is as follows. Section 1.2 and 1.3 describe the factor regression framework and the data, respectively. Section 1.4 presents results for the equity and fixed-income portfolios separately and on an aggregated fund level. Moreover, the section provides results for the investments strategies undertaken by the fund.

1.2 Factor regressions

Throughout the analysis, we use the global five-factor model of Fama and French (2015) in Equation (1.1) as our main model for portfolio composites that hold only listed equities. For portfolio composites that hold fixed-income securities, we use the credit and term factors of Fama and French (1993), but as suggested by Hallerbach and Houweling (2011), we apply a duration-adjusted credit factor. The two-factor regression model is presented in Equation (1.2). For the fund portfolio which encompass equity, fixed-income and real asset investments, we follow the recommendation in Dahlquist et al. (2015) and combine the factor models into the seven-factor model in Equation (1.3).

$$r_t - r_t^{BM} = \alpha + \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + \epsilon_t. \tag{1.1}$$

$$r_t - r_t^{BM} = \alpha + \beta_1 \text{DEF Adj}_t + \beta_2 TERM_t + \epsilon_t. \tag{1.2}$$

$$\begin{aligned} r_t - r_t^{BM} = \alpha &+ \beta_1 MKT_t + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t \\ &+ \beta_6 \text{DEF Adj}_t + \beta_7 TERM_t + \epsilon_t. \end{aligned} \tag{1.3}$$

For each of the regression specifications the dependent variable is the monthly return on the considered portfolio r_t minus the monthly return of the corresponding benchmark r_t^{BM}. After-cost returns are obtained by further subtracting monthly management costs.[1] Except when explicitly stated, regressions are performed on an after-cost basis. The independent variables are specified in Table 2.

1.3 Data

For our main models we use Fama-French factor data from Kenneth French's web site along with fixed-income factor return series constructed using data sourced from Bloomberg.

The data sourced from Kenneth French's web site and Bloomberg cover the period January 1998-December 2024 and were downloaded on 29 January 2025. Table 2 presents the full list of factors and the data sources.

To make the analysis easier to replicate, we use monthly US dollar returns as publicly available factor returns are typically denominated in US dollars.

In the analysis of the equity, fixed-income and total fund portfolios we consider three samples periods: last 5 years, last 10 years and since inception. The former two are self-explaining while the latter spans January 1998-December 2024 for the fixed-income portfolios and January 1999-December 2024 for the equity portfolios. When considering the investment strategies we are limited

[1] Costs are on an annual frequency and monthly costs are obtained by distributing them evenly across the year.

to the eleven years of data available. Furthermore, the security selection investment strategy did not include any fixed-income securities before October 2014 and therefore the specific fixed-income time-series contains fewer observations.

1.3.1 Equity data

Factors sourced from Kenneth French's data library
Global research factors commonly used in empirical asset pricing studies are available from Kenneth French's data library.[2] From the data library we collect global factor returns for the CAPM, the Fama and French (1992) three-factor model, the Carhart (1997) four-factor model and the Fama and French (2015) five-factor model. Finally, for the risk-free rate we use the yield on one-month treasury bills which is also sourced from the data library.

1.3.2 Fixed-income data

Inspired by Fama and French (1993), we use a credit premium factor and a term premium factor for the fixed-income regressions. As historical series for these factors are not publicly available for a global portfolio, we use data from Bloomberg. In particular, the data required to construct the fixed-income factors has been sourced from Bloomberg (complementing historical data from Barclays Point and Barclays Live), and are US dollar unhedged returns. The following three sections explain the construction of these factor returns.

Term premium factor (TERM)
We define the term premium factor as the difference between the return on the Bloomberg Global Aggregate Treasury 10+Y index (more than 10 years to maturity) and the return on the Bloomberg Global Aggregate Treasury 1-3Y index. This term premium is slightly different from the one in Fama and French (1993) which is based returns on 1-3M Treasury bills. We use 1-3Y Treasury notes since historically consistent global returns for 1-3M Treasury bills are not readily available (a similar approach is taken by Ilmanen (1996) and Ilmanen et al. (2004)).[3]

A potential issue in the construction of the global term premium is the currency mismatch between long-term and short-term treasuries. An unbalanced distribution can lead to the factor incorporating sovereign credit risk and other drivers of returns separate from maturity. Thus, regression analysis with a non-zero loading to the term premium could be an exposure to both the term premium and other risk factors.

