Analyzing NBIM returns

Bernt Arne Ødegaard

24 November 2021

Introduction

These notes illustrate the usage of `R` to analyze the historical returns of the Norwegian "Oil Fund"
(GPFG). It is based on the report Dahlquist and Ødegaard (2018), and illustrate the implementation of
some of these calculations using `R`. Many of the calculations have been updated with data through 2020.

1 Data

The prime data source is the most recent spreadsheet of historical returns provided by NBIM adjoint to
their annual report.

The following shows the routine that builds `xts` series by pulling the data from that excel spreadsheet.
This example collects the data for returns in USD.

```
library(xts)                          # time series library
library(readxl)                       # reading excel files library
datadir <- "/home/bernt/data/2021/nbim/" # set datadir to where the file lives
filename <- paste0(datadir,"monthly-returns_2020.xlsx")
DataEquityReturnsUSD <- read_xlsx(filename, sheet="Equity - USD",skip=2)
dates <- as.yearmon(as.Date(as.character(na.omit(DataEquityReturnsUSD$Month)), format="%Y-%m-%d"))
n <- length(dates)
dates <- dates[2:n]                   # cut the first date, as this is empty
Equity_Rets_USD <- xts(na.omit(DataEquityReturnsUSD$'Actual portfolio'), order.by=dates)
names(Equity_Rets_USD) <- "Equity_Rets_USD"                                                     10
Equity_Benchmark_Rets_USD <- xts(na.omit(DataEquityReturnsUSD$'Benchmark index'), order.by=dates)
names(Equity_Benchmark_Rets_USD) <- "Equity_Benchmark_Rets_USD"

DataFixedIncomeReturnsUSD <- read_xlsx(filename, sheet="Fixed income - USD",skip=2)
dates <- as.yearmon(as.Date(as.character(na.omit(DataFixedIncomeReturnsUSD$Month)), format="%Y-%m-%d"))
Fixed_Income_Rets_USD <- xts(na.omit(DataFixedIncomeReturnsUSD$'Actual portfolio'), order.by=dates)
names(Fixed_Income_Rets_USD) <- "Fixed_Income_Rets_USD"
Fixed_Income_Benchmark_Rets_USD <- xts(na.omit(DataFixedIncomeReturnsUSD$'Benchmark index'), order.by=dates)
names(Fixed_Income_Benchmark_Rets_USD) <- "Fixed_Income_Benchmark_Rets_USD"
                                                                                                20
DataTotalReturnsUSD <- read_xlsx(filename, sheet="Fund combined - USD",skip=2)
dates <- as.yearmon(as.Date(as.character(na.omit(DataTotalReturnsUSD$Month)), format="%Y-%m-%d"))
Total_Rets_USD <- xts(na.omit(DataTotalReturnsUSD$Fund), order.by=dates)
names(Total_Rets_USD) <- "Total_Rets_USD"
Total_Benchmark_Rets_USD <- xts(na.omit(DataTotalReturnsUSD$'Benchmark index'), order.by=dates)
names(Total_Benchmark_Rets_USD) <- "Total_Benchmark_Rets_USD"
```

These routines are sourced everywhere, look for the "`source`" statement at the top of most of the
following examples.

2 Aggregate wealth plots

Purpose: Illustrate the increase in wealth from asset returns (not accounting for inflows/outflows).
Figure 4 shows the picture for wealth (in NOK) implied in the equity part of the portfolio, where wealth
is calculated as

