1	2	Σ
45	45	90/100

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Modellierung & Simulation I

Serie 10

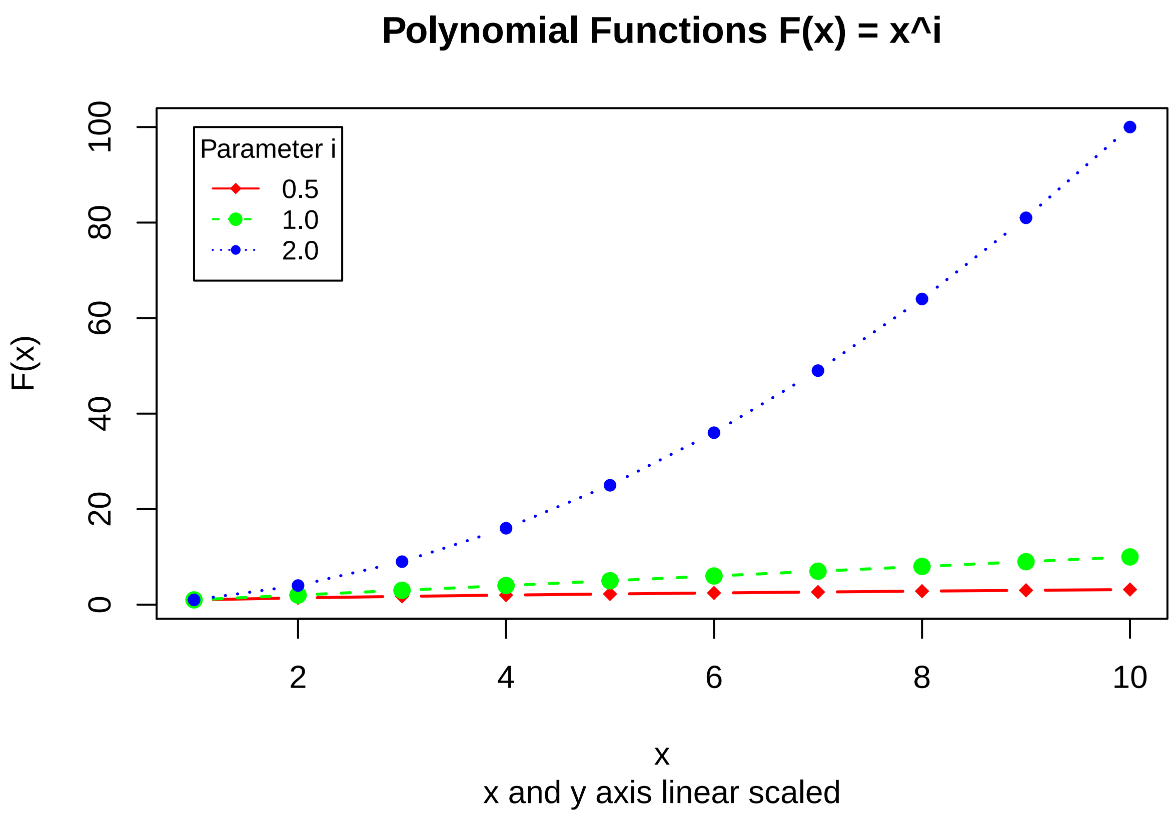
Problem 10.1

The code for this task can be found in "code_1_.Rmd". Knitr was used to generate a pdf with outputs from the notebook. Those follow on the next pages.