Default premium factor (DEF)
In line with Fama and French (1993) we define the default premium factor as the difference between returns on corporate bonds and treasury bonds with more than 10 years to maturity. Table 1 presents the data sources used in calculating the default premium factor.

For the period beginning in 1999, we use data from the Barclays Global Aggregate. For the period, the default premium factor return is computed as the return on the Barclays Global Aggregate Corporate 10+Y index less the return on the Barclays Global Aggregate Treasury 10+Y index. As Barclays Global Aggregate data is unavailable for the period prior to 1999, we use the corresponding Barclays US Aggregate data set. Specifically, we let the default premium factor return be given as the return on the US Aggregate Corporate Long index less the return on US Aggregate Treasury Long index. As shown in Table 1, corporate bond return data for the period January 1999-December 2000 is sourced via Barclays Point. Further, as the indices are maintained and have been renamed by Bloomberg, we source them from Bloomberg as of 2022.

The potential currency distribution issue highlighted for the term premium factor is likewise relevant for the default premium.

[2] See the "Developed Market Factors and Returns" section on http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

[3] Empirical observations on single currencies show that the calculated term premia using either bonds with one to three years until maturity or bonds with less than three months until maturity exhibit a high correlation.

Table 1
Sources used in computing the default premium factor returns

	Corporate bond index	Treasury bond index
Jan 1998 to Dec 1998	US Aggregate Corporate Long (Barclays Live)	US Aggregate Treasury Long (Barclays Live)
Jan 1999 to Dec 2000	Global Aggregate Corporate 10+Y (Barclays Point)	Global Aggregate Treasury 10+Y (Barclays Live)
Jan 2001 to Dec 2022	Global Aggregate Corporate 10+Y (Barclays Live)	Global Aggregate Treasury 10+Y (Barclays Live)
Jan 2022 to Dec 2024	Global Aggregate Corporate 10+ Yrs (Bloomberg)	Global 10+ Year Total Return (Bloomberg)

Note: Data sources in parentheses.

Duration adjusted default premium factor (DEF Adj)
Hallerbach and Houweling (2011) observe that the default factor, as it is defined in Fama and French (1993), by construction captures term effects, since corporate bonds in general have lower durations than government bonds. In order to achieve more reliable estimates of sensitivity to default risk compensation, one must account for this duration mismatch. Therefore, we match the duration of the corporate bond series to that of the government bond series according to

$$\text{DEF Adj}_t = \frac{D_t^{GOV}}{D_t^{CORP}} r_t^{CORP} - r_t^{GOV}. \tag{1.4}$$

DEF Adj_t denotes the return on the duration adjusted default factor while r_t^{GOV} and r_t^{CORP} are the monthly total returns on the government and corporate bond indices, respectively. D_t^{GOV} and D_t^{CORP} are the month t analytical option-adjusted modified durations of the government and corporate bond indices, respectively.

The duration adjustment is comparable to that in Asvanunt and Richardson (2016) but with the difference that they estimate empirical durations while we obtain analytical durations from Bloomberg.

Table 2
Factor descriptions and sources. Spanned period: January 1998 to December 2024

Factor	Description	Source
MKT	Equity market return in excess of the risk free rate	F-F
SMB	Small Minus Big, return spread between small cap and large cap stocks	F-F
HML	High Minus Low, return spread between high book-to-market and low book-to-market stocks	F-F
WML	Winners Minus Losers, return spread between past winners and losers	F-F
RMW	Robust Minus Weak, return spread between high and low profitability stocks	F-F
CMA	Conservative Minus Aggressive, return spread between stocks with low and high investment ratios	F-F
DEF	Default premium, excess returns from long term corporate bonds to long-term government bonds (10Y+)	Bloomberg
DEF Adj	Adjusted default premium, default premium adjusted for differences in duration between corporates and treasuries	Bloomberg
TERM	Term premium, return spread between long (10Y+) and short term (1-3Y) government bonds	Bloomberg

1.4 Regression results

We start by presenting results for equity and fixed-income asset class composites (as defined in the Global Investment Performance Standards (GIPS) report) net of cost against the main factor model specifications. The results are presented in Section 1.4.1. Section 1.4.2 presents the results for the investment strategies. Unless otherwise stated, regressions are based on relative returns after management costs.

Before turning to the analysis, Table 3 shows the time periods used in the regressions for management entities and the fund level. The table presents annualised arithmetic monthly return averages. The start dates are aligned with the inception of the relevant composites as used in the GIPS reporting.