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

**Figure 1** Aggregate wealth, Equity portfolio, in NOK
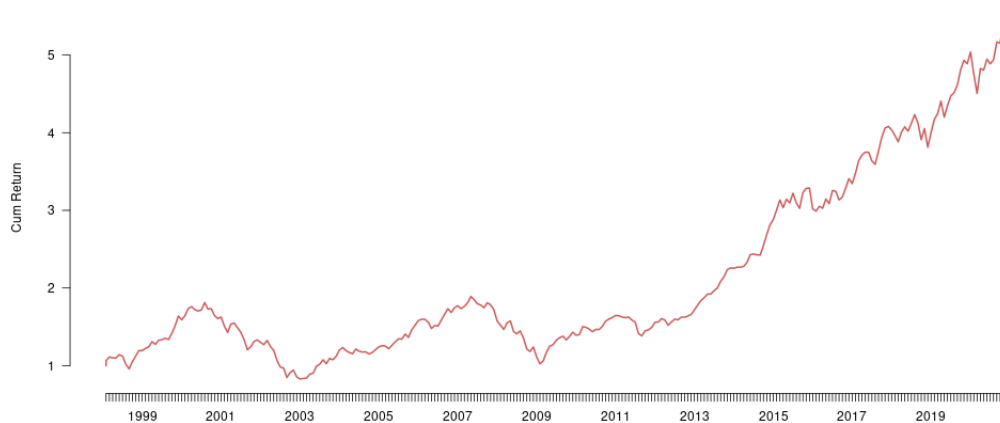
```
source (".../2021_06_read_current/read_nbim_NOK_returns_from_excel.R")
outdir <- "../.../results/2021_06_cumulative_wealth_plots/"

Rp <- as.matrix(Equity_Rets_NOK)
wp  <- 1.0
Wealth <- c(wp)
for ( i in 1:length(Rp)) {
    wp <- wp*(1+Rp[i])
    Wealth <- c(Wealth,wp)
}
dates <- c(as.yearmon("1998-02"),index(Equity_Rets_NOK))
Wealth <- xts(Wealth,order.by=dates)
filename <- paste0(outdir,"wealth_evolution_equity_portfolio_NOK.png")
png(filename,width=1000,heigh=500)
plot.zoo(Wealth,
        main="", ylab="Cum Return", xlab="", las=1,lwd=2, bty="n", col="indianred")
dev.off()
```

10

Let us look aat the cumulative and difference wealth plots for the returns in USD.

Figure 2 Aggregate wealth, Equity, USD

Evolution of portfolio and benchmark
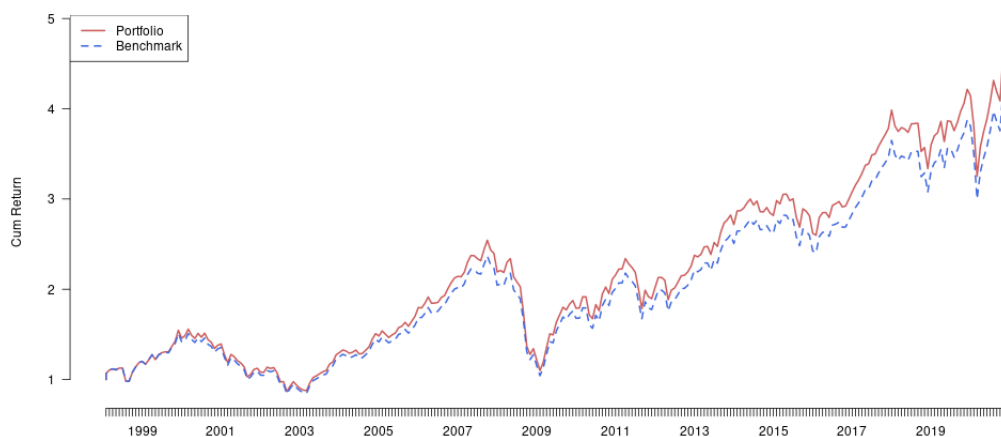
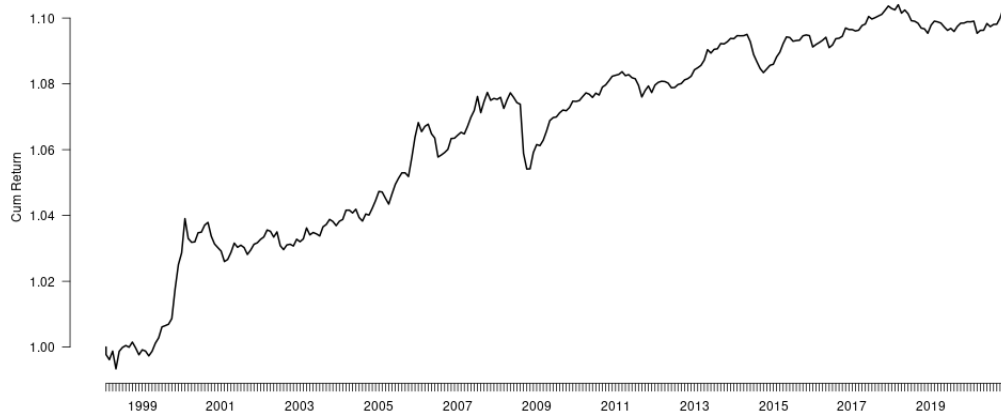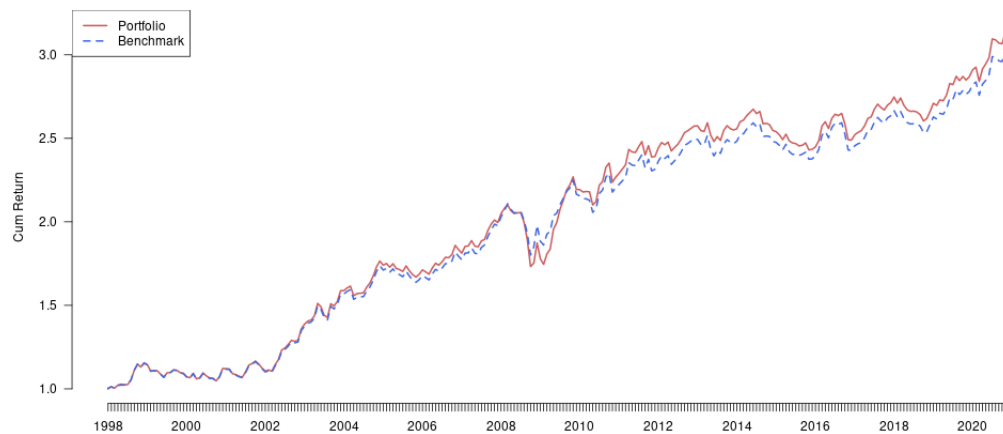Evolution of difference portfolio

