Projektdokumentation mit R

Klassifikationsverfahren im Data Mining

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1 Business Understanding

Eine Bank möchte vorhersehen können, ob ein Kunde eine Kreditrate mehr als 90 Tage nicht begleicht. Dafür möchten sie eine Data Mining Lösung entwickelt haben. Für die Entwicklung des Modells bekamen wir 120.000 Datensätze mit jeweils 11 Attributen gestellt, deren Bedeutung uns anhand eines Data-Dictionarys erklärt wurden. Die Bank möchte jetzt das Attribut DefaultLast2Years anhand der restlichen Attribute vorhersagen.

2 Data Understanding

-Einlesen der Daten und überprüfen, ob korrekt eingelesen wurde.

```
#dat = read.csv("C:/Users/Lenovo/Downloads/trainset.csv", sep = ",", dec = ".", row.names = "X")
dat=read.csv("C:\\Users\\ARISH\\Desktop\\Klassifikation im Data Mining\\Projekt\\trainset.csv",sep=",", str(dat)
```

```
##     'data.frame':           120000 obs. of  11     variables:
##     $ DefaultLast2Years                    : int    0 0 0 0 0 0 0 0 0 0 ...
##       $ ProportionOfUnsecuredLines: num      0.665 0.253 0.882 0.018 1 ...
##     $ Age                                  : int    44 26 46 52 31 63 42 54 73 28 ...
##       $ NumberOfTime30.59DaysPast : int      0 0 0 0 0 0 1 0 0 0 ...
##     $ DebtRatio                            : num    0.42 0.117 0.538 0.721 0 ...
##     $ MonthlyIncome                        : int    2000 4639 6741 8667 0 3883 1 8375 10097 0 ...
##   $ OpenCreditLinesAndLoans              : int  2 9 20 16 0 9 6 6 21 0 ...
##     $   X90DaysLate                        :  int    0  0  0 0 0    0  0  0  0  4 ...
##     $   RealEstateLoansOrLines             :  int    1  0  1 3 0    0  2  1  4  0 ...
##     $   X60.89DaysPast                     :  int    0  0  0 0 0    0  0  0  0  0 ...
##     $   Dependents                         :  int    3  0  0 0 0    0  3  0  0  0 ...
```

```
summary(dat)
```

```
##  DefaultLast2Years ProportionOfUnsecuredLines                Age
##  Min.         :0.00000        Min.       :      0.00          Min.       :  0.0
##       1st Qu.:0.00000          1st Qu.:      0.03            1st Qu.:  41.0
##       Median :0.00000          Median :      0.15            Median :  52.0
##       Mean      :0.06695       Mean      :      6.30          Mean      :  52.3
##       3rd Qu.:0.00000          3rd Qu.:      0.56            3rd Qu.:  63.0
##  Max.         :1.00000        Max.       :50708.00          Max.       :109.0
##
##  NumberOfTime30.59DaysPast          DebtRatio                MonthlyIncome
##     Min.       : 0.0000                Min.       :      0.0     Min.       :       0
##     1st Qu.: 0.0000                    1st Qu.:      0.2       1st Qu.:    3400
##     Median : 0.0000                    Median :      0.4       Median :    5400
##     Mean      : 0.4286                 Mean      :    355.3      Mean      :    6669
##     3rd Qu.: 0.0000                    3rd Qu.:      0.9       3rd Qu.:    8250
##     Max.       :98.0000                Max.       :329664.0     Max.       :3008750
##                                                                  NA's       :23792
##     OpenCreditLinesAndLoans        X90DaysLate          RealEstateLoansOrLines
##     Min.       : 0.000             Min.       : 0.0000      Min.       : 0.000
##     1st Qu.: 5.000                 1st Qu.: 0.0000          1st Qu.: 0.000
##     Median : 8.000                 Median : 0.0000          Median : 1.000
##     Mean      : 8.461              Mean      : 0.2742       Mean      : 1.021
##     3rd Qu.:11.000                 3rd Qu.: 0.0000          3rd Qu.: 2.000
##     Max.       :58.000             Max.       :98.0000      Max.       :54.000
```

```
##
##  X60.89DaysPast               Dependents ##
Min.              : 0.000        Min.       :0.000
##  1st Qu.: 0.000               1st Qu.: 0.000
##   Median  :  0.000    Median  :  0.000  ##
Mean    : 0.248    Mean    : 0.758 ##  3rd Qu.:
0.000   3rd  Qu.:  1.000  ##   Max.     :98.000
Max.   :13.000
##                               NA's    :3179
```

```
head(dat)
```

```
##                DefaultLast2Years  ProportionOfUnsecuredLines  Age
##  77315                         0                  0.66520616  44
##  59212                         0                  0.25298626  26
##  71951                         0                  0.88230887  46
##  135632                        0                  0.01799581  52
##  129226                        0                  0.99999990  31
##  64958                         0                  0.61210221  63
##             NumberOfTime30.59DaysPast DebtRatio MonthlyIncome
##  77315                              0  0.4202899          2000
##  59212                              0  0.1170259          4639
##  71951                              0  0.5375260          6741
##  135632                             0  0.7209275          8667
##  129226                             0  0.0000000             0
##  64958                              0  0.1390319          3883
##             OpenCreditLinesAndLoans X90DaysLate RealEstateLoansOrLines
##  77315                            2           0                      1
##  59212                            9           0                      0
##  71951                           20           0                      1
##  135632                          16           0                      3
##  129226                           0           0                      0
##  64958                            9           0                      0
##             X60.89DaysPast Dependents
##  77315                   0          3
##  59212                   0          0
##  71951                   0          0
##  135632                  0          0
##  129226                  0          0
##  64958                   0          0
```