Table 3
Spanned time periods and average relative returns

			Average %-USD relative returns		
	Start	End	Since inception	Last 10 years	Last 5 years
Management entities					
Equity	Jan 1999	Dec 2024	0.36	0.32	0.42
Fixed-income	Jan 1998	Dec 2024	0.20	0.32	0.60
Fund	Jan 1998	Dec 2024	0.19	0.19	0.21

Note: Average relative returns are based on the annualised arithmetic average of monthly US dollar returns after management costs.

1.4.1 Equity and fixed-income management entities and aggregated fund level

This section considers the equity and fixed-income management entities as well as the aggregated fund level (henceforth: fund).

Equity management
Table 4 presents regression results for the five-factor model of Fama and French (2015) applied to the three considered time periods. Table 5 presents the same analysis but with returns after management costs.

Table 6 considers the full period and presents the average equity relative return after management costs in column (1) and parameter estimates from four different factor models in columns (2)-(5). The table illustrates how factor exposures change along with the extension of the model.

Table 4
Equity management before costs five-factor regressions for selected time periods

Regression results with Fama-French global return factors for selected time periods. The dependent variables are the monthly return on the equity management portfolio subtracted the return on the equity management benchmark. Results for the three considered periods: since inception, last 10 years and last 5 years are presented in column (1)-(3), respectively. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Since inception	Last 10 years	Last 5 years
	(1)	(2)	(3)
Intercept	0.44	0.39	0.50
	(2.99)	(3.24)	(3.14)
MKT	0.01	0.00	-0.00
	(3.84)	(1.44)	(-0.09)
SMB	0.04	0.02	0.01
	(5.44)	(2.16)	(1.43)
HML	-0.00	0.02	0.01
	(-0.30)	(2.93)	(2.05)
RMW	-0.00	0.00	0.01
	(-0.18)	(0.54)	(1.35)
CMA	-0.02	-0.02	-0.01
	(-2.24)	(-2.26)	(-1.42)
Observations	312	120	60
Adjusted R^2	0.34	0.19	0.09

Table 5
Equity management after costs five-factor regressions for selected time periods

Regression results with Fama-French global return factors for selected time periods. The dependent variables are the monthly return on the equity management portfolio subtracted the return on the equity management benchmark and management costs. Results for the three considered periods: since inception, last 10 years and last 5 years are presented in column (1)-(3), respectively. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Since inception	Last 10 years	Last 5 years
	(1)	(2)	(3)
Intercept	0.34	0.33	0.45
	(2.27)	(2.77)	(2.83)
MKT	0.01	0.00	-0.00
	(3.83)	(1.44)	(-0.09)
SMB	0.04	0.01	0.01
	(5.37)	(2.15)	(1.42)
HML	-0.00	0.02	0.01
	(-0.32)	(2.95)	(2.06)
RMW	-0.00	0.00	0.01
	(-0.21)	(0.55)	(1.35)
CMA	-0.02	-0.02	-0.01
	(-2.22)	(-2.26)	(-1.43)
Observations	312	120	60
Adjusted R^2	0.34	0.19	0.09

Table 6
Equity management one-, three-, four- and five-factor regressions

Regression results with Fama-French global return factors for the full period. The dependent variables are the monthly return on the equity management portfolio subtracted the return on the equity management benchmark and management costs. Column (1) holds the unadjusted active return, whereas column (2)-(5) presents regression results for the: one-factor model, the Fama and French (1992) three-factor model, the Carhart (1997) four-factor model and the Fama and French (2015) five-factor model, respectively. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Unadj	1-Factor	3-Factor	4-Factor	5-Factor
	(1)	(2)	(3)	(4)	(5)
Intercept	0.36	0.25	0.28	0.20	0.34
	(2.27)	(1.75)	(2.05)	(1.57)	(2.27)
MKT		0.02	0.01	0.02	0.01
		(4.64)	(4.47)	(4.77)	(3.83)
SMB			0.04	0.04	0.04
			(5.81)	(6.30)	(5.37)
HML			-0.02	-0.01	-0.00
			(-2.45)	(-2.29)	(-0.32)
WML				0.01	
				(2.41)	
RMW					-0.00
					(-0.21)
CMA					-0.02
					(-2.22)
Observations	312	312	312	312	312
Adjusted R^2	0.00	0.15	0.32	0.35	0.34

Fixed-income management

Table 7 shows the regression results for a global term premium and duration-adjusted default premium two-factor model applied to the three considered periods. The table seeks to provide an indication of the exposures and the parameter estimate sensitivity towards the choice of sample.

