Computer exercise - Market and Systemic Risk Management

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Introduction

This is the computational appendix with the analysis made for the Financial Report at the Pokè Bank Johto Region regarding the investment in the Rocket S.A. portfolio.

Dependency installation

```r
rm(list=ls())        # Clean memory

# Verify if a package is installed, if not, download and install before loading.
chooseCRANmirror(graphics = FALSE, ind = 10)
if (!require("pacman")) install.packages("pacman")
pacman::p_load(reshape2, ggplot2, latex2exp, gridExtra, readxl,
               RColorBrewer, grid, knitr, zoo, scales, evir)

# Shapper is a wrapper for the Python package with the Shap values.
# In case you don't have it on Python, you need to install running the following line
#shapper::install_shap()
```

```r
# Prevents code from getting out of the page
## Works with almost everything except urls and strings.
## Last options hold the position of figures
opts_chunk$set(tidy.opts=list(width.cutoff=50),tidy=TRUE, fig.pos = "!H", out.extra = "")

# Set a seed
set.seed(6969)

# Choosing a color palette
cores <- brewer.pal(8, "Dark2")

# Set a working directory
setwd("C:\\Users\\aisha\\OneDrive\\Documentos\\Mestrado Tinbergen\\Year 2\\Block 05\\Market and Systemi
