Government Pension Fund Global (GFPG) ("The Oil Fund") - using the data

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Introduction

The Norwegian *Government Pension Fund Global* is currently the world's largest Sovereign Wealth Fund, with Assets Under Management (AUM) of 12 billion NOK.

In these notes we show how to use the data provided by NBIM to do various calculations.

The calculations are shown using `R`.

NBIM Data

NBIM provides downloadable data that can be used to do your own evaluation of the funds investments.

Monthly returns broken down by

- Asset class (equity/fixed income/total)
- Reference currency (NOK/USD/Currency Index)

Lots of additional data

- NBIM portfolio compositions
- ...

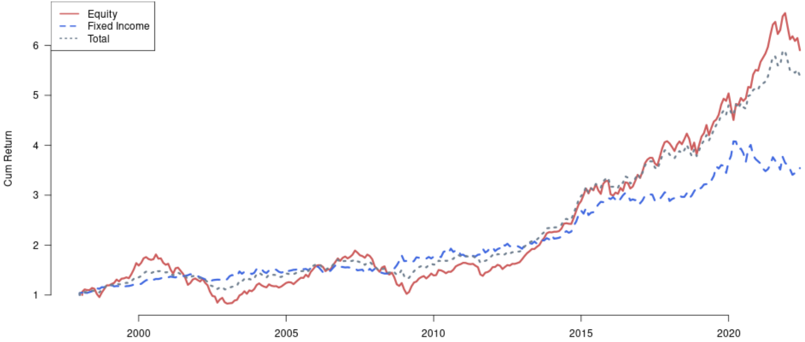
```
library(xts)                                # time series library
library(readxl)                             # reading excel files library
datadir <- "/home/bernt/data/2023/nbim/" # set datadir to where the file lives
filename <- paste0(datadir,"monthly-returns-1h2022.xlsx")

DataEquityReturnsUSD <- read_xlsx(filename, sheet="Equity - USD",skip=2)
dates <- as.yearmon(as.Date(as.character(na.omit(DataEquityReturnsUSD$Mont
                    format="%Y-%m-%d"))
n <- length(dates)
dates <- dates[2:n]                        # cut the first date, as this is empty
Equity_Rets_USD <- xts(na.omit(DataEquityReturnsUSD$`Actual portfolio`),
                 order.by=dates)
names(Equity_Rets_USD) <- "Equity_Rets_USD"
Equity_Benchmark_Rets_USD <- xts(na.omit(DataEquityReturnsUSD$`Benchma
                           order.by=dates)
names(Equity_Benchmark_Rets_USD) <- "Equity_Benchmark_Rets_USD"

DataFixedIncomeReturnsUSD <- read_xlsx(filename, sheet="Fixed income - US
dates <- as.yearmon(as.Date(as.character(na.omit(DataFixedIncomeReturnsUSD
                    format="%Y-%m-%d"))
Fixed_Income_Rets_USD <- xts(na.omit(DataFixedIncomeReturnsUSD$`Actual p
                     order.by=dates)
names(Fixed_Income_Rets_USD) <- "Fixed_Income_Rets_USD"
Fixed_Income_Benchmark_Rets_USD <- xts(na.omit(DataFixedIncomeReturnsUS
```

Looking at the financial investments.
Evaluating: What *return* do one earn on an investment, without counting for in and outflow from the fund?
The *wealth relative* implied in the asset returns

$$W_T = \prod_{t=1}^{T} (1 + r_t)$$

Or, how much will one NOK invested in 1998 have grown to?

Aggregate wealth, Total, Equity and Fixed income, in NOK



R code for doing picture

```
source ("../2023_01_read_current/read_nbim_NOK_returns_from_excel.R")
outdir <- "../../results/2023_01_cumulative_wealth_plots/"

Equity_Rets_NOK <- na.omit(Equity_Rets_NOK)
Equity_Benchmark_Rets_NOK <- na.omit(Equity_Benchmark_Rets_NOK)
Rp <- as.matrix(Equity_Rets_NOK)
Rb <- as.matrix(Equity_Benchmark_Rets_NOK)
Rdiff <- Rp-Rb
wp  <- 1.0
WealthP <- c(wp)
wb  <- 1.0
WealthB <- c(wb)
wd <- 1.0
WealthDiff <- c(wd)
for ( i in 1:length(Rp)) {
    wp <- wp*(1+Rp[i])
    WealthP <- c(WealthP,wp)
    wb <- wb*(1+Rb[i])
    WealthB <- c(WealthB,wb)
    wd <- wd*(1+Rdiff[i])
    WealthDiff <- c(WealthDiff,wd)
}
```

Aggregate wealth, Equity portfolio, in NOK

The Sharpe Ratio

A Sharpe ratio is

$$S = \frac{r_p - r_f}{\sigma(r_p - r_f)}$$

Calculate this for the fund's equity portfolio using Ken French's market portfolio as a benchmark. That means we use the fund's returns in USD.