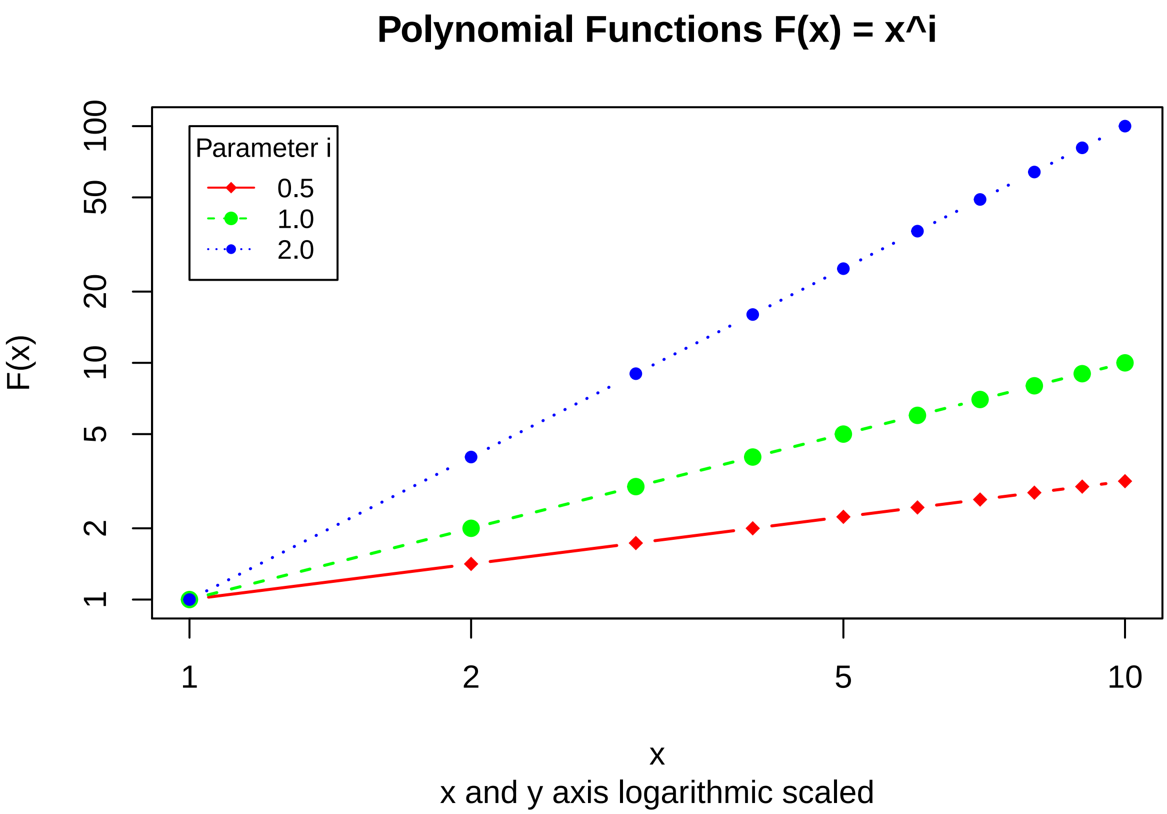
R Notebook Exercise 10.1

1. $F_i(x) = x^i, i \in \{0.5, 1, 2\}$

```
#x and y axis linear
x <- seq(1, 10, 1)

y1 <- x^0.5
y2 <- x^1
y3 <- x^2

xrange <- range(x)
yrange <- range(range(y1), range(y2), range(y3))

plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)" ) # set up the plot
colors <- rainbow(3)
linetype <- c(1:3)
plotchar <- seq(18,18+3,1)

lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Polynomial Functions F(x) = x^i", "x and y axis linear scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```



```r
#x and y axis logarithmic
plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)", log="xy") # set up the plot
lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Polynomial Functions F(x) = x^i", "x and y axis logarithmic scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```

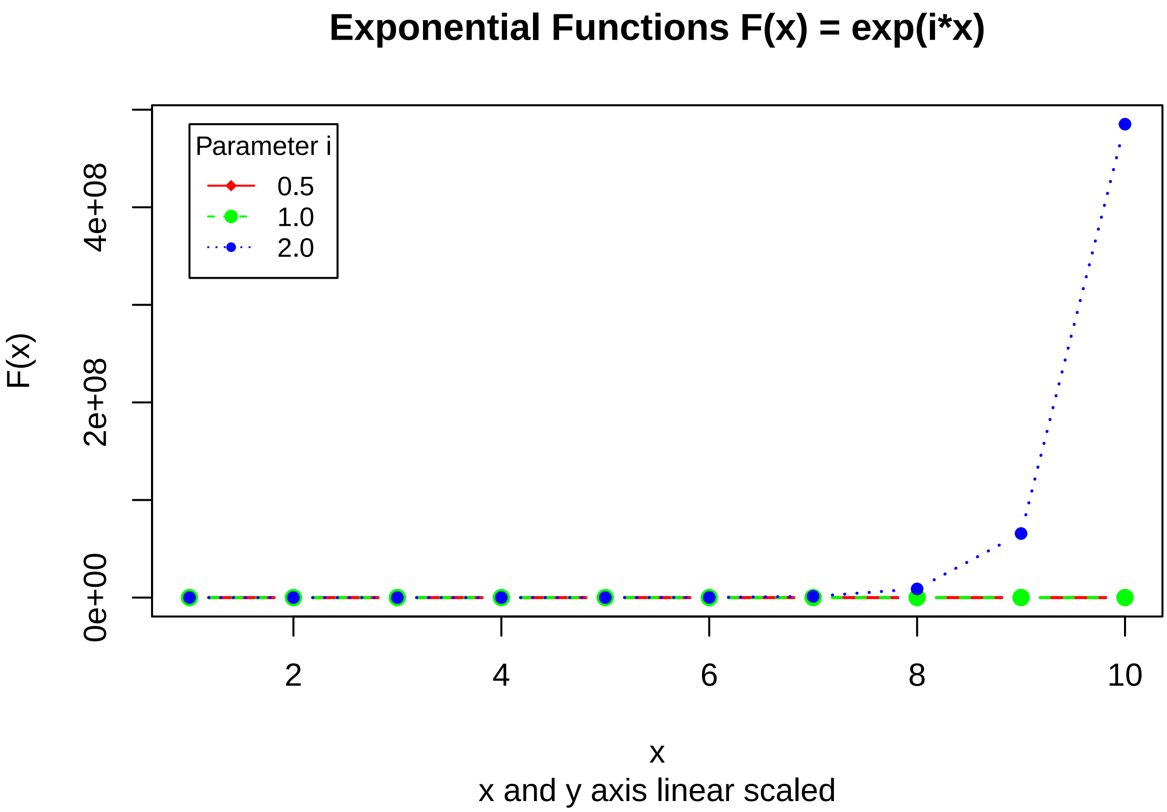


Because there is a polynomial dependency between $F(x)$ and x, the scaling of both axis leads to $\hat{x}(x) = ln(x)$ and $\hat{F}(x) = ln(F(x)) = ln(x^i) = i * ln(x) = i * \hat{x}(x)$. Therefor we get points $(\hat{x}(x), i * \hat{x}(x))$, which represents a straight line with slope i.