Table 7
Fixed-income management two-factor regressions for selected time periods

Regression results with global fixed-income factors for selected time periods. The dependent variables are the monthly return on the fixed-income management portfolio subtracted the return on the fixed-income management benchmark and management costs. Results for the three considered periods: since inception, last 10 years and last 5 years, are presented in column (1)-(3), respectively. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Since 1998	Last 10 years	Last 5 years
	(1)	(2)	(3)
Intercept	0.16	0.30	0.43
	(0.66)	(2.61)	(2.93)
DEF_{adj}	0.05	0.00	0.00
	(2.33)	(0.51)	(0.68)
TERM	-0.03	-0.03	-0.03
	(-3.83)	(-5.60)	(-4.03)
Observations	324	120	60
Adjusted R^2	0.19	0.36	0.43

Fund

Using the seven-factor model described in the methodology section, this section analyses the aggregated fund portfolio spanning equity, fixed-income, and real-asset management. Using a cross-asset factor model allows equity investments to exhibit fixed-income risk factor exposure and vice versa. This implies that the estimated alphas are not directly comparable to those of the five- and two-factor models in the previous sections.

Table 8 presents the results from regressing the relative fund return after management costs onto the seven factors of the main model for different sample periods. The table provides an indication of the exposures and the parameter estimate sensitivity towards the choice of sample.

Table 8
Fund factor regressions for selected time periods

Regression results with global seven-factor model for selected time periods. The dependent variable are the monthly fund return subtracted the return on the fund benchmark and management costs. Results for the three considered periods: since inception, last 10 years and last 5 years, are presented in column (1)-(3), respectively. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Since 1998	Last 10 years	Last 5 years
	(1)	(2)	(3)
Intercept	0.14	0.22	0.15
	(0.94)	(2.29)	(1.09)
MKT	0.01	-0.00	-0.01
	(2.61)	(-0.74)	(-1.76)
SMB	0.03	0.02	0.01
	(5.64)	(3.33)	(2.04)
HML	0.01	0.00	0.00
	(1.92)	(0.57)	(0.51)
RMW	0.01	0.00	0.00
	(1.17)	(0.36)	(0.49)
CMA	-0.03	0.00	0.01
	(-2.26)	(0.28)	(0.44)
DEF_{adj}	0.02	0.01	0.02
	(1.90)	(2.49)	(3.08)
TERM	-0.02	-0.03	-0.02
	(-4.74)	(-6.63)	(-3.62)
Observations	324	120	60
Adjusted R^2	0.37	0.38	0.36

1.4.2 Investment strategies

In this section we perform various factor regressions for the three investment strategies: fund allocation, security selection, and asset management.[4] We provide results for the full sample and the last five years. Finally, we emphasise that the considered return time-series are rather short from a statistical perspective.

Equity management
Table 9 reports alphas and exposures obtained from applying the Fama and French (2015) five-factor model to the equity composites of the strategies.

Table 9
Equity management five-factor regressions for the investment strategies before management costs

Regression results with Fama-French global return factors for the three fund strategies. The dependent variables are the monthly return on the equity management portfolio of a given strategy subtracted the return on the equity management benchmark of the strategy. Full sample since 2013. Columns (1), (3), and (5) use the full sample, while columns (2), (4), and (6) use the last five years. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Fund Allocation		Security Selection		Asset Management	
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.01	0.08	1.11	1.66	0.17	0.16
	(-0.16)	(1.09)	(2.49)	(2.93)	(4.64)	(3.70)
MKT	0.00	0.00	0.02	-0.01	-0.00	-0.00
	(3.11)	(1.76)	(1.63)	(-0.57)	(-0.48)	(-1.16)
SMB	0.01	0.00	0.04	0.05	-0.00	0.00
	(1.85)	(0.81)	(2.02)	(1.78)	(-0.96)	(0.26)
HML	0.01	0.01	0.02	0.04	0.00	0.00
	(2.73)	(1.53)	(1.05)	(1.72)	(0.54)	(0.28)
RMW	0.00	-0.00	0.00	0.07	0.00	0.00
	(0.00)	(-0.64)	(0.01)	(1.78)	(1.15)	(1.41)
CMA	-0.00	0.00	-0.08	-0.09	0.00	0.00
	(-0.64)	(0.58)	(-2.28)	(-2.52)	(0.96)	(0.45)
Observations	144	60	144	60	144	60
Adjusted R^2	0.19	0.37	0.14	0.15	0.03	-0.02

[4]For descriptions of these investment strategies, see NBIM.no.