- Maximum, extrem hohe Maximalwerte zwischen 3. Quantil und
- Einbinden der benötigten Libraries
- Erste Auffälligkeiten: viele NAs bei MonthlyIncome und viele Ausreißer

```
library(rpart.plot)
```

```
## Loading required package: rpart
```

```
library(rpart) library(fifer)
```

```
## Warning: package 'fifer' was built under R version 3.4.4 ## Loading
required package: MASS
```

```
library(rpart) library(ROCR)
```

```
## Warning: package 'ROCR' was built under R version 3.4.4 ## Loading
required package: gplots
## Warning: package 'gplots' was built under R version 3.4.4
##
## Attaching package: 'gplots'
## The following object is masked from 'package:stats':
##
##     lowess
```

```
library(randomForest)
```

```
## randomForest 4.6-12
## Type rfNews() to see new features/changes/bug fixes.
```

```
library(pmml)
```

```
## Loading required package: XML
```

```
library(mice)
```

```
## Loading required package: lattice
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
## The following object is masked from 'package:randomForest': ##
##     combine
## The following object is masked from 'package:MASS': ##
##     select
## The following objects are masked from 'package:stats': ##
##     filter, lag
## The following objects are masked from 'package:base': ##
##     intersect, setdiff, setequal, union
```

- Ändern der falsch klassifizierten Attribute

```
dat$DefaultLast2Years = as.factor(dat$DefaultLast2Years) #zu Factor ändern, da ja nein
str(dat)
```

```
## 'data.frame':                120000 obs. of  11 variables:
##  $ DefaultLast2Years          : Factor w/ 2 levels "0","1": 1 1 1 1 1 1 1 1 1 1 ...
##  $ ProportionOfUnsecuredLines: num  0.665 0.253 0.882 0.018 1 ...
##  $ Age                        : int  44 26 46 52 31 63 42 54 73 28 ...
##  $ NumberOfTime30.59DaysPast : int  0 0 0 0 0 0 1 0 0 0 ...
##  $ DebtRatio                  : num  0.42 0.117 0.538 0.721 0 ...
```

```
##  $ MonthlyIncome              :  int  2000 4639  6741 8667 0 3883 1 8375 10097 0 ...
##  $ OpenCreditLinesAndLoans    :  int  2 9 20 16  0 9 6 6 21 0 ...
##  $ X90DaysLate                :  int  0  0  0 0 0  0  0  0  0  4 ...
##  $ RealEstateLoansOrLines     :  int  1  0  1 3 0  0  2  1  4  0 ...
##  $ X60.89DaysPast             :  int  0  0  0 0 0  0  0  0  0  0 ...
##  $ Dependents                 :  int  3  0  0 0 0  0  3  0  0  0 ...
```

- Verstehen der einzelnen Attribute und mögliche Änderungen vorschlagen

```
#ProportionOfUnsecuredLines
#Unsichere Kredite/ alle Kredite -> kann  größer als 1 sein aber nicht größer 2
nrow(dat[dat$ProportionOfUnsecuredLines>2,]) # = 298 Anomalien
```

```
## [1] 298
```

```
#Age
#Sollte nicht größer als 65, da wir Laufzeiten nicht kennen 65 = Rentenalter, keine
#großen Investitionen und nicht jünger als 18, da erst mit 18 Kredite genommen werden können
nrow(dat[dat$Age>65,]) # = 22863
```

```
## [1] 22863
```

```
nrow(dat[dat$Age < 18,]) # = 1
```