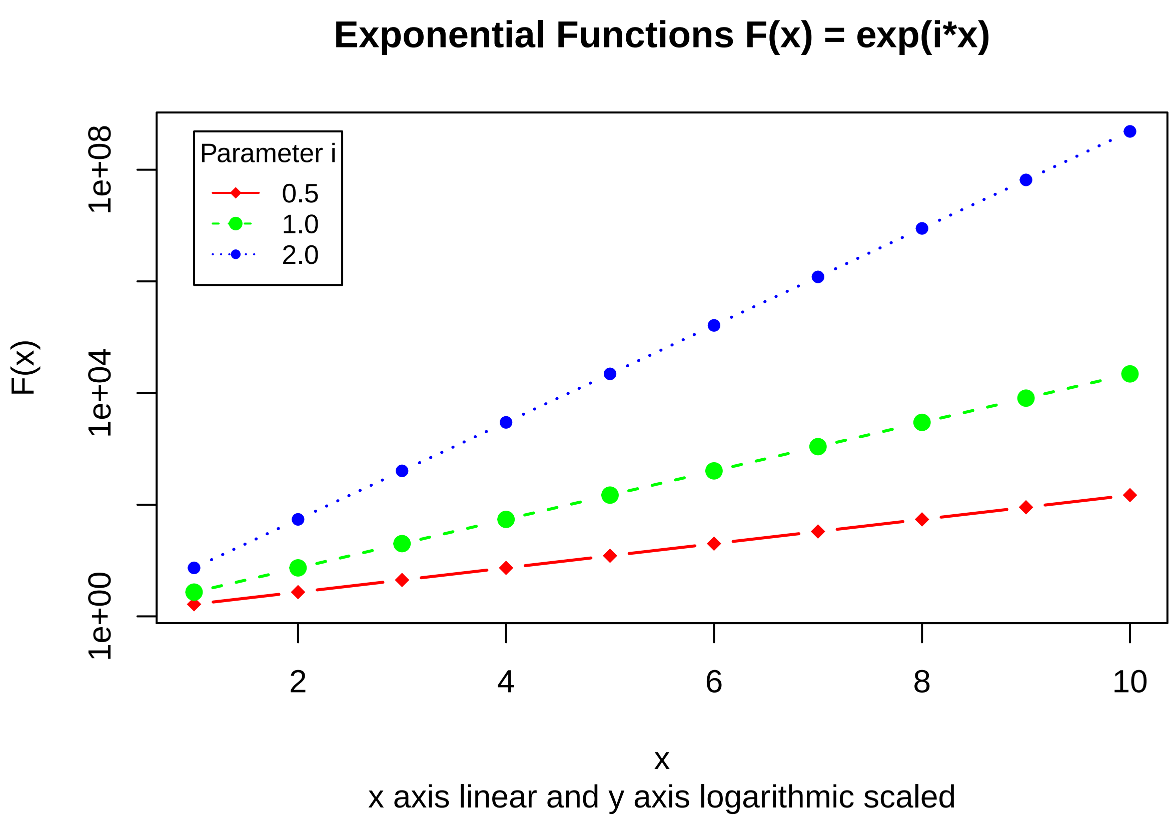
2. $F_i(x) = exp(i * x), i \in \{0.5, 1, 2\}$

```r
#x and y axis linear
x <- seq(1, 10, 1)

y1 <- exp(0.5*x)
y2 <- exp(1*x)
y3 <- exp(2*x)

xrange <- range(x)
yrange <- range(range(y1), range(y2), range(y3))

plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)" ) # set up the plot
colors <- rainbow(3)
```

```r
linetype <- c(1:3)
plotchar <- seq(18,18+3,1)

lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Exponential Functions F(x) = exp(i*x)", "x and y axis linear scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```



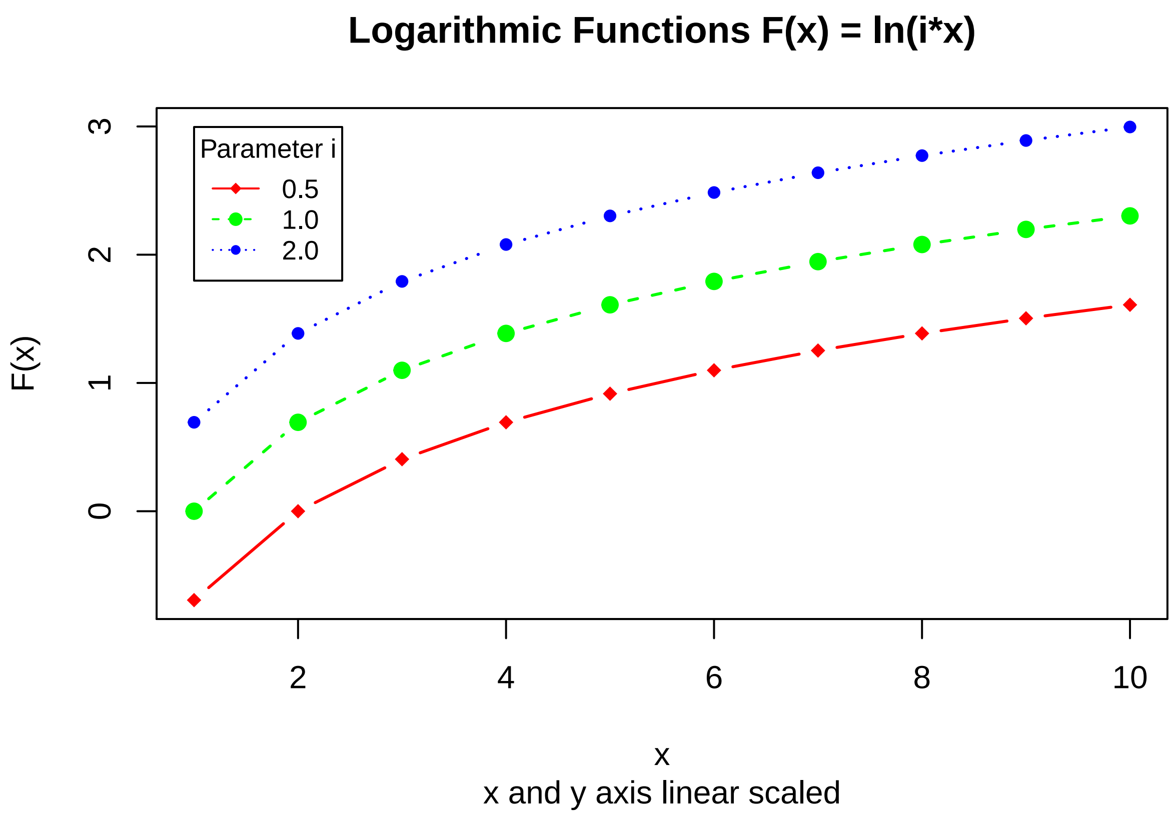