Fixed-income management

Table 10 considers the fixed-income management of the strategies. Specifically, it presents regression results from the applications of the main fixed-income factor model across strategies. As described in the methodology section the factor model uses the duration adjusted default premium and term premium factors to describe the fixed-income returns.

Table 10
Fixed-income management two-factor regressions for the investment strategies before management costs

Regression results with a duration-adjusted default premium factor and a term premium factor for the three fund strategies. The dependent variables are the monthly return on the fixed-income management portfolio of a given strategy subtracted the corresponding return on the fixed-income management benchmark of the strategy. Full sample since 2013. Columns (1), (3), and (5) use the full sample, while columns (2), (4), and (6) use the last five years. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent. The asterisk is to indicate that inception of fixed-income security selection is October 2014.

	Fund Allocation		Security Selection		Asset Management	
	(1)	(2)	(3)*	(4)	(5)	(6)
Intercept	-0.00	0.13	0.53	0.55	0.27	0.26
	(-0.03)	(1.06)	(2.71)	(1.42)	(6.26)	(4.06)
DEF_{adj}	0.01	0.01	-0.06	-0.06	0.01	0.01
	(2.19)	(2.03)	(-5.73)	(-3.14)	(2.45)	(3.28)
TERM	-0.03	-0.03	0.01	0.01	-0.00	-0.00
	(-6.29)	(-4.37)	(1.78)	(0.68)	(-2.66)	(-1.63)
Observations	144	60	123	60	144	60
Adjusted R^2	0.34	0.47	0.39	0.52	0.13	0.27

Total

In this section, we consider the aggregated portfolios of the strategies. The totals of security selection and asset management contain equity and fixed-income management, whereas the fund allocation portfolio contains equity, fixed-income, and real-asset management. As previously mentioned, we seek to explain returns on aggregated portfolios using a global seven-factor model combining the factors from our main equity and fixed-income factor models.

Table 11 reports alpha and exposure estimates from the applications of the seven-factor model to after-cost relative return series across investment strategies.

Table 11
Total factor regressions for the investment strategies after management costs

Regression results from applying the global seven-factor model to the three fund strategies. The dependent variables are the monthly return on a given strategy subtracted the return on the benchmark of the strategy and management costs. Full sample since 2013. Columns (1), (3), and (5) use the full sample, while columns (2), (4), and (6) use the last five years. Newey and West (1987) corrected t-statistics (using 3 lags) are shown in parentheses. The alpha estimates are annualised and in percent.

	Fund Allocation		Security Selection		Asset Management	
	(1)	(2)	(3)	(4)	(5)	(6)
Intercept	-0.05	-0.11	0.55	0.77	0.16	0.17
	(-0.65)	(-0.87)	(1.61)	(2.03)	(6.45)	(6.16)
MKT	-0.00	-0.01	0.01	-0.01	0.00	-0.00
	(-0.17)	(-1.56)	(1.31)	(-1.64)	(0.84)	(-0.55)
SMB	0.01	0.01	0.03	0.02	0.00	0.00
	(2.64)	(1.44)	(2.38)	(1.66)	(1.29)	(2.01)
HML	0.01	0.00	-0.03	-0.00	0.00	-0.00
	(1.11)	(0.63)	(-1.80)	(-0.22)	(0.08)	(-0.56)
RMW	-0.00	-0.00	0.00	0.03	0.00	0.00
	(-0.29)	(-0.67)	(0.06)	(1.34)	(1.13)	(2.29)
CMA	0.01	0.01	-0.01	-0.04	0.00	0.00
	(0.82)	(0.89)	(-0.63)	(-1.82)	(1.58)	(1.68)
DEF_{adj}	0.00	0.01	0.02	0.03	0.00	0.00
	(0.23)	(1.91)	(2.29)	(2.59)	(2.55)	(3.63)
TERM	-0.01	-0.01	-0.07	-0.04	-0.00	-0.00
	(-4.08)	(-2.35)	(-6.07)	(-2.91)	(-2.38)	(-1.10)
Observations	144	60	144	60	144	60
Adjusted R^2	0.33	0.40	0.25	0.25	0.12	0.17

2 Risk-adjusted returns

The purpose of this section is to give a detailed description of a set of methods to compute risk-adjusted performance measures.