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

```
#NumberOfTime30.59DaysPast
#Obergrenze für letzte 2 Jahre -> höchstens 24(12,8) mal da monat = 30 Tage. Analog für die anderen bei
head(sort(dat$NumberOfTime30.59DaysPast, decreasing = TRUE), n=10)
```

```
##  [1] 98 98 98 98 98 98 98 98 98 98
```

```
#DebtRatio
#nicht größer als eins, da sonst Einkommen < Forderungen
head(sort(dat$DebtRatio, decreasing = TRUE), n=10)
```

```
##  [1] 329664 326442 307001 220516 168835 110952 106885 101320  61907  60212
```

```
nrow(dat[dat$DebtRatio > 1,])
```

```
## [1] 28136
```

```
nrow(dat[dat$DebtRatio > 1 & is.na(dat$MonthlyIncome) == TRUE,]) # offensichtlich hoher zusammenhang zw
```

```
## [1] 22335
```

```
nrow(dat[dat$DebtRatio < 1 & is.na(dat$MonthlyIncome) == TRUE,]) # Kreditbetrag berechnen?
```

```
## [1] 1289
```

```
#MonthlyIncome
#Oberstes Quantil exorbitant hoch
# siehe spiegel 2005 http://www.spiegel.de/wirtschaft/milliardaere-microsoft-erhoeht-gehalt-von-bill-ga # vorstand deutsche bank
3.000.000 im jahr  = 250.000 im Monat
head(sort(dat$MonthlyIncome, decreasing = TRUE), n=10)
```

```
##  [1] 3008750 1794060 1072500  835040  730483  702500  699530  649587
##  [9]  582369  562466
```

```
#OpenCreditLinesAndLoans zum Zeitpunkt der Einstellung über 11 ungewöhnlich (11 = 3. Quantil, ab da sta
head(sort(dat$OpenCreditLinesAndLoans, decreasing = TRUE), n=10)
```

```
##  [1] 58 57 57 56 54 54 54 54 53 52
```

```
dat[dat$OpenCreditLinesAndLoans == 58,]
```

```
##       DefaultLast2Years ProportionOfUnsecuredLines Age
##  30588                 0                0.003032193  53
##       NumberOfTime30.59DaysPast DebtRatio MonthlyIncome
##  30588                         0  5.967504          8000
##       OpenCreditLinesAndLoans X90DaysLate RealEstateLoansOrLines
##  30588                      58          0                     54
##       X60.89DaysPast Dependents
##  30588              0          0
```

```
#X60 und 90 gleich hoch? 90 > 60 Anomalie, da man mindestens 60 Tage zu spät sein muss um  90 Tage zu sp
nrow(dat[dat$X60.89DaysPast,])
```

```
## [1] 6069
```

```
nrow(dat[dat$X90DaysLate,])
```

```
## [1] 6661
```

```
#RealEstateLoansOrLines muss kleiner sein als Opencreditlinesandloans, da echte Teilmenge
head(sort(dat$RealEstateLoansOrLines, decreasing = TRUE), n=10)
```

```
##  [1] 54 29 25 25 25 23 23 21 20 19
```

```
dat[dat$RealEstateLoansOrLines == 54,]
```

```
##       DefaultLast2Years ProportionOfUnsecuredLines Age
##  30588                 0                0.003032193  53
##       NumberOfTime30.59DaysPast DebtRatio MonthlyIncome
##  30588                         0  5.967504          8000
##       OpenCreditLinesAndLoans X90DaysLate RealEstateLoansOrLines
##  30588                      58          0                     54
##       X60.89DaysPast Dependents
##  30588              0          0
```

```
dat[dat$RealEstateLoansOrLines > dat$OpenCreditLinesAndLoans,] #keine anomalien
```

```
##  [1] DefaultLast2Years                ProportionOfUnsecuredLines ##
[3] Age                                  NumberOfTime30.59DaysPast
##  [5] DebtRatio                        MonthlyIncome
##  [7] OpenCreditLinesAndLoans          X90DaysLate
##  [9] RealEstateLoansOrLines           X60.89DaysPast
## [11] Dependents
## <0 rows> (or 0-length row.names)
```

```
#Dependents
head(sort(dat$Dependents, decreasing = TRUE), n=10) #keine auffälligkeiten
```

```
##  [1] 13 10 10 10 10  9  9  9  9  8
```

```
nrow(dat[dat$Age > 65, ])
```

```
## [1] 22863
```

```
nrow(dat[dat$NumberOfTime30.59DaysPast == 98,])
```

```
## [1] 220
```

```r
nrow(dat[dat$X60.89DaysPast == 98,])
```

```
## [1] 220
```

```r
nrow(dat[dat$X90DaysLate == 98,])
```

```
## [1] 220
```

```r
quantile(dat$X90DaysLate) #drittes quantil noch bei 0, viertes schon bei 98???
```

```
##   0%  25%  50%  75% 100% 
##    0    0    0    0   98 
```

```r
head(sort(dat$X90DaysLate, decreasing = TRUE)) # die ersten 10 nach 220 ausgeben und schauen auch für d
```

```
## [1] 98 98 98 98 98 98
```

```r
nrow(dat[dat$DebtRatio > 1,])
```

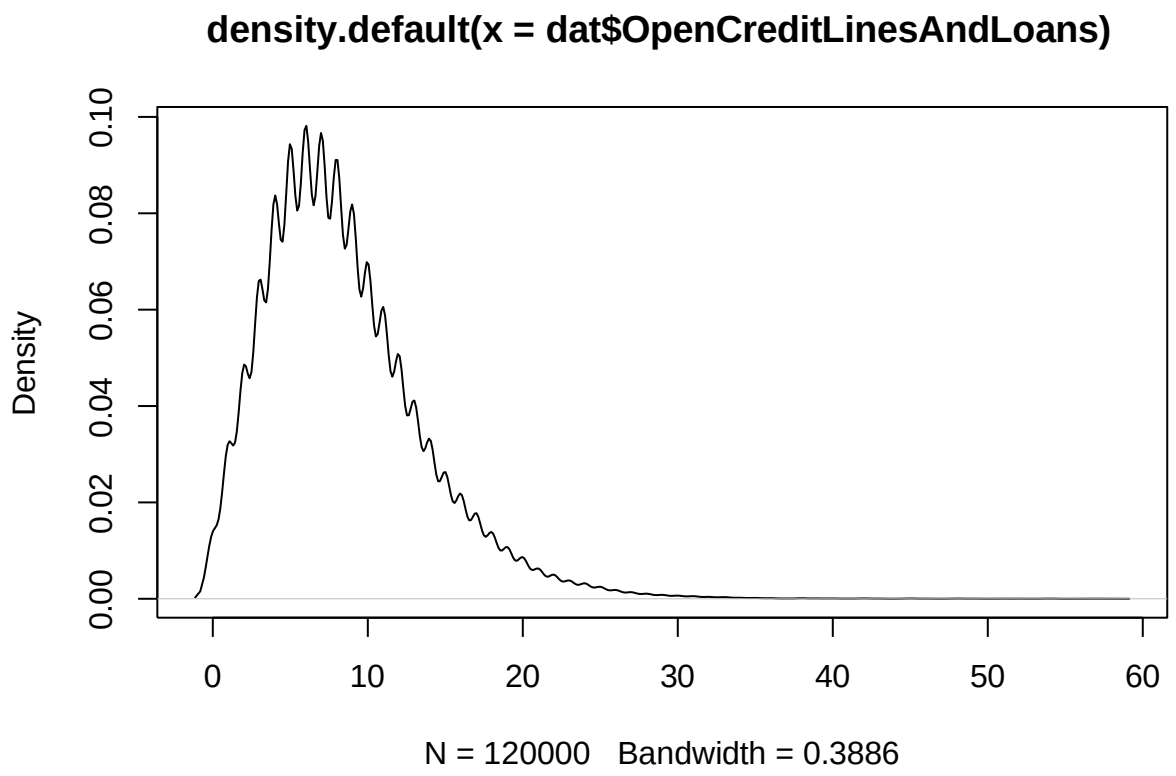
```
## [1] 28136
```

```r
nrow(dat[dat$Age>65 & dat$DebtRatio>1,]) # sehr alt und negatives einkommen -> unrealistisch
```