```r
#x axis linear and y axis logarithmic
plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)", log="y") # set up the plot
lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Exponential Functions F(x) = exp(i*x)", "x axis linear and y axis logarithmic scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```



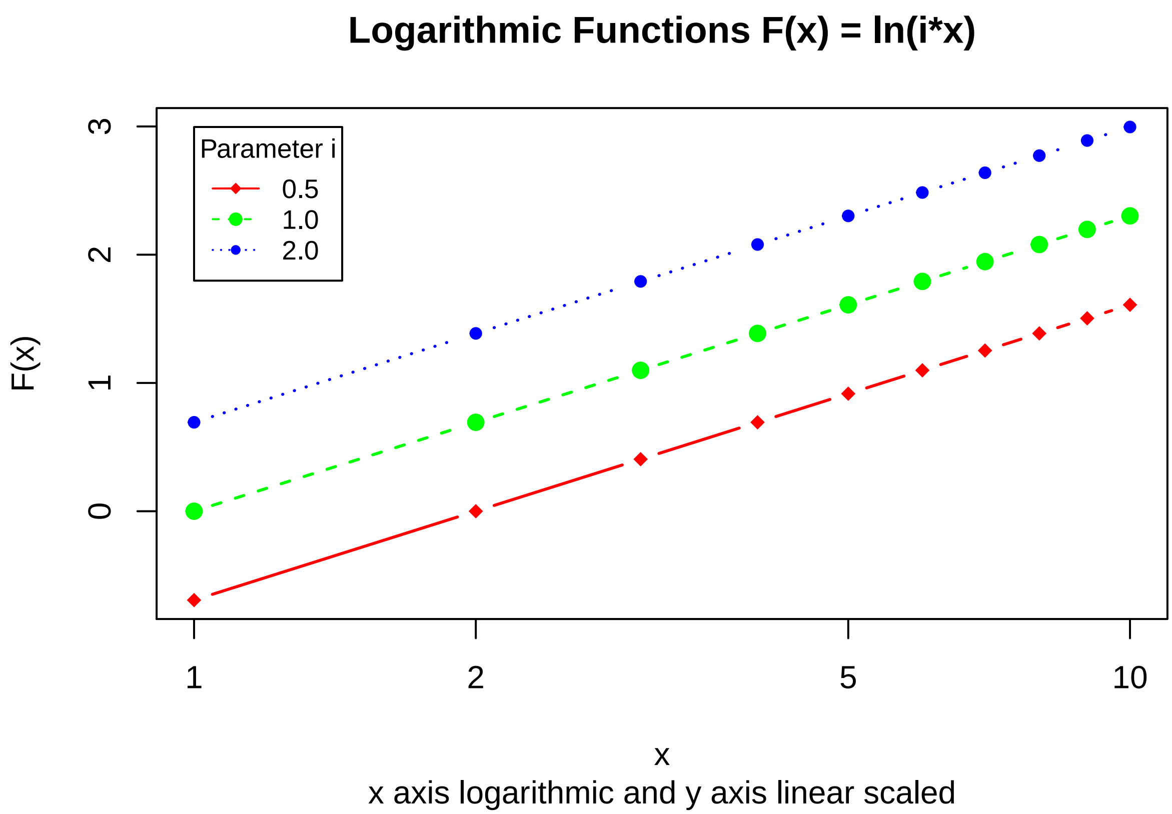
Because there is a exponential dependency between $F(x)$ and x, the logarithmic scaling of the y axis leads to $\hat{x}(x) = x$ and $\hat{F}(x) = ln(F(x)) = ln(exp(i*x)) = i*x = i*\hat{x}(x)$. Therefor we get points $(\hat{x}(x), i*\hat{x}(x))$, which represents a straight line with slope i.