The portfolio return and the benchmark return are both measured in the currency basket. The 1-month US T-bill rate collected from Kenneth French's website is used as a proxy for the risk-free return. In principle, this is not consistent with measuring the portfolio and benchmark returns in the currency basket. On the other hand, there is no established alternative.

2.1 Methodology

In the following section, the methods used for calculating risk-adjusted measures are described. r_t, rb_t and rf_t are defined as the return in month t of the portfolio, the benchmark, and the risk-free asset, respectively. T is the number of months in the sample period. All returns are simple rather than in logs.

2.1.1 Sharpe ratio

rx_t denotes the portfolio excess return $r_t - rf_t$ in month t. The formula for the monthly Sharpe ratio is[5]

$$\widehat{SR}_m = \hat{\mu}_{rx}/\hat{\sigma}_r, \tag{2.1}$$

where $\hat{\mu}_{rx}$ is the sample average of portfolio excess returns, and $\hat{\sigma}_r$ is the sample standard deviation of portfolio returns computed with the $T-1$ divisor. The Sharpe ratio of the benchmark is computed similarly. Monthly Sharpe ratios are annualised using

$$\widehat{SR}_a = \widehat{SR}_m\sqrt{12}. \tag{2.2}$$

This annualisation is an approximation, as it ignores compounding by assuming that annual returns are sums of monthly returns. This is not the case when using simple returns. It also assumes that monthly returns have zero autocorrelation. This formula is used, as it is the most conventional way of annualising Sharpe ratios and, therefore, makes the results comparable.

2.1.2 Information ratio

$rrel_t$ denotes the relative return in month t, $r_t - rb_t$. The monthly information ratio is computed as

$$\widehat{IR}_m = \hat{\mu}_{rrel}/\hat{\sigma}_{rrel}, \tag{2.3}$$

where $\hat{\mu}_{rrel}$ is the sample average of relative returns, and $\hat{\sigma}_{rrel}$ is the sample standard deviation of relative returns using the $T-1$ divisor. The annualised information ratios are computed in the same way as for the Sharpe ratio.

[5] See Sharpe (1966, 1994).

2.1.3 Jensen's alpha

The Capital Asset Pricing Model (CAPM) regression using the benchmark as a proxy for the market portfolio is

$$rx_t = \alpha_m + \beta bx_t + \epsilon_t, \tag{2.4}$$

where $bx_t = rb_t - rf_t$ is the benchmark excess return in month t. Jensen's alpha measured on a monthly level is the Ordinary Least Squares (OLS) estimate of the intercept in this regression.[6] That is,

$$\hat{\alpha}_m = \hat{\mu}_{rx} - \hat{\beta}\hat{\mu}_{bx}, \tag{2.5}$$

where $\hat{\beta}$ is the OLS estimate of the slope coefficient in the CAPM regression (2.4), and $\hat{\mu}_{bx}$ is the sample average of benchmark excess returns. The monthly alpha is annualised using

$$\hat{\alpha}_a = \hat{\alpha}_m \times 12. \tag{2.6}$$

2.1.4 Appraisal ratio

The monthly appraisal ratio is computed as[7]

$$\widehat{AR}_m = \hat{\alpha}_m / \hat{\sigma}_\epsilon, \tag{2.7}$$

where $\hat{\alpha}_m$ is Jensen's alpha from (2.5), and $\hat{\sigma}_\epsilon$ is the sample standard deviation of the residuals from estimating the CAPM regression model in (2.4). For computing $\hat{\sigma}_\epsilon$, we use the $T-2$ divisor to reflect the number of estimated parameters. Monthly appraisal ratios are annualised in the same way as the Sharpe ratios.

[6] See Jensen (1968).
[7] See Treynor and Black (1973).

2.2 Results

In this section, the risk-adjusted measures for management entities are calculated after costs, while for investment strategies, measures are calculated before costs, and after costs on fund level. The following composites are considered: total fund, equity- and fixed-income management entities, and the three main strategies: fund allocation, security selection, and asset management. Real estate is included in the fund and total fund allocation composites from 2017. Renewable infrastructure is included in the same composites from 2021. Subject to availability, results are computed since inception, for the last ten years, and the last five years.

2.2.1 Sharpe ratio

Tables 12, 13, and 14 present Sharpe ratios across different contexts: Table 12 examines management entities' performance after costs across various time periods, while tables 13 and 14 analyse investment strategies showing both gross (before costs) and net (after costs) ratios for the 2013-2024 period and the last five years, respectively.