```

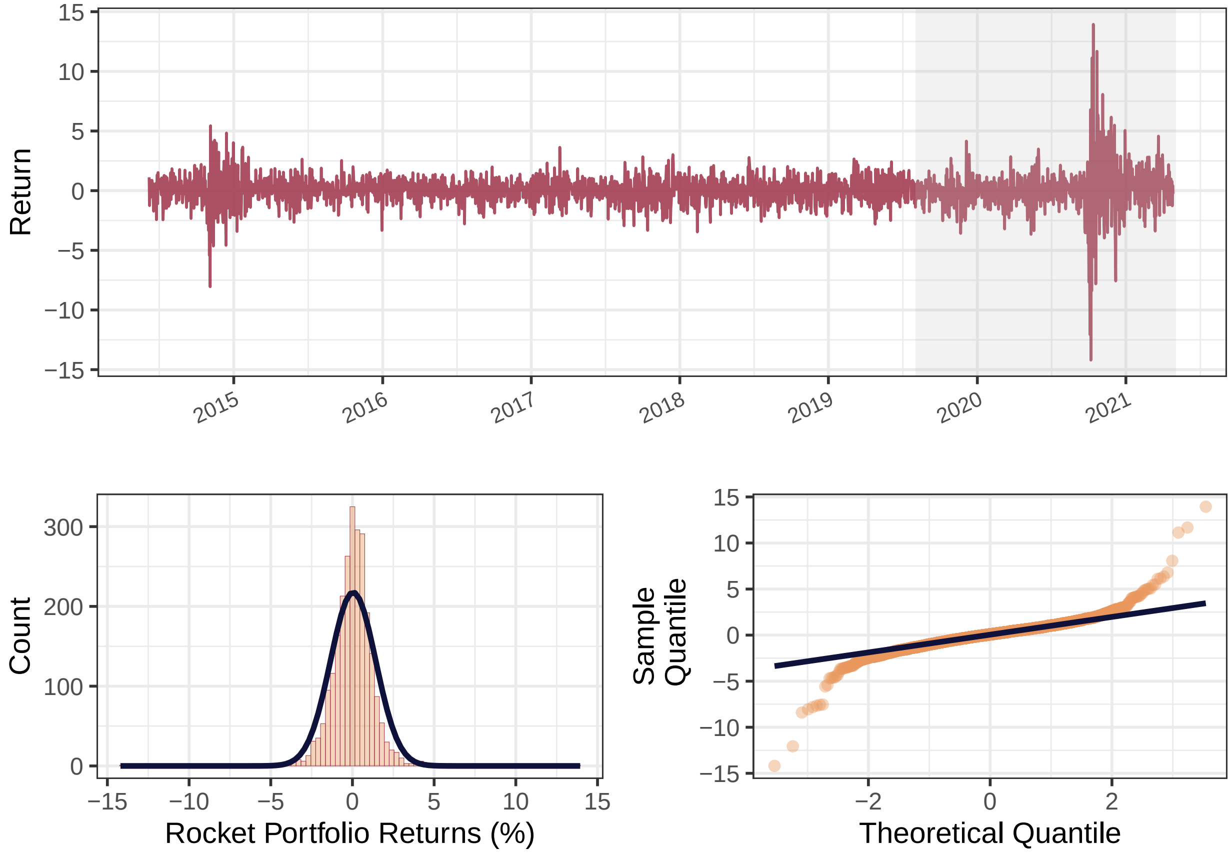
Data preparation

```
url <- "https://raw.githubusercontent.com/aishameriane/SystemicRisk/main/data.csv"
dfData01 <- read.csv2(url, sep = ",", dec = ".", header = TRUE)
dfData01 <- dfData01[, c("Market", "Schmidt")]

ending <- as.Date("2021-06-25")
# Had to cut one day to make vectors with the same
# size
starting <- as.Date(as.Date("2021-06-25") - 2516)
Date <- as.Date(starting:ending, origin = starting)


Date <- seq(starting, ending, by = "1 days")
dfData01 <- cbind(Date, dfData01)
```

Exploring data for heavy tails

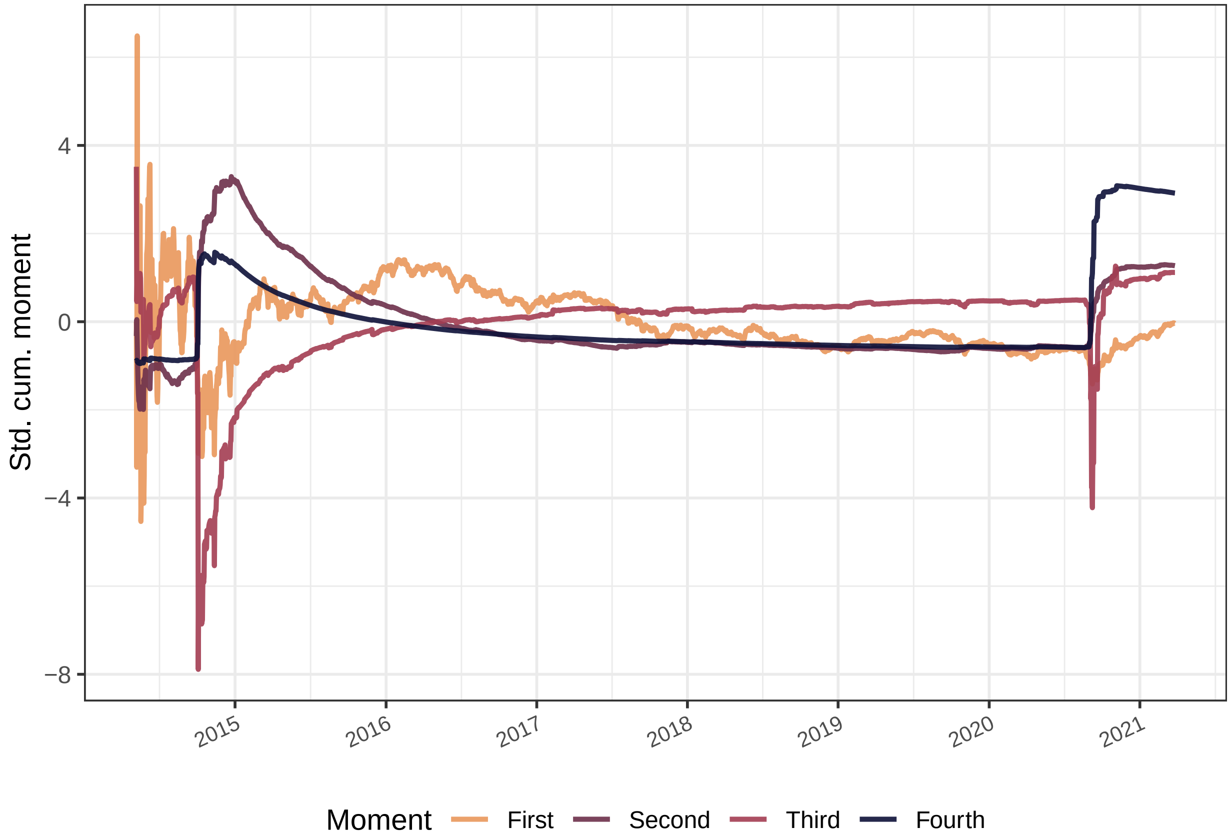
```
# Data from recessions available at:
# https://eabcn.org/dc/chronology-euro-area-business-cycles
recessions_1 <- c("2019Q4")

recessions_2 <- c("2021Q3")

recessions.trim <- data.frame(1, 1, 1, as.Date(as.yearqtr(recessions_1)),
    as.Date(as.yearqtr(recessions_2)))
names(recessions.trim) <- c("DATE", "Variable", "Value",
    "Peak", "Trough")


dfData02 <- melt(dfData01, id.vars = "Date")
names(dfData02) <- c("DATE", "Variable", "Value")

p0 <- ggplot(dfData02[which(dfData02$Variable == "Schmidt"),
    ]) + geom_line(aes(x = DATE, y = Value, color = Variable),