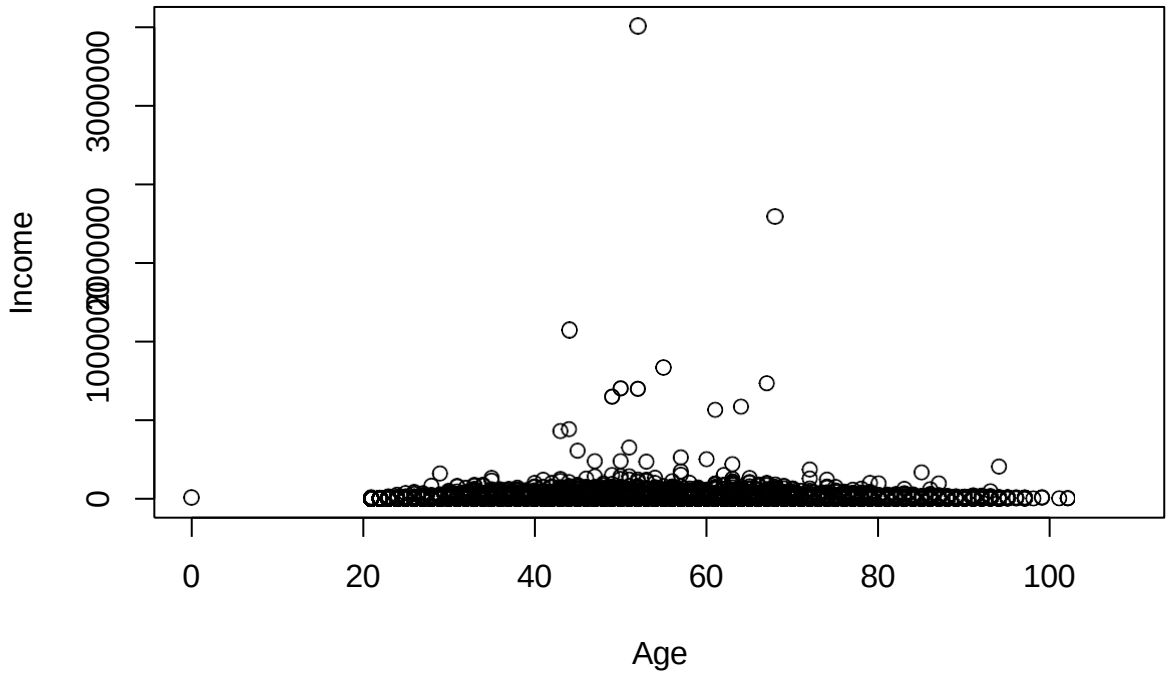
```
## [1] 6880
```

–

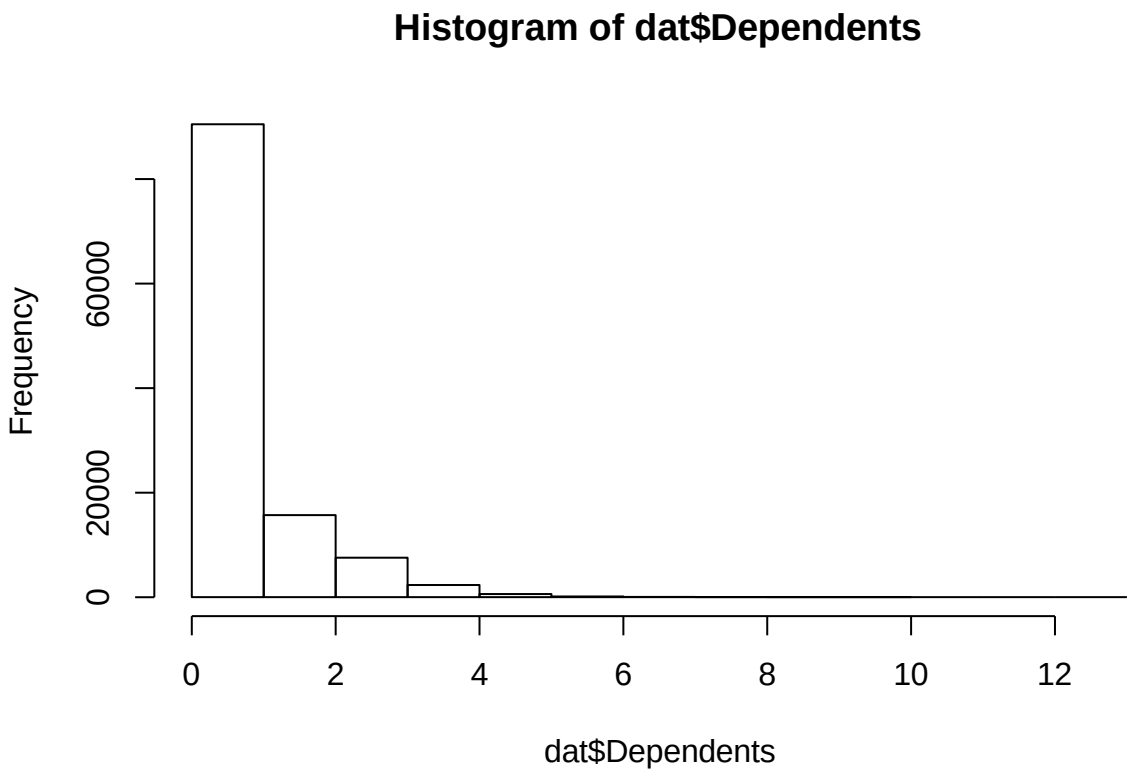
```r
#Plots zur Veranschaulichung
plot(density(dat$OpenCreditLinesAndLoans)) #quasi Normalverteilt -> Mittelwert nehmen
```