Figure 3 Aggregate wealth, Fixed Income, USD

Evolution of portfolio and benchmark
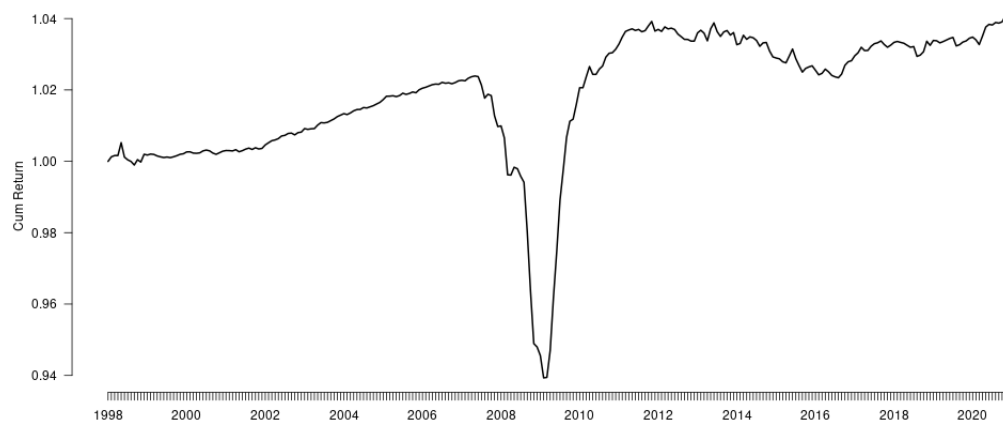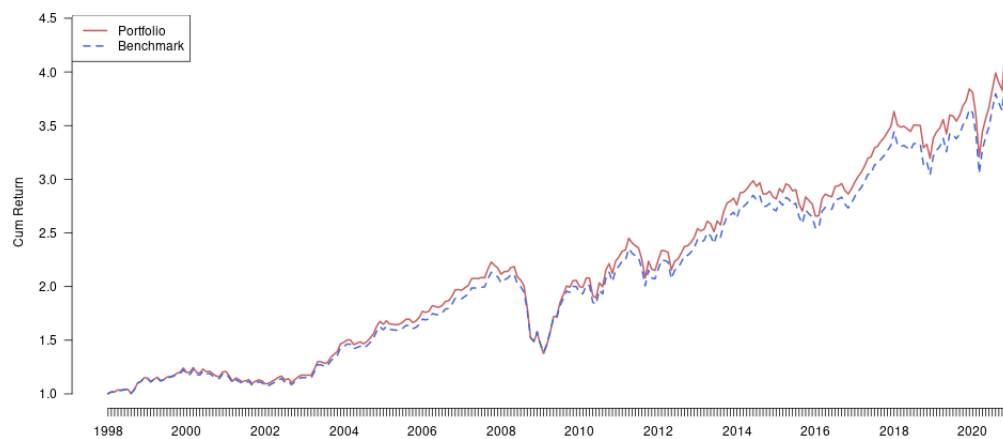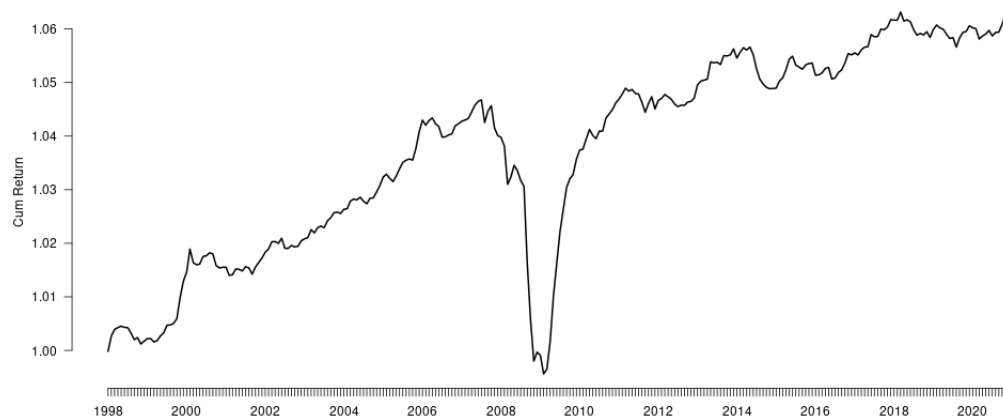