3. $F_i(x) = ln(i*x), i \in \{0.5, 1, 2\}$

```
#x and y axis linear
x <- seq(1, 10, 1)

y1 <- log(0.5*x)
y2 <- log(1*x)
y3 <- log(2*x)

xrange <- range(x)
yrange <- range(range(y1), range(y2), range(y3))

plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)" ) # set up the plot
colors <- rainbow(3)
linetype <- c(1:3)
plotchar <- seq(18,18+3,1)

lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Logarithmic Functions F(x) = ln(i*x)", "x and y axis linear scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```




```r
#x axis logarithmic and y axis linear
plot(xrange, yrange, type="n", xlab="x",
     ylab="F(x)", log="x") # set up the plot
lines(x, y1, type="b", lwd=1.5, lty=linetype[1], col=colors[1], pch=plotchar[1])
lines(x, y2, type="b", lwd=1.5, lty=linetype[2], col=colors[2], pch=plotchar[2])
lines(x, y3, type="b", lwd=1.5, lty=linetype[3], col=colors[3], pch=plotchar[3])

title("Logarithmic Functions F(x) = ln(i*x)", "x axis logarithmic and y axis linear scaled")
legend(xrange[1], yrange[2], c("0.5", "1.0", "2.0"), cex=0.8, col=colors,
       pch=plotchar, lty=linetype, title="Parameter i")
```