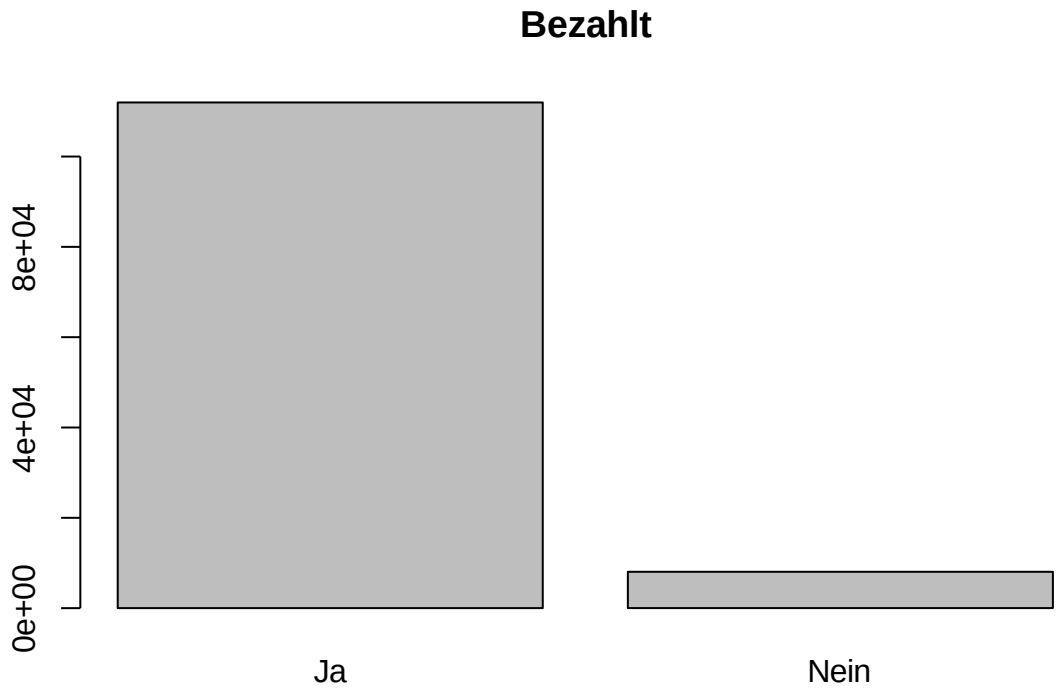
```
plot(dat$Age, dat$MonthlyIncome, xlab ="Age", ylab = "Income") #Nur sehr wenige Ausreißer
```



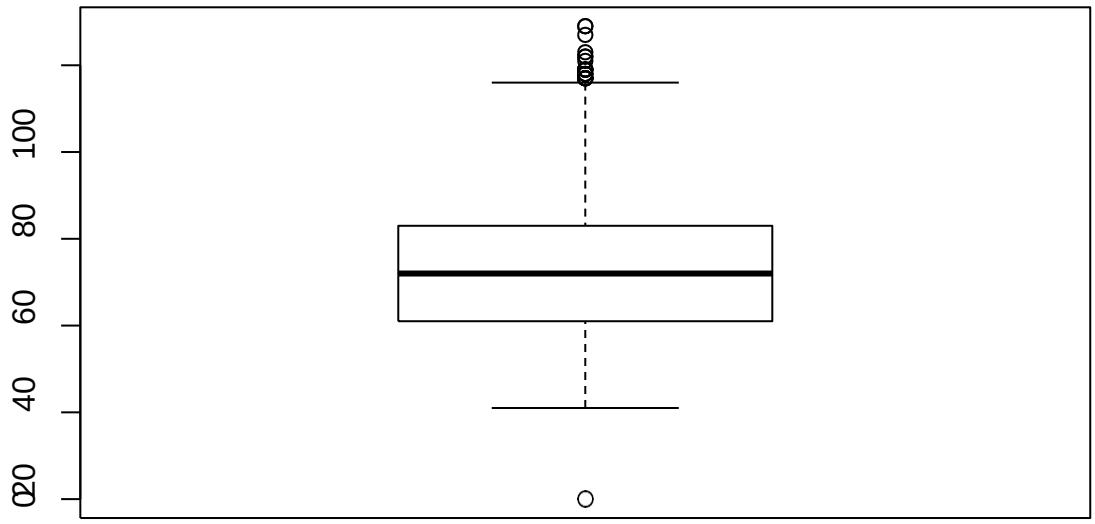

```
hist(dat$Dependents) #wenige Dependents über 6
```




```
counts = table(dat$DefaultLast2Years)
barplot(counts, main = "Bezahlt", names.arg=c("Ja", "Nein")) # Viel mehr Leute haben bezahlt als nicht
```




```
boxplot(dat$Age) # Nochmal visualisieren, dass die meisten Leute zwischen 40 und 60 sind.
```



Korrelationen suchen

```
#Korrelationen suchen zwecks Regressionsanalyse
cor(dat$MonthlyIncome, dat$NumberOfTime30.59DaysPast, use = "pairwise.complete.obs")
```

[1] -0.010377

```
cor(dat$MonthlyIncome, dat$X60.89DaysPast, use = "pairwise.complete.obs")
```

[1] -0.01131145

```
cor(dat$MonthlyIncome, dat$X90DaysLate, use = "pairwise.complete.obs")
```

[1] -0.01292171

```
cor(dat$X90DaysLate, dat$NumberOfTime30.59DaysPast, use = "pairwise.complete.obs")
```

[1] 0.9841773

```
cor(dat$X60.89DaysPast, dat$X90DaysLate, use = "pairwise.complete.obs")
```

[1] 0.9930968

```
cor(dat$X60.89DaysPast, dat$NumberOfTime30.59DaysPast, use = "pairwise.complete.obs")
```

[1] 0.9875823

```
cor(dat$X60.89DaysPast, dat$RealEstateLoansOrLines, use = "pairwise.complete.obs")
```

