



UNIVERSITY OF WASHINGTON

CFRM 462 - COMPUTATIONAL FINANCE AND FINANCIAL ECONOMETRICS

Equity Portfolio Optimization

A MUTUAL FUND ASSET ALLOCATION PROJECT

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Executive Summary

Contents

Executive Summary	i
1 Introduction	1
Dataset Description	1
VFINX - S&P 500 Index Fund	1
VEURX - European Stock Index Fund	1
VEIEX - Emerging Markets Index Fund	1
VBLTX - Long-Term Bond Index Fund	2
VBISX - Short-Term Bond Index Fund	2
VPACX - Pacific Stock Index Fund	2
2 Analysis	3
Fund Returns Analysis	3
A Project Source Code	5
Initialization and Constants	5
Helper Functions	5
Downloading and Exporting Price Data	6
References	8

Chapter 1

Introduction

Dataset Description

VFINX - S&P 500 Index Fund

The Vanguard 500 Index Fund¹ (VFINX) is an ETF that invests in 500 of the largest U.S. companies. These companies span many different industries, and thus provides investors with full exposure to the domestic stock market. The fund focuses on large-capitalization companies that encompass nearly 75% of the U.S. equity market. The fund treats the Standard & Poor's 500² as its benchmark, and thus acts as a measurement of overall stock market performance.

VEURX - European Stock Index Fund

The Vanguard European Stock Index Fund³ (VEURX) is an ETF that provides investors with exposure to the major stock markets of Europe. The fund holds positions in approximately 1,200 securities across European markets, which represents nearly half of global (non U.S.) equity. In addition to systematic risk, this fund is also exposed to currency risk, and may have significant regional risk as all markets in which the fund invests in are located in Europe. This fund treated the MSCI Europe Index⁴ as its benchmark through March 26, 2013, but has used the FTSE Developed Europe Index⁵ as its benchmark thereafter.

VEIEX - Emerging Markets Index Fund

The Vanguard Emerging Markets Stock Index Fund⁶ (VEIEX) is an ETF that provides investors with exposure to emerging markets around the world including but not limited to: Brazil, Russia, India and China. As emerging markets tend to be more volatile, this fund has the potential for higher returns, but with considerably higher risk. Similar to the European Stock Index Fund, the returns of this fund too are exposed to significant currency risk. This fund treated the FTSE Emerging Index⁷ as its benchmark through November 2, 2015, but has since switched to the FTSE Emerging Markets All Cap China A Transition Index.⁸

¹ The Vanguard Group Inc. (2016a)

² S&P Dow Jones Indices LLC (2016)

³ The Vanguard Group Inc. (2016c)

⁴ MSCI Inc. (2016a)

⁵ FTSE Russell (2016c)

⁶ The Vanguard Group Inc. (2016b)

⁷ FTSE Russell (2016e)

⁸ FTSE Russell (2016d)

VBLTX - Long-Term Bond Index Fund

The Vanguard Long-Term Bond Index Fund⁹ (VBLTX) is an ETF that provides investors with exposure to long-term bond investments. This fund holds positions in both corporate and U.S. Government bonds with a maturity of 10 years or more. However, due to the fact that long-term bonds are highly exposed to price fluctuations caused by changing interest rate, which is attributable to the high duration and convexity of the underlying long-term bonds. This fund used the Barclays U.S. Long Government Float Adjusted Index¹⁰ as its benchmark through December 31, 2009, but has since switched to the Barclays U.S. Long Government/Credit Float Adjusted Index.¹¹

VBISX - Short-Term Bond Index Fund

The Vanguard Short-Term Bond Index Fund¹² (VBISX) is an ETF that provides investors with exposure to a diversified portfolio of short-term bonds. This fund holds positions in both corporate and U.S. Government short-term bonds with maturities of 1 to 5 years. Due to the fact that short-term bonds have low duration and convexity, investors can expect minimal price movement with relation to interest rates from this fund, and thus lower yield. This fund uses the Barclays U.S. Government/Credit Float Adjusted 1-5 Year Index¹³ as its benchmark.

VPACX - Pacific Stock Index Fund

The Vanguard Pacific Stock Index Fund¹⁴ (VPACX) is an ETF that provides investors with exposure to a diversified portfolio of securities in markets of developed nations in the Pacific region. The fund holds positions in over 2,000 securities across the Pacific, with the bulk of them being located in Japan. This investment pool represents approximately a quarter of the global (non U.S.) equity market capitalization. The fund initially used the MSCI Pacific Index¹⁵ as its benchmark until March 26, 2013, before switching to the FTSE Developed Asia Pacific Index¹⁶ through September 30, 2015, until finally switching to the FTSE Developed Asia Pacific All Cap Index,¹⁷ which it uses today.