Table 12
Sharpe ratio after management costs for various sample sizes: management entities

Annualised Sharpe ratio estimates after costs for various sample periods. The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

		Since inception	Last 10 years	Last 5 years
Portfolio	Equity	0.41	0.64	0.58
	Fixed Income	0.47	-0.02	-0.43
	Fund	0.53	0.59	0.46
Benchmark	Equity	0.39	0.62	0.55
	Fixed Income	0.42	-0.09	-0.52
	Fund	0.52	0.57	0.44

Table 13
Sharpe ratio for 2013-2024: strategies

Annualised Sharpe ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks. The asterisk is to indicate that inception of fixed-income security selection is October 2014.

			Fund allocation	Securities selection*	Asset management
Portfolio	Gross	Equity	0.76	0.62	0.81
		Fixed Income	0.07	0.30	0.02
		Fund	0.70	0.63	0.75
	Net	Fund	0.70	0.61	0.75
Benchmark	Gross	Equity	0.76	0.55	0.79
		Fixed Income	0.06	0.23	-0.05
		Fund	0.71	0.56	0.73

Table 14
Sharpe ratio for the last five years: strategies

Annualised Sharpe ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

			Fund allocation	Securities selection	Asset management
Portfolio	Gross	Equity	0.56	0.48	0.60
		Fixed Income	-0.48	-0.13	-0.55
		Fund	0.44	0.41	0.50
	Net	Fund	0.44	0.40	0.49
Benchmark	Gross	Equity	0.55	0.40	0.59
		Fixed Income	-0.52	-0.16	-0.61
		Fund	0.44	0.32	0.48

2.2.2 Information ratio

Tables 15, 16, and 17 present Information ratios across different contexts: Table 15 examines management entities' performance after costs across various time periods, while tables 16 and 17 analyse investment strategies showing both gross (before costs) and net (after costs) ratios for the 2013-2024 period and the last five years, respectively.

Table 15
Information ratio after management costs for various sample sizes: management entities

Annualised information ratio estimates after costs for various sample periods. The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

	Since inception	Last 10 years	Last 5 years
Equity	0.52	0.86	1.32
Fixed Income	0.21	0.81	1.47
Fund	0.29	0.48	0.47

Table 16
Information ratio for 2013-2024: strategies

Annualised information ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks. The asterisk is to indicate that inception of fixed-income security selection is October 2014.

		Fund allocation	Securities selection*	Asset management
Gross	Equity	-0.05	0.80	1.78
	Fixed Income	0.03	0.42	1.91
	Fund	-0.29	0.75	2.48
Net	Fund	-0.31	0.62	2.17

Table 17
Information ratio for the last five years: strategies

Annualised information ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

		Fund allocation	Securities selection	Asset management
Gross	Equity	0.43	1.19	2.04
	Fixed Income	0.92	0.41	2.01
	Fund	-0.24	1.34	3.02
Net	Fund	-0.25	1.19	2.70

2.2.3 Jensen's alpha

Tables 18, 19, and 20 present Jensen's alpha across different contexts: Table 18 examines management entities' performance after costs across various time periods, while tables 19 and 20 analyse investment strategies showing both gross (before costs) and net (after costs) ratios for the 2013-2024 period and the last five years, respectively.

Table 18
Jensen's alpha after management costs for various sample sizes: management entities

Annualised Jensen's alpha estimates after costs (percent) for various sample periods from a regression of relative return on a constant and the benchmark excess return. The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

	Since inception	Last 10 years	Last 5 years
Equity	0.26	0.24	0.39
Fixed Income	0.23	0.30	0.46
Fund	0.08	0.22	0.28

Table 19
Jensen's alpha for 2013-2024: strategies

Annualised Jensen's alpha estimates before costs (Gross) and after costs (Net), from a regression of relative return on a constant and the benchmark excess return. The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks. The asterisk is to indicate that inception of fixed-income security selection is October 2014.

		Fund allocation	Securities selection*	Asset management
Gross	Equity	-0.05	0.92	0.18
	Fixed Income	0.03	0.39	0.29
	Fund	-0.05	0.73	0.20
Net	Fund	-0.06	0.59	0.17

Table 20
Jensen's alpha for the last five years: strategies

Annualised Jensen's alpha estimates before costs (Gross) and after costs (Net), from a regression of relative return on a constant and the benchmark excess return. The estimates are based on monthly returns of equity, fixed-income and total portfolios and corresponding benchmarks.