Sharpe ratios - Equity portfolio

	Mean (%)	Sharpe
fund portfolio	7.6	0.102
benchmark	7.2	0.096
RMRF	7.8	0.111

The table shows Sharpe ratios for the fund's equity portfolio. Returns in USD. Using the French risk free rate. The fund and the benchmark are international portolioe. RMRF is the excess return for Ken French's US market portfolio.

```r
library(xtable)
source ("~/data/2023/french_global_data/read_global_5_pricing_factors.R")
source ("../2023_01_read_current/read_nbim_USD_returns_from_excel.R")
outdir <- "../../results/2023_02_describe_returns/"
data <- merge(Equity_Rets_USD, Equity_Benchmark_Rets_USD,
              RF, RM, RMRF,all=FALSE)
eRp <- data$Equity_Rets_USD     - data$RF
eRb <- data$Equity_Benchmark_Rets_USD - data$RF
RMRF <- data$RMRF

sharpe_p <- mean(eRp)/sd(eRp)
sharpe_b <- mean(eRb)/sd(eRb)
sharpe_m <- mean(RMRF)/sd(RMRF)

tab <- matrix(nrow=3,ncol=2)
tab[1,1] <- 1200 * mean(data$Equity_Rets_USD)
tab[1,2] <- sharpe_p
tab[2,1] <- 1200 * mean(data$Equity_Benchmark_Rets_USD)
tab[2,2] <- sharpe_b
tab[3,1] <- 1200 * mean(data$RM)
tab[3,2] <- sharpe_m

rownames(tab) <- c("fund portfolio","benchmark", "RMRF")
colnames(tab) <- c("Mean (%)", "Sharpe")
```

$$T = \frac{r_p - r_f}{\beta_p}$$

Calculate this for the fund's equity portfolio using Ken French's market portfolio as a benchmark. That means we use the fund's returns in USD.

Treynor measures - 1998–2022

	Beta	Treynor
fund portfolio	1.05	0.0047
benchmark	1.05	0.0044
RMRF	1.00	0.0051

The table shows Treynor measures for the fund's equity portfolio. Returns in USD. Using the French risk free rate. The fund and the benchmark are international portolios. RMRF is the excess return for Ken French's US market portfolio.

```r
library(xtable)
source ("~/data/2023/french_global_data/read_global_5_pricing_factors.R")
source ("../2023_01_read_current/read_nbim_USD_returns_from_excel.R")
outdir <- "../../results/2023_02_describe_returns/"
data <- merge(Equity_Rets_USD, Equity_Benchmark_Rets_USD,
              RF, RM, RMRF,all=FALSE)
eRp <- data$Equity_Rets_USD - data$RF
eRb <- data$Equity_Benchmark_Rets_USD - data$RF
RMRF <- data$RMRF

beta_p <- cov(eRp,RMRF)/var(RMRF)
treynor_p <- mean(eRp)/beta_p
beta_b <- cov(eRb,RMRF)/var(RMRF)
treynor_b <- mean(eRb)/beta_b
treynor_m <- mean(RMRF)/1

tabT <- matrix(nrow=3,ncol=2)
colnames(tabT) <- c("Beta","Treynor")
rownames(tabT) <- c("fund portfolio","benchmark", "RMRF")

tabT[1,1] <- beta_p
tabT[1,2] <- treynor_p
tabT[2,1] <- beta_p
tabT[2,2] <- treynor_b
```

Alpha estimation

Alpha is an attempt to answer the question: Does the return on a portfolio/asset exceed its *required* return?

Jensens alpha is the difference between actual performance and required return

$$\alpha_p = r_p - \text{reqiured return} = r_p - \hat{r}_p$$

To find an estimate of requred return an asset pricing model is required.