⁹ The Vanguard Group Inc. (2016d)

¹⁰ Index Portfolio and Risk Solutions Group (IPRS) (2015b)

¹¹ Index Portfolio and Risk Solutions Group (IPRS) (2015c)

¹² The Vanguard Group Inc. (2016f)

¹³ Index Portfolio and Risk Solutions Group (IPRS) (2015a)

¹⁴ The Vanguard Group Inc. (2016e)

¹⁵ MSCI Inc. (2016b)

¹⁶ FTSE Russell (2016b)

¹⁷ FTSE Russell (2016a)

Chapter 2

Analysis

Fund Returns Analysis

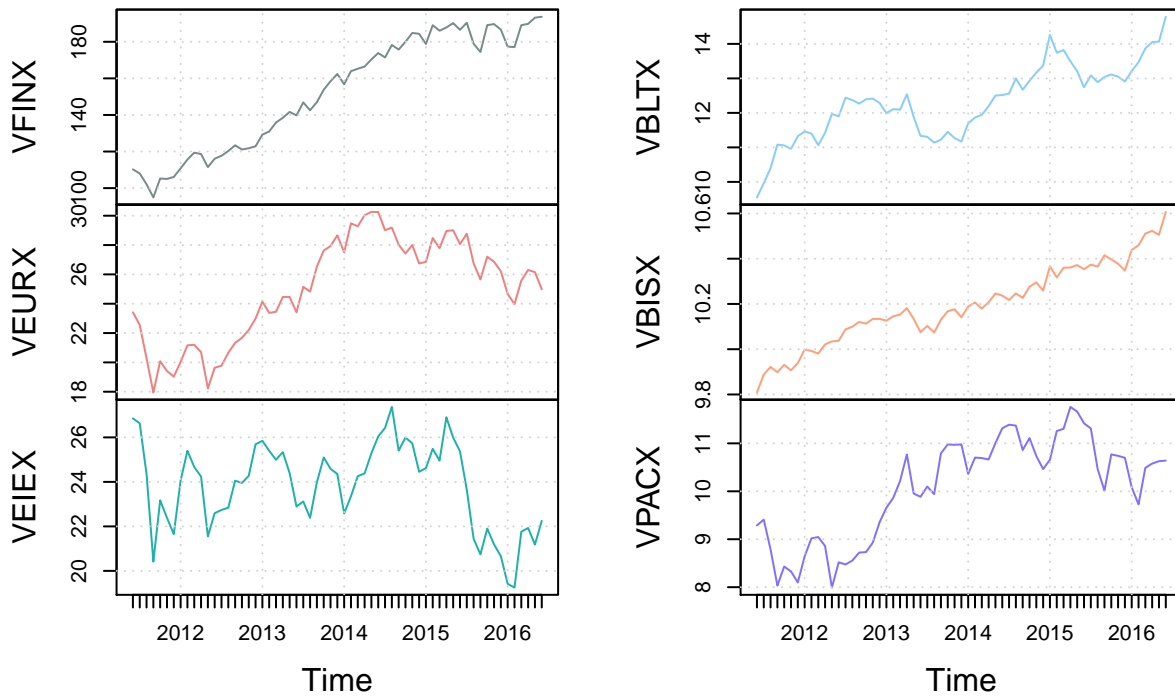


Figure 1: Time plot of fund prices

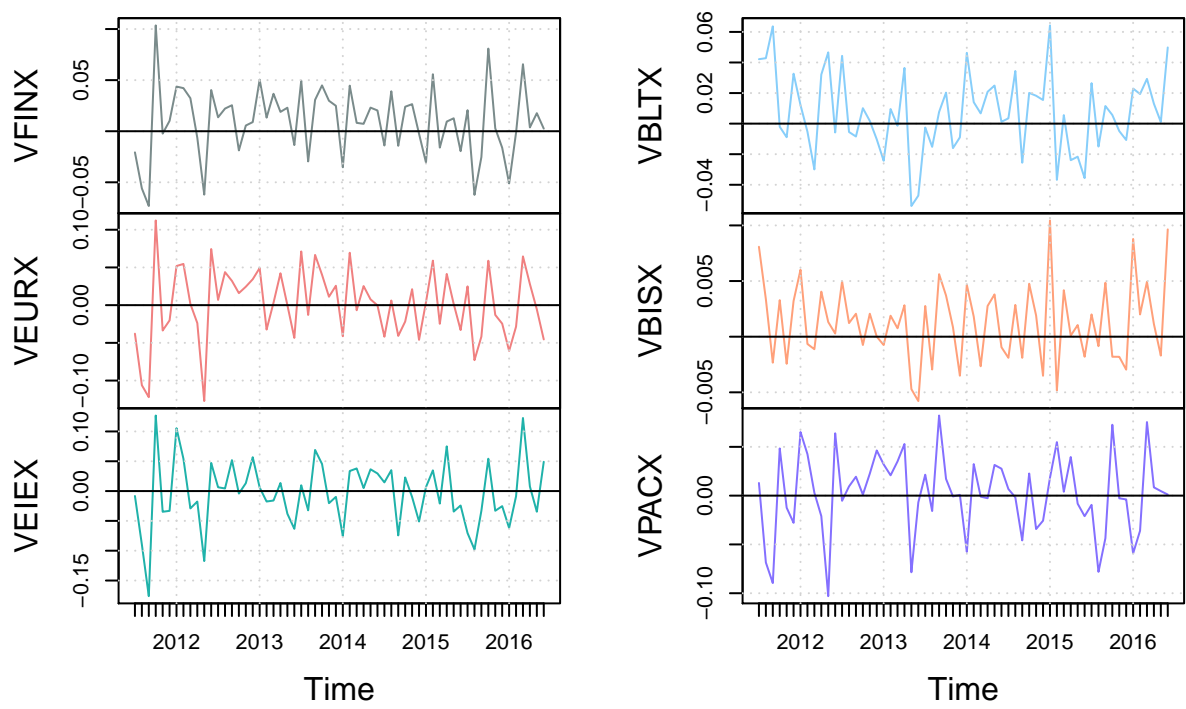


Figure 2: Time plot of fund continuously compounded returns

Appendix A

Project Source Code

Initialization and Constants

```
library(boot)
library(captioner)
library(IntroCompFinR)
library(knitr)
library(PerformanceAnalytics)
library(tseries)
library(xlsx)

# Captioner setup
figures <- captioner(prefix = "Figure")
tables <- captioner(prefix = "Table")

# Constants
asset.names <- c("VFINX", "VEURX", "VEIEX", "VBLTX", "VBISX", "VPACX")
asset.colors <- c("lightcyan4", "lightcoral", "lightseagreen", "lightskyblue",
  "lightsalmon", "lightslateblue")
export.pricedata.name <- "price_data.xlsx"
```

Helper Functions

```
# Function to add a figure caption to figures object
figures.add <- function(...) {
  figures(..., display = FALSE)
}

# Function to add a table caption to tables object
tables.add <- function(...) {
  tables(..., display = FALSE)
}

# Function to cite a figure
figures.cite <- function(figure.ref) {
```



```

    figures(figure.ref, display = "cite")
}

# Function to cite a table
tables.cite <- function(table.ref) {
    tables(table.ref, display = "cite")
}

# Function to get adjusted close prices from online services See
# ??get.hist.quote for more info/options
get.adjclose <- function(instrument, interval, start = "1800-01-01", end = Sys.date()) {
    prices <- get.hist.quote(instrument = instrument, quote = c("AdjClose"),
        start = start, end = end, compression = interval, retclass = "zoo")
    prices
}

```

Downloading and Exporting Price Data

```

# Defining date range
start.date <- "2011-06-01"
end.date <- "2016-06-30"