[1] -0.04057814

```
cor(dat$X60.89DaysPast, dat$ProportionOfUnsecuredLines, use = "pairwise.complete.obs")
```

```
## [1] -0.001029492
```

```
cor(dat$RealEstateLoansOrLines, dat$ProportionOfUnsecuredLines, use = "pairwise.complete.obs") ## [1] 0.007125576
```

```
cor(dat$Age, dat$Dependents, use = "pairwise.complete.obs")
cor(dat$MonthlyIncome, dat$Dependents, use = "pairwise.complete.obs")
```

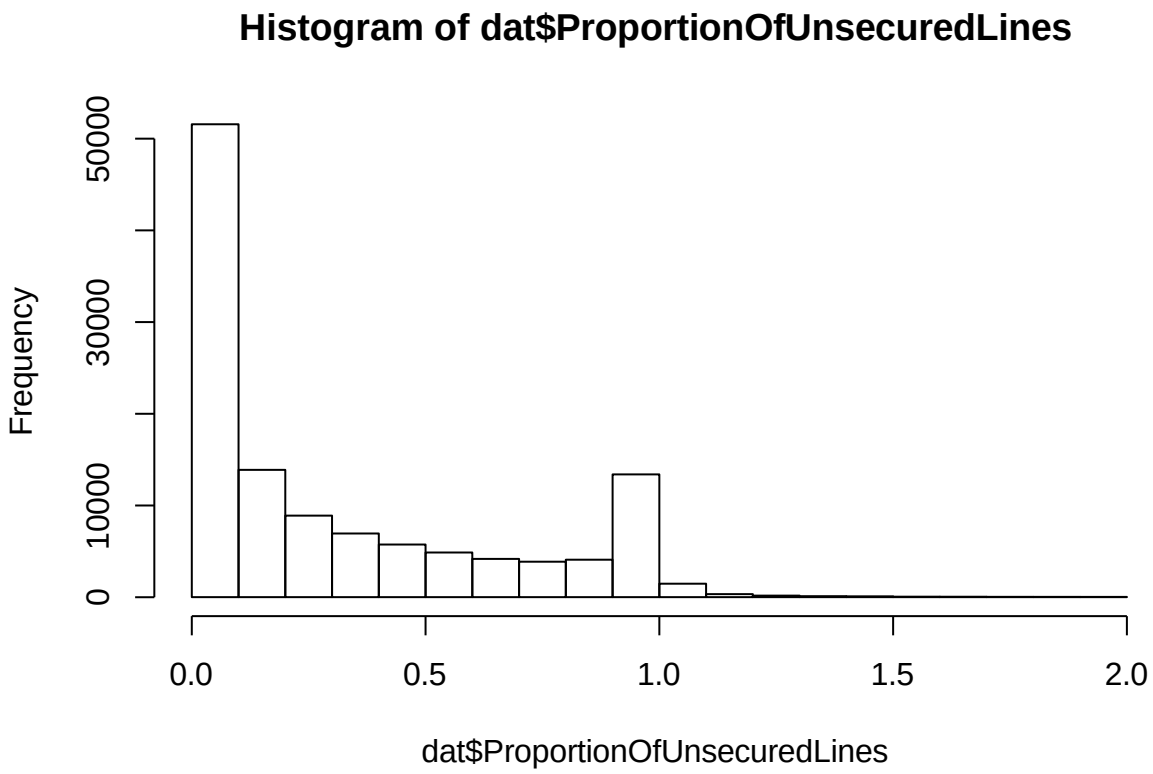
```
## [1] 0.05991752
```

```
#Ergebnis ernüchternd
```

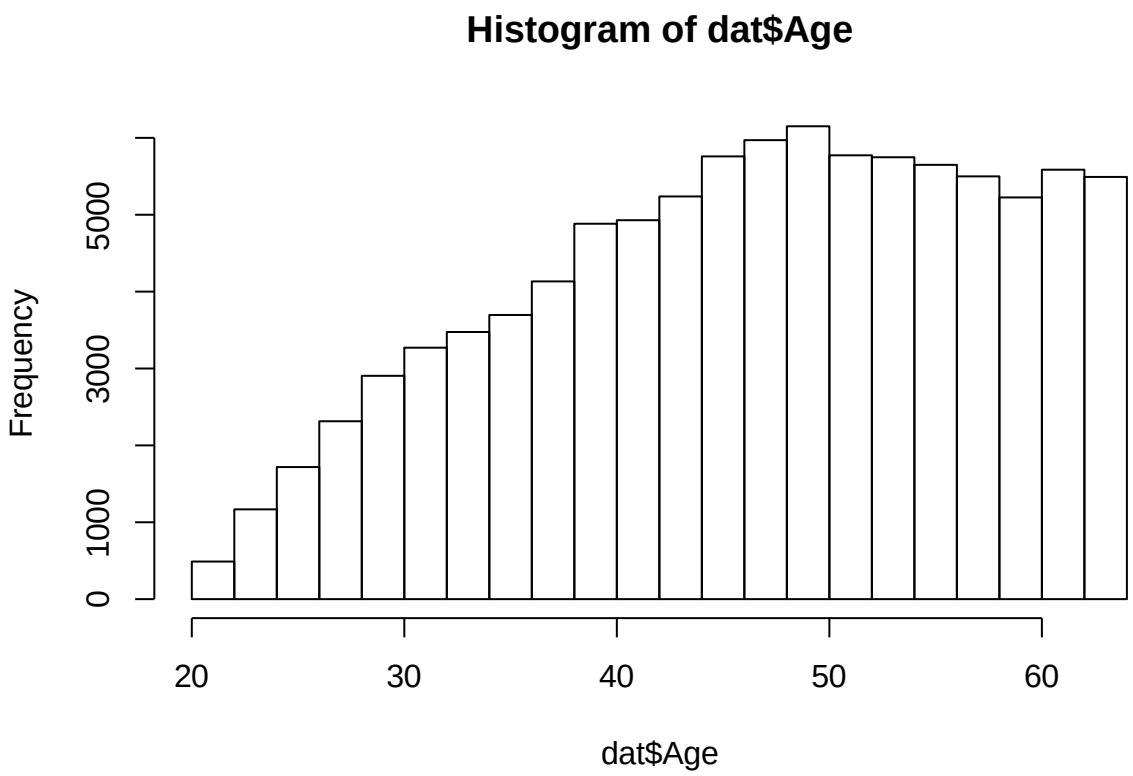
3 Data Preparation

```
#Preparation #Unsecured

auf NA for(i in 1:nrow(dat)){
  if(dat$ProportionOfUnsecuredLines[i] >2){ #kann nicht > 2 sein
    dat$ProportionOfUnsecuredLines[i] = NA
  }
}

#Age auf NA
for(i in 1:nrow(dat)){
  if(dat$Age[i] >=65 | dat$Age[i] < 18){ #Rentenalter! Laufzeit unbekannt
    dat$Age[i] = NA
  }
}

#Obergrenze für letzte 2 Jahre -> höchstens 24(12,8) mal da monat = 30 Tage. Analog für die anderen bei

for(i in 1:nrow(dat)){
  if(dat$NumberOfTime30.59DaysPast[i] >24){
    dat$NumberOfTime30.59DaysPast[i] = NA
  }
}

for(i in 1:nrow(dat)){
  if(dat$X60.89DaysPast[i] >12){
    dat$X60.89DaysPast[i] = NA
  }
}

for(i in 1:nrow(dat)){
  if(dat$X90DaysLate[i] >=8){
    dat$X90DaysLate[i] = NA
```