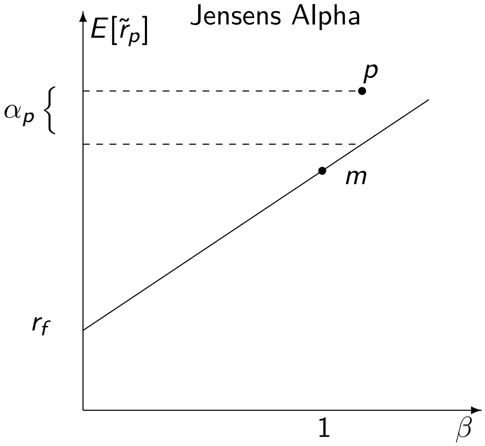
The classical such asset pricing model is the CAPM, which is what Jensen used

$$\hat{r}_p = (r_f + \beta_p(r_m - r_f))$$

Alpha is then

$$\alpha_p = r_p - (r_f + \beta_p(r_m - r_f))$$

Alpha estimation



The CAPM is not the only possible asset pricing model. Models such as the Fama-French three and five factor models are common alternatives.

If $\alpha_p > 0$, this is interpreted as positive performance.

Alpha estimation

Estimate the "alpha" of the equity portfolio, using the global Fama French factors.

$$r_{pt} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + \varepsilon_t$$

$$r_{pt} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + b^{SMB} SMB_t + b^{HML} HML_t + \varepsilon_t$$

$$r_{pt} - r_{ft} = \alpha + \beta(r_{mt} - r_{ft}) + b^{SMB} SMB_t + b^{HML} HML_t + b^{RMW} RMW_t + + b^{CM}$$

Here r_{pt} is the portfolio return, r_{ft} the risk free rate, and r_{mt} the return on a market portfolio. Here SMB_t and HML_t are the two Fama French factors on market size and book to market, and then the two additional Fama French factors RMW and CMA. All of these are the global (developed) factors.

Alpha estimation

	Dependent variable:		
	eRp		
	One Factor	Three Factors	Five Factors
Constant	−0.0004	−0.001	-0.001^{**}
	(0.0004)	(0.0003)	(0.0004)
RMRF	1.048^{***}	1.054^{***}	1.056^{***}
	(0.008)	(0.008)	(0.009)
SMB		-0.037^{**}	−0.028
		(0.018)	(0.019)
HML		0.068^{***}	0.082^{***}
		(0.012)	(0.020)
RMW			0.054^{**}
			(0.024)
CMA			−0.028
			(0.029)

Alpha estimation

This is the estimation one would grab for without thinking too hard.
But the NBIM portfolio should be evaluated by asking whether it "outperforms" the benchmark b, and we should investigate the models of type

$$r_{pt} - r_{bt} = r_{diff,t} = \alpha + \beta(r_{mt} - r_{ft}) + \varepsilon_t$$

Alpha estimation

	Dependent variable:		
		diffRp	
	One Factor	Three Factors	Five Factors
Constant	0.0003**	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)
RMRF	0.017***	0.016***	0.012***
	(0.002)	(0.002)	(0.003)
SMB		0.040***	0.038***
		(0.005)	(0.006)
HML		−0.015***	−0.002
		(0.004)	(0.006)
RMW			−0.002
			(0.007)
CMA			−0.025***
			(0.009)

Alpha estimation

```
library(stargazer)
source ("~/data/2023/french_global_data/read_global_5_pricing_factors.R"
source ("../2023_01_read_current/read_nbim_USD_returns_from_excel.R")
outdir <- "../../results/2023_01_alpha_estimation/"

data <- merge(Equity_Rets_USD,
              Equity_Benchmark_Rets_USD,
              RF,RMRF,SMB,HML,RMW,CMA,all=FALSE)
Rp  <- data$Equity_Rets_USD
eRp <- Rp-data$RF
RMRF <- data$RMRF
SMB <- data$SMB
HML <- data$HML
RMW <- data$RMW
CMA <- data$CMA

regr9822_1 <- lm(eRp~RMRF)
regr9822_3 <- lm(eRp~RMRF+SMB+HML)
regr9822_5 <- lm(eRp~RMRF+SMB+HML+RMW+CMA)

filename <- paste0(outdir,
                   "alpha_estimation_equity_USD_whole_period_one_three_five
```