		Fund allocation	Securities selection	Asset management
Gross	Equity	0.06	1.37	0.17
	Fixed Income	0.20	0.22	0.35
	Fund	-0.04	1.06	0.20
Net	Fund	-0.04	0.94	0.18

2.2.4 Appraisal ratio

Tables 21, 22, and 23 present Appraisal ratios across different contexts: Table 21 examines management entities' performance after costs across various time periods, while tables 22 and 23 analyse investment strategies showing both gross (before costs) and net (after costs) ratios for the 2013-2024 period and the last five years, respectively.

Table 21
Appraisal ratio after management costs for various sample sizes: management entities

Annualised appraisal ratio estimates after costs for various sample periods. The estimates are based on monthly returns on the equity, fixed-income and total portfolios and corresponding benchmarks.

	Since inception	Last 10 years	Last 5 years
Equity	0.40	0.70	1.23
Fixed Income	0.26	0.96	1.51
Fund	0.14	0.57	0.64

Table 22
Appraisal ratio for 2013-2024: strategies

Annualised appraisal ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns on the equity, fixed-income and total portfolios and corresponding benchmarks. The asterisk is to indicate that inception of fixed-income security selection is October 2014.

		Fund allocation	Securities selection*	Asset management
Gross	Equity	-0.25	0.67	1.86
	Fixed Income	0.08	0.57	1.90
	Fund	-0.16	0.70	2.40
Net	Fund	-0.18	0.57	2.09

Table 23
Appraisal ratio for the last five years: strategies

Annualised appraisal ratio estimates before costs (Gross) and after costs (Net). The estimates are based on monthly returns on the equity, fixed-income and total portfolios and corresponding benchmarks.

		Fund allocation	Securities selection	Asset management
Gross	Equity	0.34	1.12	2.13
	Fixed Income	0.77	0.40	2.10
	Fund	-0.09	1.35	2.95
Net	Fund	-0.10	1.20	2.64

References

Asvanunt, Attakrit and Richardson, Scott. The credit risk premium. *The Journal of Fixed Income*, 26(3):6–24, 2016.

Carhart, Mark. On Persistance in Mutual Fund Performance. *The Journal of Finance vol. 52(1), pp. 57-82*, 1997.

Dahlquist, Magnus, Polk, Christopher, Priestley, Richard, and Ødegaard, Bernt Arne. Norges Bank's Expert Group on Principles for Risk Adjustment of Performance Figures – Final Report. *Available at http://www.norges-bank.no/pages/104035/Expert_Group_Final_Report_Nov_2015.pdf*, 2015.

Fama, Eugene F. and French, Kenneth R. The Cross-Section of Expected Stocks Returns. *The Journal of Finance vol. 47(2), pp. 427-465*, 1992.

Fama, Eugene F and French, Kenneth R. Common risk factors in the returns on stocks and bonds. *Journal of financial economics*, 33(1):3–56, 1993.

Fama, Eugene F. and French, Kenneth R. A five-factor asset pricing model. *Journal of Financial Economics*, 116(1):1 – 22, 2015.

Hallerbach, Winfried G. and Houweling, Patrick. Ibbotson's Default Premium: Risky Data. *The Journal of Investing, Summer, Vol. 22 No. 2, pp. 95-105. Available at SSRN: http://ssrn.com/abstract=1898178*, 2011.

Ilmanen, Antti. Does Duration Extensions Enhance Long-Term Expected Returns? *The Journal of Fixed Income*, 6(2):23–36, 1996.

Ilmanen, Antti, Byrne, Rory, Gunasekera, Heinz, and Minikin, Robert. Which Risks Have Been Best Rewarded? *The Journal of Portfolio Management*, 30(2):53–57, 2004.

Jensen, Michael C. The Performance of Mutual Funds in the Period 1945-1964. *Journal of Finance, vol. 23(2), pp. 389-416*, 1968.

Newey, Withney K. and West, Kenneth D. A simple, positive semi-definite, heteroskedasticity and autocorrelationconsistent covariance matrix. *Econometrica, Vol. 55, No. 3, 703-708*, 1987.

Sharpe, William F. Mutual Fund Performance. *Journal of Business, vol. 39 (January) pp. 119-138*, 1966.

Sharpe, William F. The Sharpe Ratio. *Journal of Portfolio Management, vol. 21(1), pp. 49-58*, 1994.

Treynor, Jack L. and Black, Fischer. How to Use Security Analysis to Improve Portfolio Selection. *Journal of Business vol. 46(1), pp. 66-85*, 1973.