Because there is a logarithmic dependency between $F(x)$ and x, the logarithmic scaling of the x axis leads to $\hat{x}(x) = ln(x)$ and $\hat{F}(x) = F(x) = ln(i * x) = ln(i) + ln(x) = ln(i) * \hat{x}(x)$. Therefor we get points $(\hat{x}(x), ln(i) + \hat{x}(x))$, which represents a straight line with unit slope and vertical offset i.

Problem 10.2.1

Please see provided code in "problem10-2.Rmd" or "problem10-2.nb.html".

Problem 10.2.2

Please see provided code in "problem10-2.Rmd" or "problem10-2.nb.html". There are also additional descriptions given in the notebook

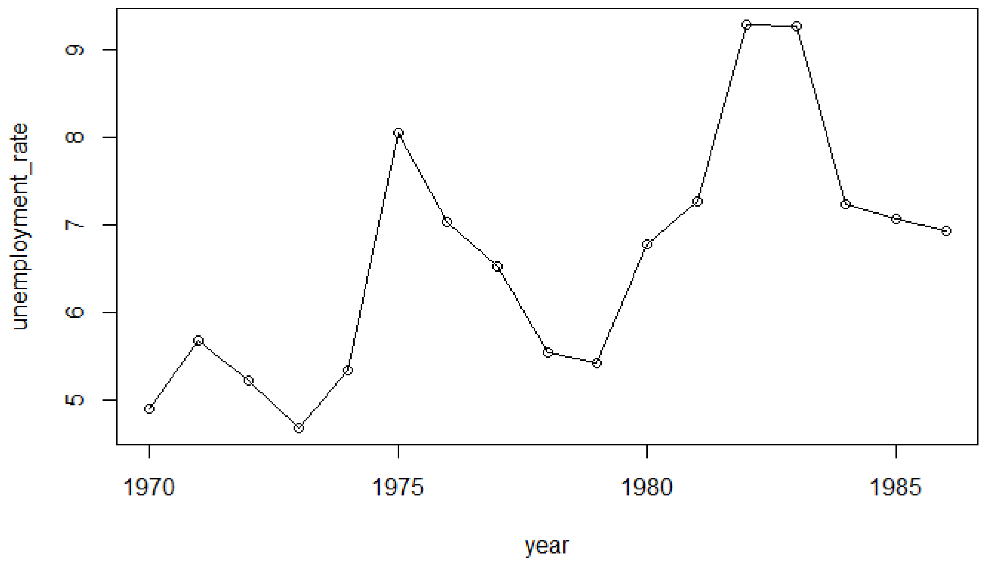
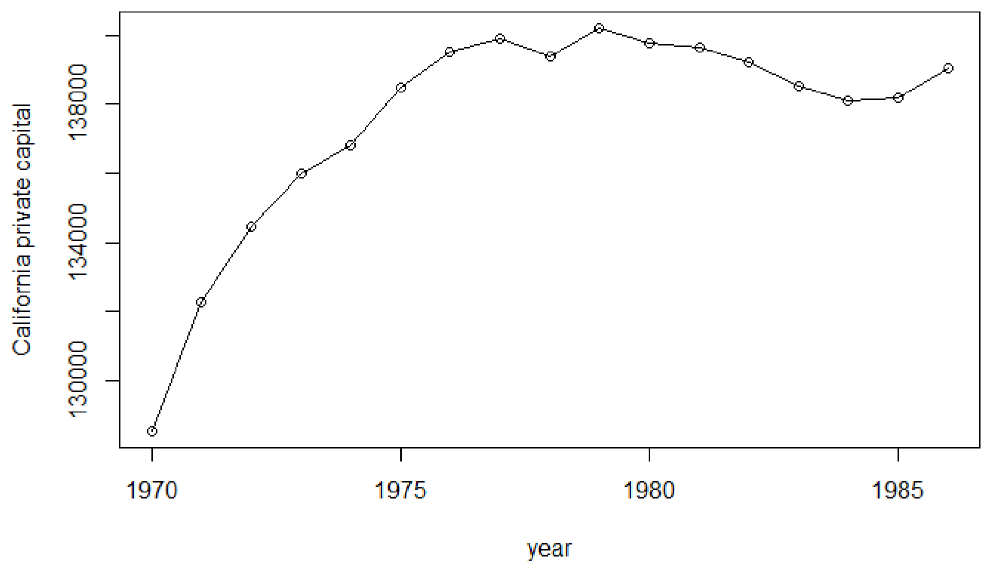
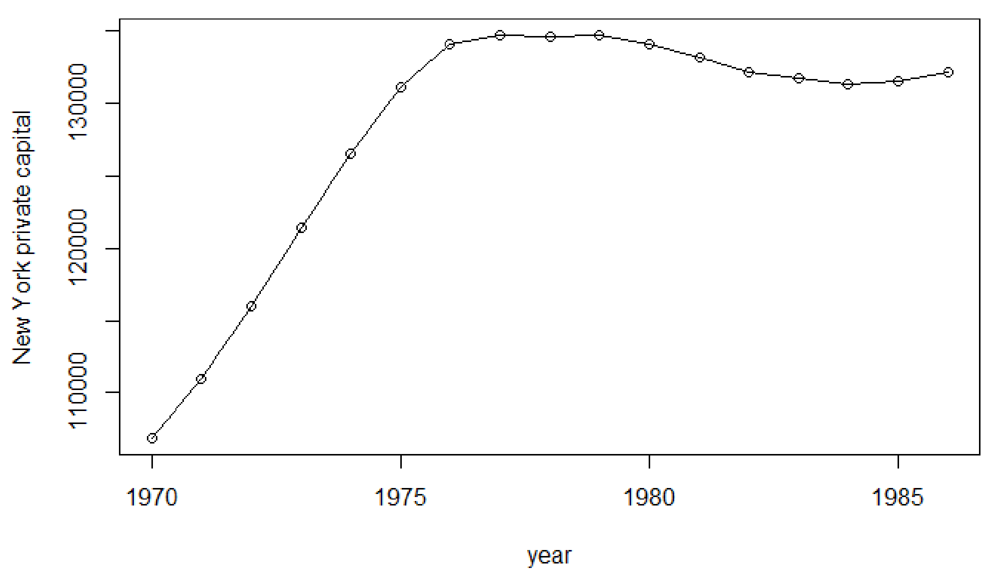
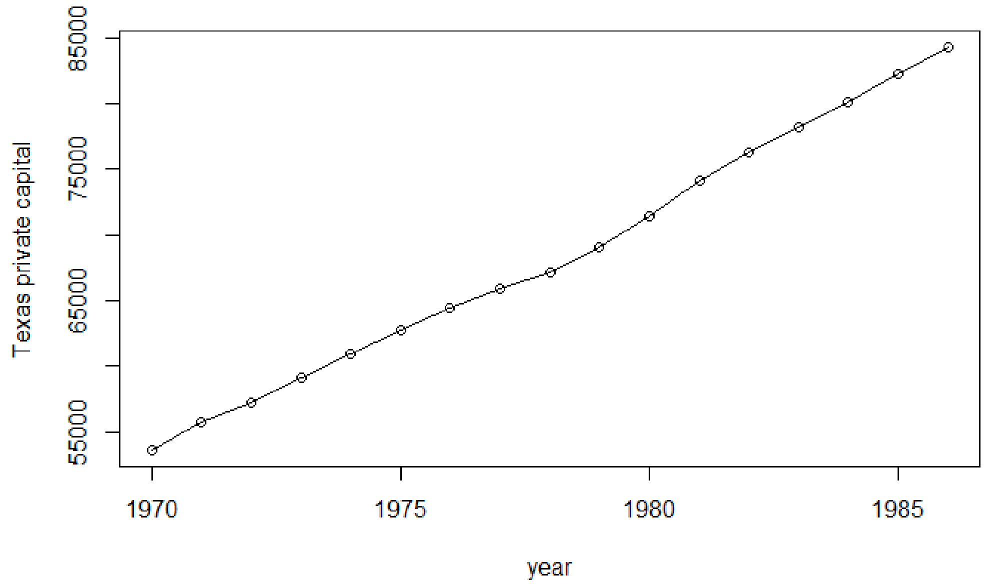


Figure 1: Unemployment rate for the united states

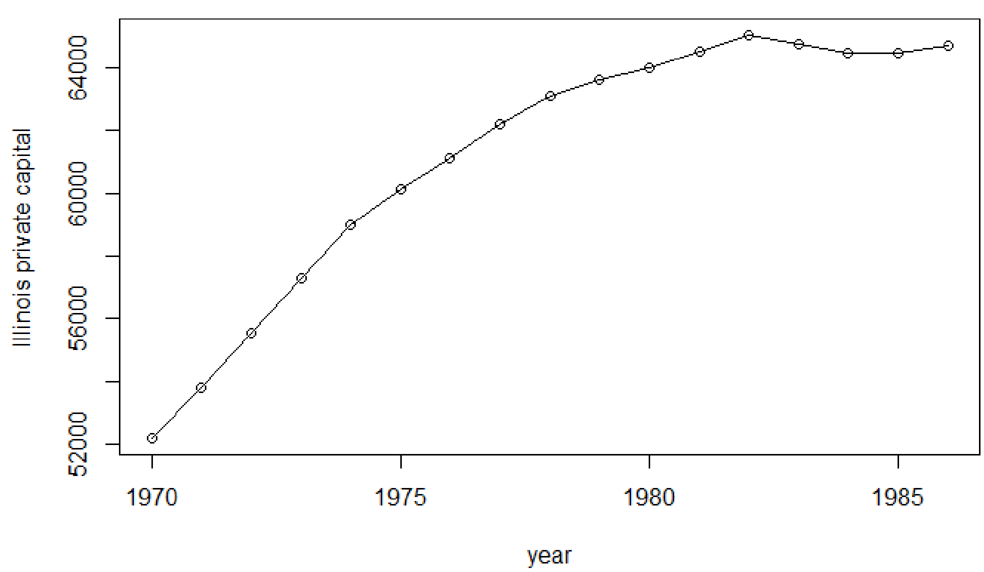
Sorting the dataset gives, that the states with the highest private capital in average are “California”, “New York”, “Texas”, “Illinois” and “Pennsylvania”:


California private capital
130000
134000
138000
1970
1975
1980
1985
year

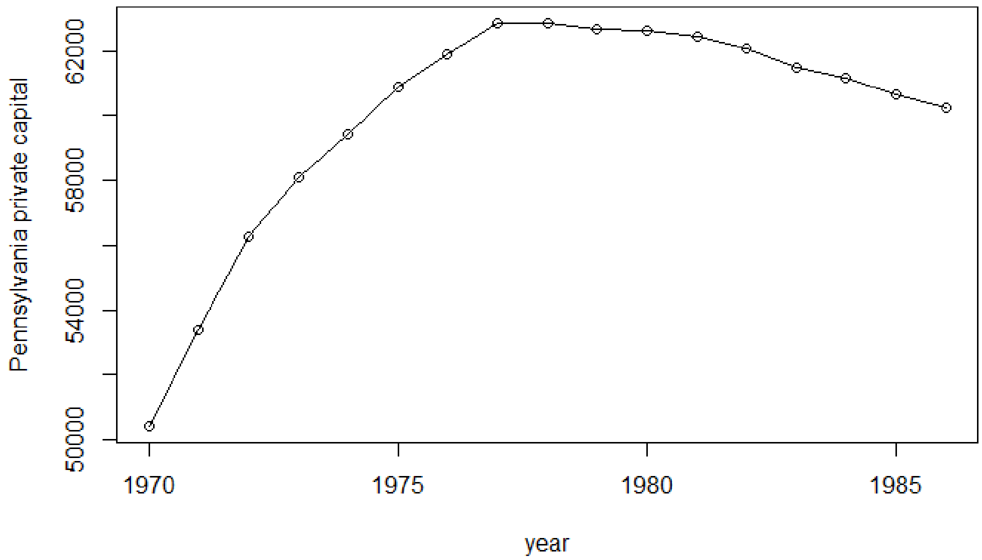

New York private capital
110000
120000
130000
1970
1975
1980
1985
year



Texas private capital
55000
65000
75000
85000
1970
1975
1980
1985
year



Illinois private capital
52000
56000
60000
64000
1970
1975
1980
1985
year



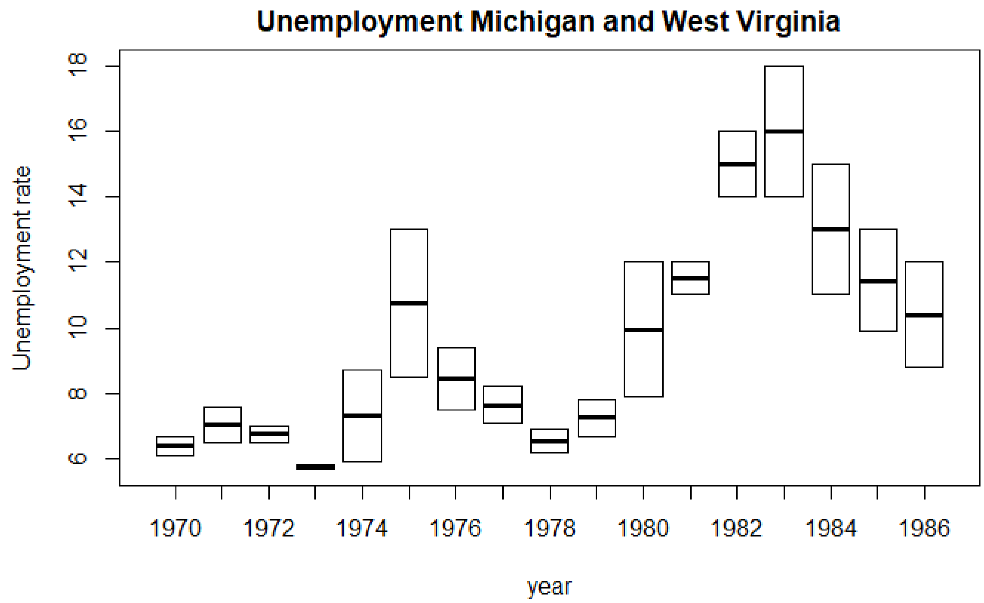