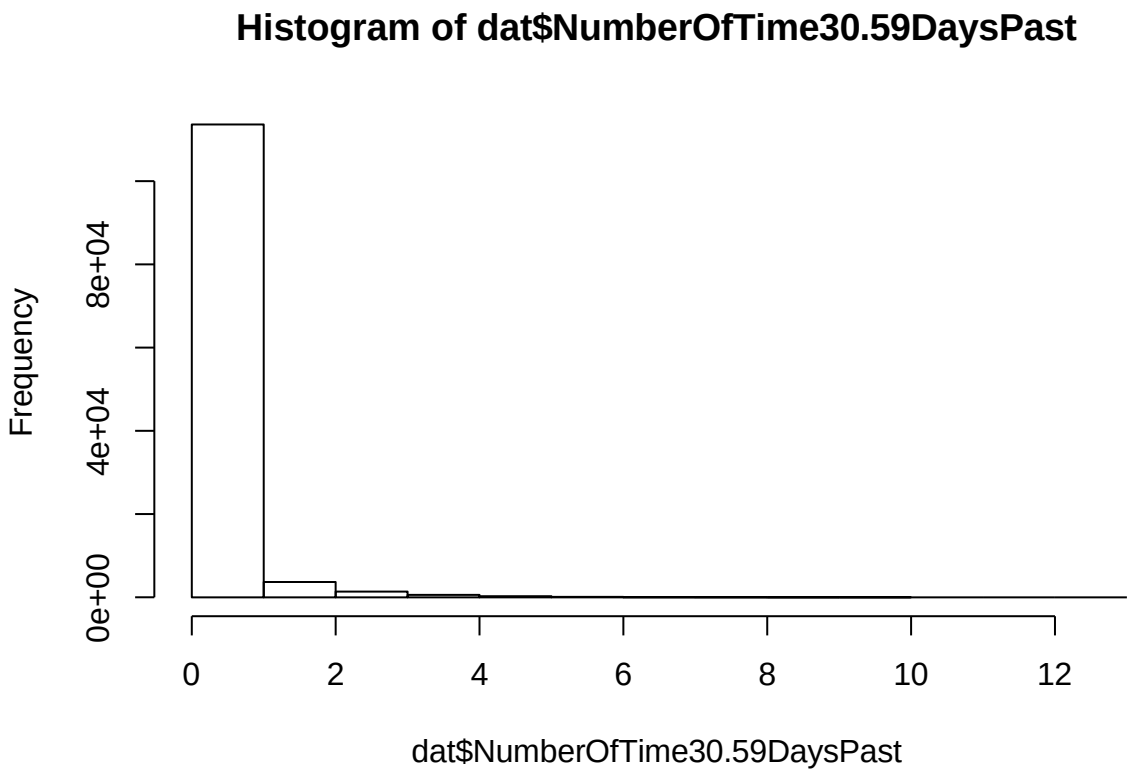
```
    }
}

#DebtRatio
for(i in 1:nrow(dat)){
    if(dat$DebtRatio[i]>1){ dat$DebtRatio[i] = NA
    }
}

#Monthly < 250.000 & monthly > 416 für HartzIV
for(i in 1:nrow(dat)){
    if(!is.na(dat$MonthlyIncome[i]) & dat$MonthlyIncome[i]>250000){
        dat$MonthlyIncome[i] = NA
    }
}

for(i in 1:nrow(dat)){
    if(!is.na(dat$MonthlyIncome[i]) & dat$MonthlyIncome[i]<416){ dat$MonthlyIncome[i] =
        NA
    }
}

for(i in 1:nrow(dat)){
    if(!is.na(dat$OpenCreditLinesAndLoans[i]) & dat$OpenCreditLinesAndLoans[i]>11){
        dat$OpenCreditLinesAndLoans[i] = NA
    }
}


#Setzen der NAs auf Mittelwert/Median, je nachdem ob Histogramm Normalverteilt ist

hist(dat$ProportionOfUnsecuredLines)
```


Histogram of dat$ProportionOfUnsecuredLines
Frequency
0
10000
30000
50000
0.0
0.5
1.0
1.5
2.0
dat$ProportionOfUnsecuredLines