    alpha = 0.9) + labs(y = "Return", x = "", color = "Series") +
    scale_x_date(date_breaks = "12 months", labels = date_format("%Y")) +
    scale_colour_manual(values = c("#A43E53")) + theme_bw() +
    theme(axis.text.x = element_text(angle = 25, hjust = 1,
        size = 8), legend.position = "none", axis.title.x = element_blank(),
        plot.margin = unit(c(0.1, 0.2, 0.05, 0.2),
            "cm")) + geom_rect(data = recessions.trim,
    aes(xmin = Peak, xmax = Trough, ymin = -Inf, ymax = +Inf),
    fill = "grey", alpha = 0.2)

# Plot a histogram with a normal density
# overlapping Source:
# https://stackoverflow.com/questions/6967664/ggplot2-histogram-with-normal-curve
n <- nrow(dfData01)
mean <- mean(dfData01[, "Schmidt"])
sd <- sd(dfData01[, "Schmidt"])
binwidth <- 0.3
```

```
df <- data.frame(x = rnorm(n, mean, sd))
dfData03 <- cbind(dfData01, df)

p1 <- ggplot(dfData03, aes(x = Schmidt, mean = mean,
    sd = sd, binwidth = binwidth, n = n)) + geom_histogram(binwidth = binwidth,
    colour = "#A43E53", fill = "#E9975C", size = 0.1,
    alpha = 0.4) + stat_function(fun = function(x) dnorm(x,
    mean = mean, sd = sd) * n * binwidth, color = "#0E1139",
    size = 1) + labs(title = "", y = "Count", x = "Rocket Portfolio Returns (%)") +