Evolution of difference portfolio

Figure 4 Aggregate wealth, Total, USD

Evolution of portfolio and benchmark

Evolution of difference portfolio

3 Alpha estimation

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

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

Here r_{pt} is the portfolio return, r_{ft} the risk free rate, r_{mt} the return on a market portfolio, and SMB_t and HML_t are the two Fama French factors on market size and book to market.

	Dependent variable:
	eRp
Constant	−0.0005
	(0.0004)
RMRF	1.059***
	(0.008)
SMB	−0.045**
	(0.018)
HML	0.067***
	(0.013)
Observations	275
Adjusted R^2	0.986
Note:	*p<0.1; **p<0.05; ***p<0.01

```
library(xts)
library(stargazer)
source ("~/data/2021/french_global_data/read_global_3_pricing_factors.R")
source ("../2021_06_read_current/read_nbim_USD_returns_from_excel.R")
outdir <- "../../results/2021_06_alpha_estimation/"

data <- merge(Equity_Rets_USD,RF,RMRF,SMB,HML,all=FALSE)
Rp   <- data$Equity_Rets_USD
eRp  <- data$Equity_Rets_USD−data$RF
RMRF <- data$RMRF                                                          10
SMB  <- data$SMB
HML  <- data$HML

regr <- lm(eRp~RMRF+SMB+HML)

filename <- paste0(outdir,"alpha_estimation_equity_USD_whole_period_three_factor_model.tex")
stargazer(regr,
        no.space=TRUE,
        model.numbers=FALSE,
        float=FALSE,                                                      20
        align=TRUE,
        digits=3,
        intercept.top=TRUE,
        intercept.bottom=FALSE,
        out=filename,
        omit.stat=c("rsq","f","ser")
        )
```

References

Magnus Dahlquist and Bernt Arne Ødegaard. A review of norges bank's active management of the government pension fund global. Technical report, January 2018. URL https://www.regjeringen.no/no/aktuelt/ekspertrapporter-om-spu/id2585465/. Report to Norwegian Ministry of Finance.