# Getting adjusted close prices for each of the securities
vfinx.adjclose <- get.adjclose("VFINX", "m", start.date, end.date)
veurx.adjclose <- get.adjclose("VEURX", "m", start.date, end.date)
veiex.adjclose <- get.adjclose("VEIEX", "m", start.date, end.date)
vbltx.adjclose <- get.adjclose("VBLTX", "m", start.date, end.date)
vbisx.adjclose <- get.adjclose("VBISX", "m", start.date, end.date)
vpacx.adjclose <- get.adjclose("VPACX", "m", start.date, end.date)

# Changing class of index to yearmon, which is ideal for monthly data
index(vfinx.adjclose) <- as.yearmon(index(vfinx.adjclose))
index(veurx.adjclose) <- as.yearmon(index(veurx.adjclose))
index(veiex.adjclose) <- as.yearmon(index(veiex.adjclose))
index(vbltx.adjclose) <- as.yearmon(index(vbltx.adjclose))
index(vbisx.adjclose) <- as.yearmon(index(vbisx.adjclose))
index(vpacx.adjclose) <- as.yearmon(index(vpacx.adjclose))

# Merging price data
prices <- merge(vfinx.adjclose, veurx.adjclose, veiex.adjclose, vbltx.adjclose,
    vbisx.adjclose, vpacx.adjclose)
colnames(prices) <- asset.names

# Computing continuously compounded returns, and casting to different
# types for function compatibility
ret.z <- diff(log(prices)) # Type 'zoo'
ret.mat <- coredata(ret.z) # Type 'matrix'
ret.df <- as.data.frame(coredata(ret.z)) # Type 'dataframe'

# Computing simple returns
ret.simple.z <- exp(ret.z) - 1

```

```

# Check if output Excel file exists, if so delete
if (file.exists(export.pricedata.name)) {
  file.remove(export.pricedata.name)
}

# Loop through each asset, and export price, simple and geometric
# return to separate sheets in an Excel file
for (i in seq_along(asset.names)) {
  simple.ret = exp(ret.df[, i]) - 1
  export.data.names <- c("Adjusted Close", "Simple Return", "Continuously Compounded Return")
  export.data = data.frame(prices[, i][-(1:1)], simple.ret, ret.df[,
    i])
  rownames(export.data) <- index(prices)[-(1:1)]
  colnames(export.data) <- export.data.names
  write.xlsx(export.data, file = export.pricedata.name, sheetName = asset.names[i],
    append = TRUE)
}

```

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