    theme(axis.text.x = element_text(size = 6), axis.title.x = element_text(size = 6),
        axis.text.y = element_text(size = 6), axis.title.y = element_text(size = 6),
        plot.margin = unit(c(-1, -0.5, -2, -0.5), "cm")) +
    theme_bw()

# Make a QQplot
p2 <- ggplot(dfData01, aes(sample = Schmidt)) + stat_qq(colour = "#E9975C",
    fill = "#E9975C", size = 1.5, alpha = 0.4) + stat_qq_line(color = "#0E1139",
    size = 1) + labs(title = "", y = "Sample\n Quantile",
    x = "Theoretical Quantile") + theme(axis.text.x = element_text(size = 6),
    axis.title.x = element_text(size = 6), axis.text.y = element_text(size = 6),
    axis.title.y = element_text(size = 6), plot.margin = unit(c(-1,
        -0.5, -2, -0.5), "cm")) + theme_bw()

# png(file = 'Series_01.png', width = 450, height =
# 300)
grid.arrange(p0, grid.arrange(p1, p2, nrow = 1), nrow = 2)
```



```
# dev.off()

# Cumulative moment plot
dfMoment <- data.frame(matrix(NA, ncol = 5, nrow = nrow(dfData01)))
names(dfMoment) <- c("Date", "First", "Second", "Third",
    "Fourth")

# This will compute the cumulative moments
# (centered on zero) up to order k
for (k in 1:4) {
    for (i in 1:nrow(dfData01)) {
        dfMoment[i, k + 1] <- mean(dfData01$Schmidt[1:i]^k)
    }
}