These diagrams show, that all states have had a strong increase in private capital. However most of them flatted out at the top in the more recent years. Texas is the only state where the private capital growth looks more or less linear in comparison towards the other states.

Problem 10.2.3

Please see provided code in "problem10-2.Rmd" or "problem10-2.nb.html". There are also additional descriptions given in the notebook

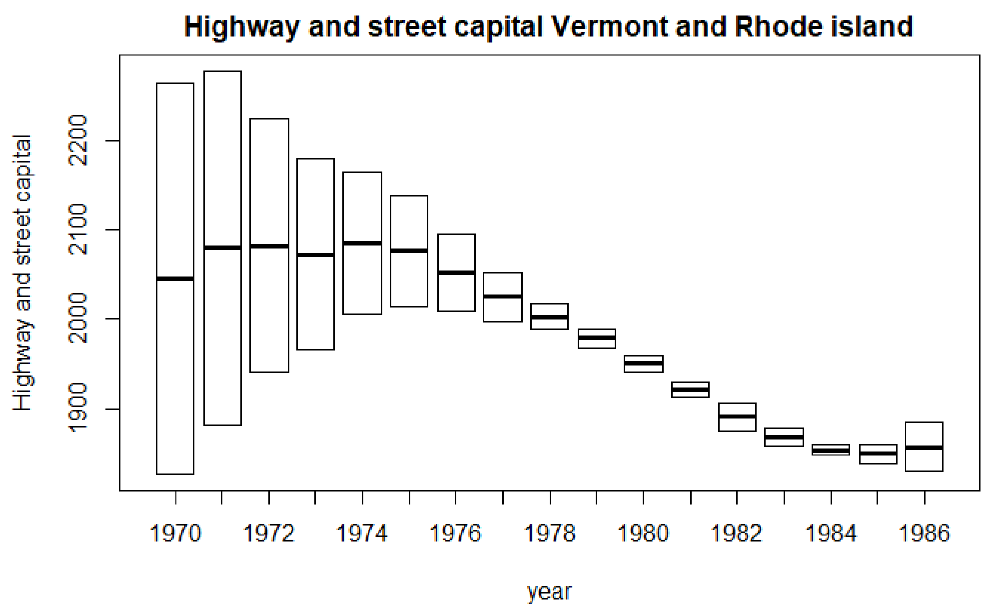
Sorting the dataset gives that the two states with the highest unemployment rate are "Michigan" and "West Virginia":

The plot shows the similarities and differences between the two states. We can see that while in the years like 1970, 1972, 1978 the unemployment rate in Michigan and West Verginia were pretty close, while in years like 1974, 1975, 1983, etc. they were pretty far apart from each other. This gets supported when looking at the data.



Sorting the dataset gives that the two states having the lowest highway and street capital on average are "Vermont" and "Rhode island":

One can see in the diagram, that while in 1970 they are still pretty diverse, they become closer in the following years until 1984. From this point on we can see the difference between the highway and street capital of Vermont and Rhode island slowly getting bigger. This gets supported by looking at the generating data.