dfMoment$Date <- dfData01$Date
dfMomentstd <- dfMoment

for (j in 2:5) {
    dfMomentstd[, j] <- (dfMoment[, j] - mean(dfMoment[,
        j]))/sd(dfMoment[, j])
}

dfMomentstd[1, 2] <- 0

dfData02 <- melt(dfMomentstd, id.vars = "Date")
```

```r
names(dfData02) <- c("DATE", "Variable", "Value")

p3 <- ggplot(dfData02) + geom_line(aes(x = DATE, y = Value,
    color = Variable), alpha = 0.9, size = 0.9) + labs(y = "Std. cum. moment",
    x = "", color = "Moment") + scale_x_date(date_breaks = "12 months",
    labels = date_format("%Y")) + scale_colour_manual(values = c("#E9975C",
    "#6D304B", "#A43E53", "#0E1139"), labels = c("First",
    "Second", "Third", "Fourth")) + theme_bw() + theme(axis.text.x = element_text(angle = 25,
    hjust = 1, size = 8), legend.position = "bottom",
    axis.title.x = element_blank(), plot.margin = unit(c(0.1,
        0.2, 0.05, 0.2), "cm"))

# png(file = 'Series_02.png', width = 450, height =
# 150)
p3
```



```r
# dev.off

sd(dfData01$Schmidt)
```

```
## [1] 1.383581
```

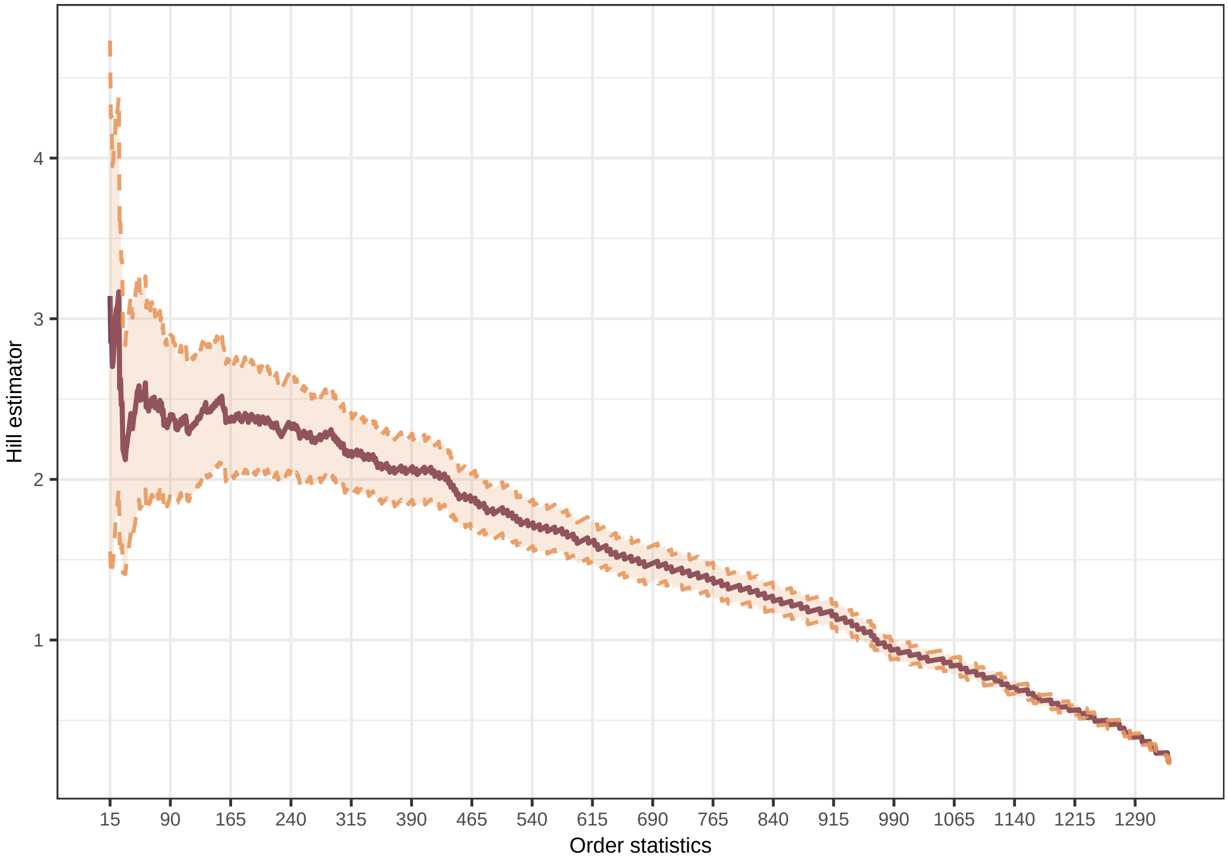
```r
mean(dfData01$Schmidt)
```

```
## [1] 0.04111641
```

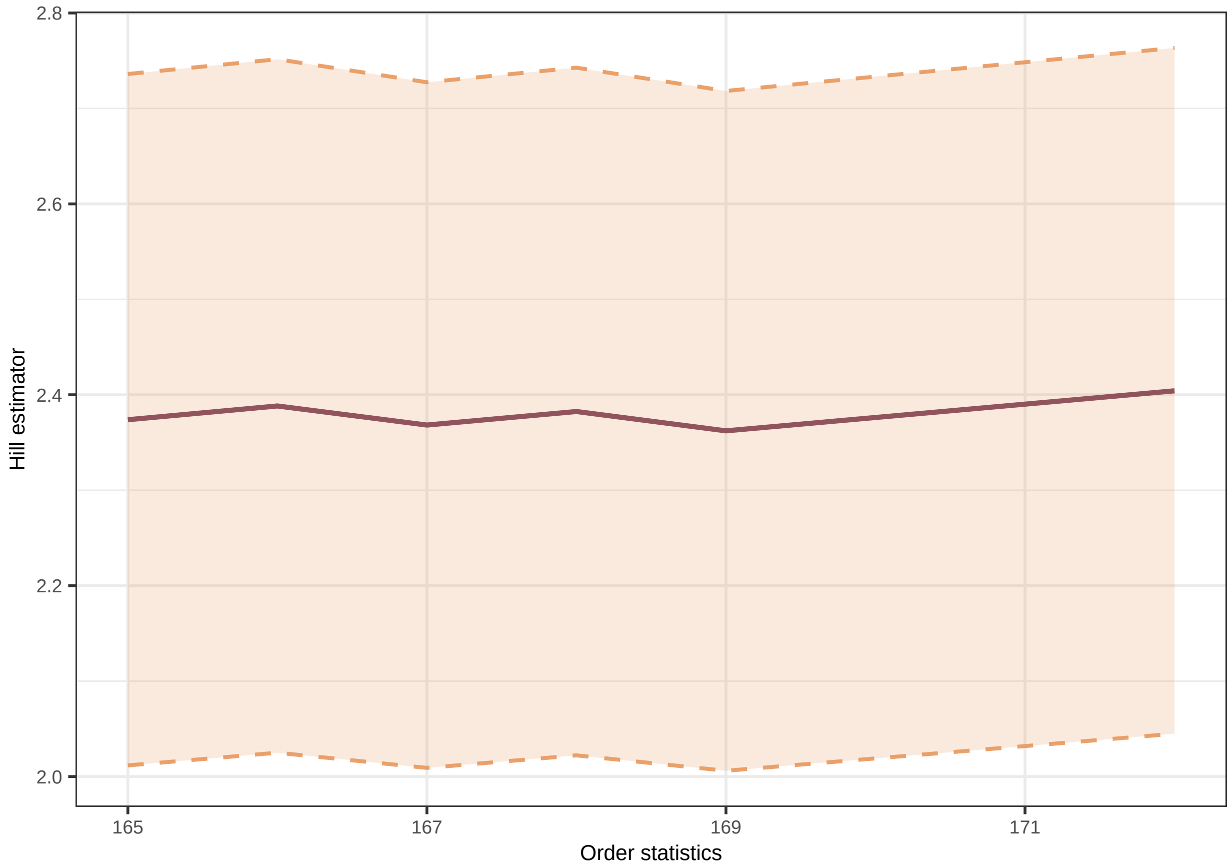
Question 1 - what is the maximum amount of asset (in mln USD) that can be invested in the risky portfolio?