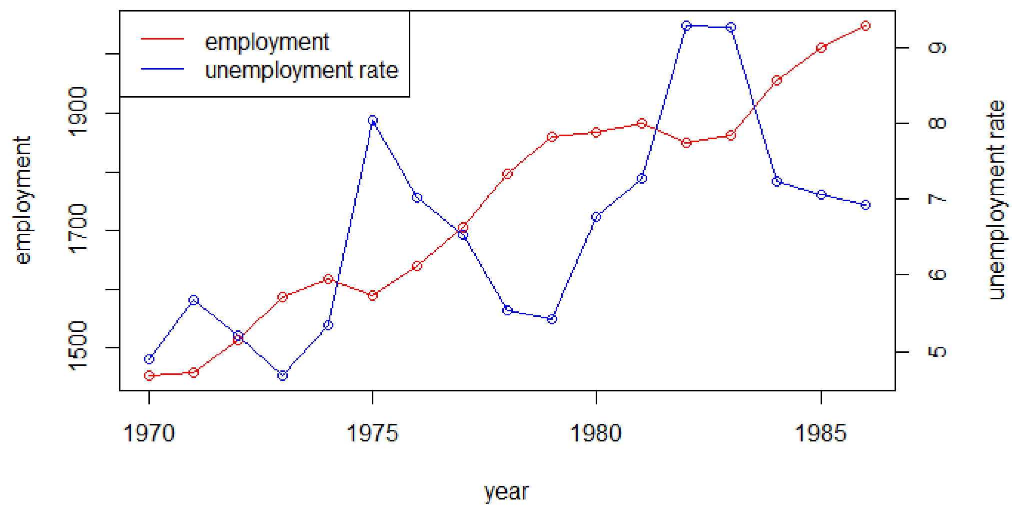
So sind Boxplots nicht gedacht!!

-10

Problem 10.2.4

Please see provided code in "problem10-2.Rmd" or "problem10-2.nb.html". There are also additional descriptions given in the notebook

The correlation value between the two data series calculated in the notebook is 0.5048884. This is also shown when looking at the diagram of the two data series. By looking at the diagram, one can assume a positive correlation between the two data series. Also it seems reasonable that the employment value and the unemployment rate are correlated. What seems strange though is that these two are positive correlated. Intuitively we would assume, that with higher employment the unemployment rate would get lower, which therefore would correspond to a negative correlation. This problem could be justified by looking further into the observed decades and their economical properties. This will probably show, that in these decades there was a huge increase in population, which explains the positive correlation.



Problem 10.2.5

Please see provided code in "problem10-2.Rmd" or "problem10-2.nb.html". There are also additional descriptions given in the notebook

The generated *.csv* file looks like "*Florida.csv*".