- Regulator: with holding the invested portfolio for 100 days, the Value-at-Risk (VaR) at 99.9% level multiplied by a multiplier 3 has to be lower than the capital of the bank
- Capital of the bank 30 million

```r
# Computes the Hill estimator Reference:
# https://github.com/bpfaff/evir/blob/master/R/eda.R
# had to adapt so it will spit the confidence
# interval
fhill <- function(data, option = c("alpha", "xi", "quantile"),
    start = 15, end = NA, reverse = FALSE, p = NA,
    ci = 0.95, auto.scale = TRUE, labels = TRUE, plot = FALSE) {
    data <- as.numeric(data)
    ordered <- rev(sort(data))
    ordered <- ordered[ordered > 0]
    n <- length(ordered)
    option <- match.arg(option)
    if ((option == "quantile") && (is.na(p)))
        stop("Input a value for the probability p")
    if ((option == "quantile") && (p < 1 - start/n)) {
        cat("Graph may look strange !! \n\n")
        cat(paste("Suggestion 1: Increase `p' above",
            format(signif(1 - start/n, 5)), "\n"))
        cat(paste("Suggestion 2: Increase `start' above ",
            ceiling(length(data) * (1 - p)), "\n"))
    }

    k <- 1:n
    loggs <- logb(ordered)
    avesumlog <- cumsum(loggs)/(1:n)
    xihat <- c(NA, (avesumlog - loggs)[2:n])
    alphahat <- 1/xihat
    y <- switch(option, alpha = alphahat, xi = xihat,
        quantile = ordered * ((n * (1 - p))/k)^(-1/alphahat))
    ses <- y/sqrt(k)
    if (is.na(end))
        end <- n
    x <- trunc(seq(from = min(end, length(data)), to = start))
    y <- y[x]
    ylabel <- option
    yrange <- range(y)
    if (ci && (option != "quantile")) {
        qq <- qnorm(1 - (1 - ci)/2)
        u <- y + ses[x] * qq
        l <- y - ses[x] * qq
        ylabel <- paste(ylabel, " (CI, p =", ci, ")",
            sep = "")
        yrange <- range(u, l)
    }
    if (option == "quantile")
        ylabel <- paste("Quantile, p =", p)
    index <- x
    if (reverse)
        index <- -x
    if (plot == TRUE) {
        if (auto.scale)
            plot(index, y, ylim = yrange, type = "l",
                xlab = "", ylab = "", axes = FALSE,
                ...) else plot(index, y, type = "l", xlab = "",
            ylab = "", axes = FALSE, ...)
        axis(1, at = index, labels = paste(x), tick = FALSE)
        axis(2)
        threshold <- findthresh(data, x)
        axis(3, at = index, labels = paste(format(signif(threshold,
            3))), tick = FALSE)
        box()
        if (ci && (option != "quantile")) {
            lines(index, u, lty = 2, col = 2)
            lines(index, l, lty = 2, col = 2)
        }
        if (labels) {
            title(xlab = "Order Statistics", ylab = ylabel)
            mtext("Threshold", side = 3, line = 3)
        }
    }
    invisible(list(x = index, y = y, u = u, l = l))
}

lHill <- fhill(dfData01$Schmidt, option = c("alpha",
    "xi", "quantile"), start = 15, end = NA, reverse = FALSE,
    p = NA, ci = 0.95, auto.scale = TRUE, labels = TRUE,
    plot = FALSE)

dfHill <- data.frame(lHill$x, lHill$y, lHill$l, lHill$u)
names(dfHill) <- c("statistics", "Estimate", "Lower",
    "Upper")

p4 <- ggplot(dfHill, aes(x = statistics, y = Estimate)) +
    geom_line(aes(x = statistics, y = Estimate), colour = "#6D304B",
        alpha = 0.9, size = 0.9) + geom_line(aes(x = statistics,
    y = Lower), colour = "#E9975C", alpha = 0.9, size = 0.7,
    linetype = "dashed") + geom_line(aes(x = statistics,
    y = Upper), colour = "#E9975C", alpha = 0.9, size = 0.7,
    linetype = "dashed") + geom_ribbon(aes(ymin = Lower,
    ymax = Upper), fill = "#E9975C", alpha = 0.2) +
    scale_x_continuous(breaks = seq(from = min(dfHill$statistics),
        to = max(dfHill$statistics), by = 75)) + theme_bw() +
    labs(y = "Hill estimator", x = "Order statistics") +
    theme(axis.text.x = element_text(size = 7), axis.title.x = element_text(size = 8),
        axis.text.y = element_text(size = 7), axis.title.y = element_text(size = 8),
        plot.margin = unit(c(0.1, 0.2, 0.05, 0.2),
            "cm"), panel.grid.minor.x = element_blank())

# png(file = 'Series_03.png', width = 450, height =
# 150)
p4
```



```
# dev.off

lHill <- fhill(dfData01$Schmidt, option = c("alpha",
    "xi", "quantile"), start = 165, end = 172, reverse = FALSE,
    p = NA, ci = 0.95, auto.scale = TRUE, labels = TRUE,
    plot = FALSE)


dfHill <- data.frame(lHill$x, lHill$y, lHill$l, lHill$u)
names(dfHill) <- c("statistics", "Estimate", "Lower",
    "Upper")

p5 <- ggplot(dfHill, aes(x = statistics, y = Estimate)) +
    geom_line(aes(x = statistics, y = Estimate), colour = "#6D304B",
        alpha = 0.9, size = 0.9) + geom_line(aes(x = statistics,
    y = Lower), colour = "#E9975C", alpha = 0.9, size = 0.7,
    linetype = "dashed") + geom_line(aes(x = statistics,
    y = Upper), colour = "#E9975C", alpha = 0.9, size = 0.7,
    linetype = "dashed") + geom_ribbon(aes(ymin = Lower,
    ymax = Upper), fill = "#E9975C", alpha = 0.2) +
    scale_x_continuous(breaks = seq(from = min(dfHill$statistics),
        to = max(dfHill$statistics), by = 2)) + theme_bw() +
    labs(y = "Hill estimator", x = "Order statistics") +
    theme(axis.text.x = element_text(size = 7), axis.title.x = element_text(size = 8),
        axis.text.y = element_text(size = 7), axis.title.y = element_text(size = 8),
        plot.margin = unit(c(0.1, 0.2, 0.05, 0.2),
            "cm"), panel.grid.minor.x = element_blank())


# png(file = 'Series_04.png', width = 150, height =
# 75)
p5
```



```
# dev.off
```

```
kstar = 170
alphastar <- dfHill[which(dfHill$statistics == kstar),
    "Estimate"]
print(alphastar)
```

```
## [1] 2.376191
```