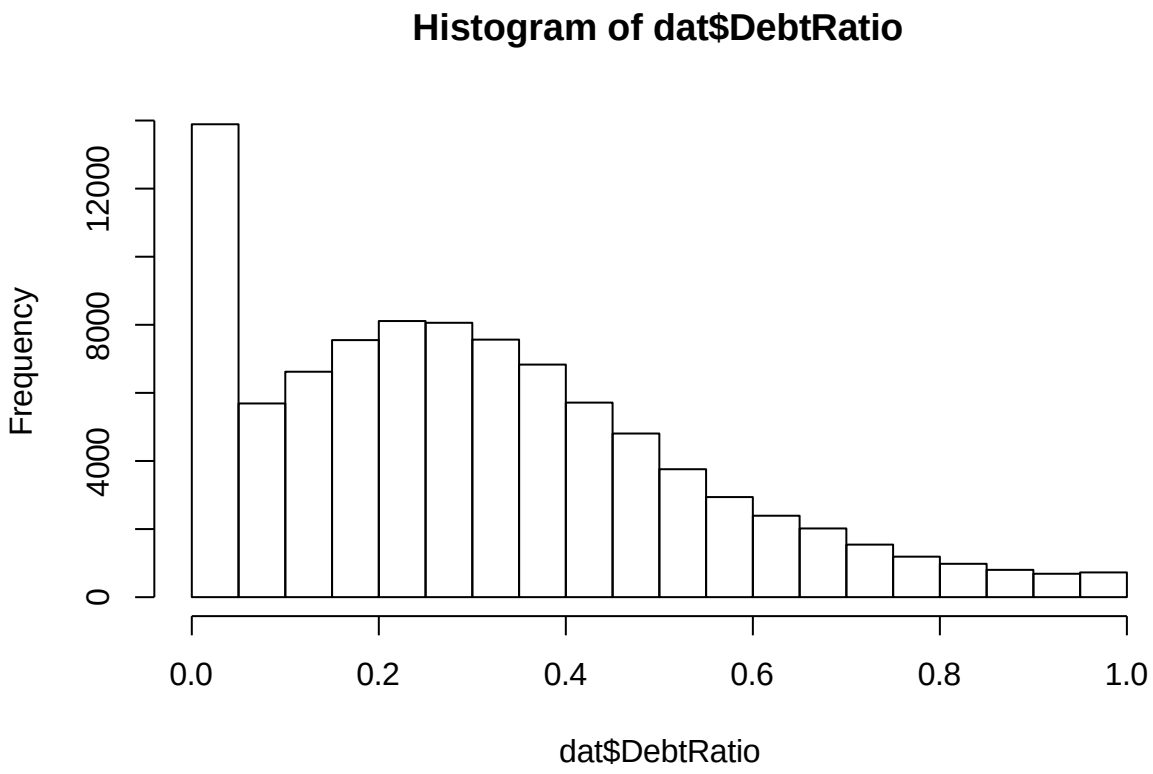
```
hist(dat$Age)
```



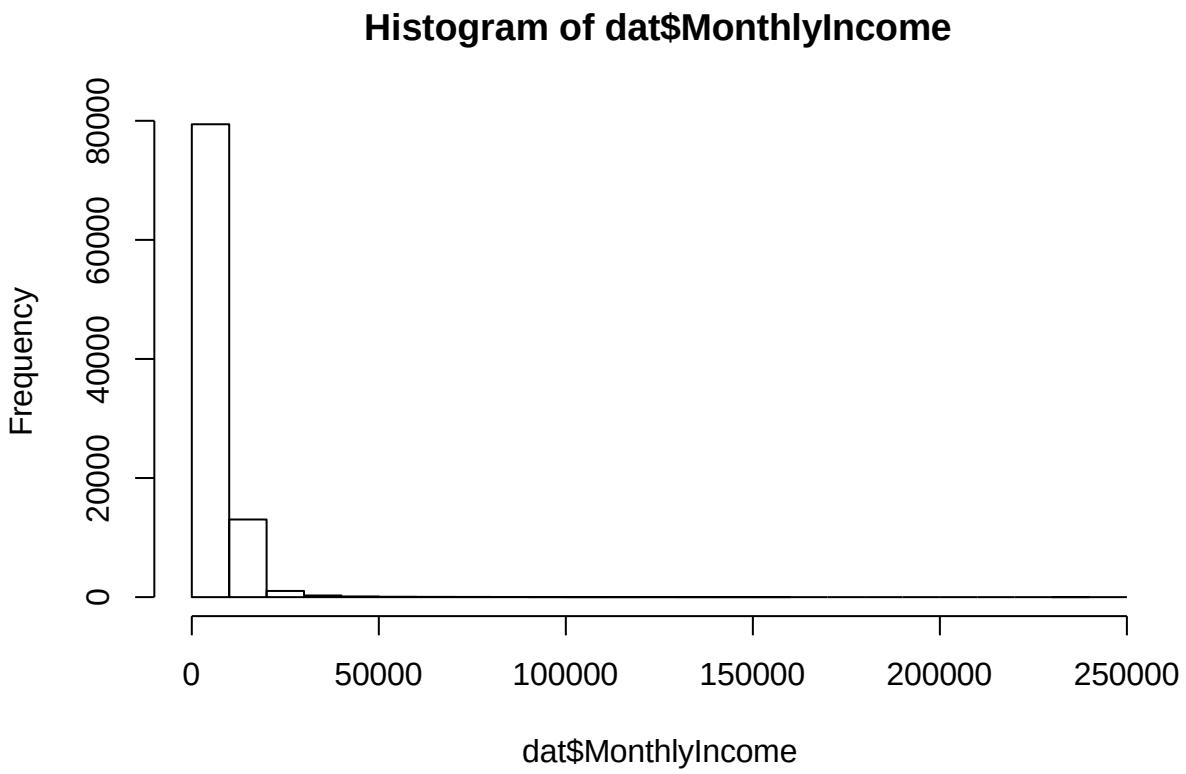

```
hist(dat$NumberOfTime30.59DaysPast)
```



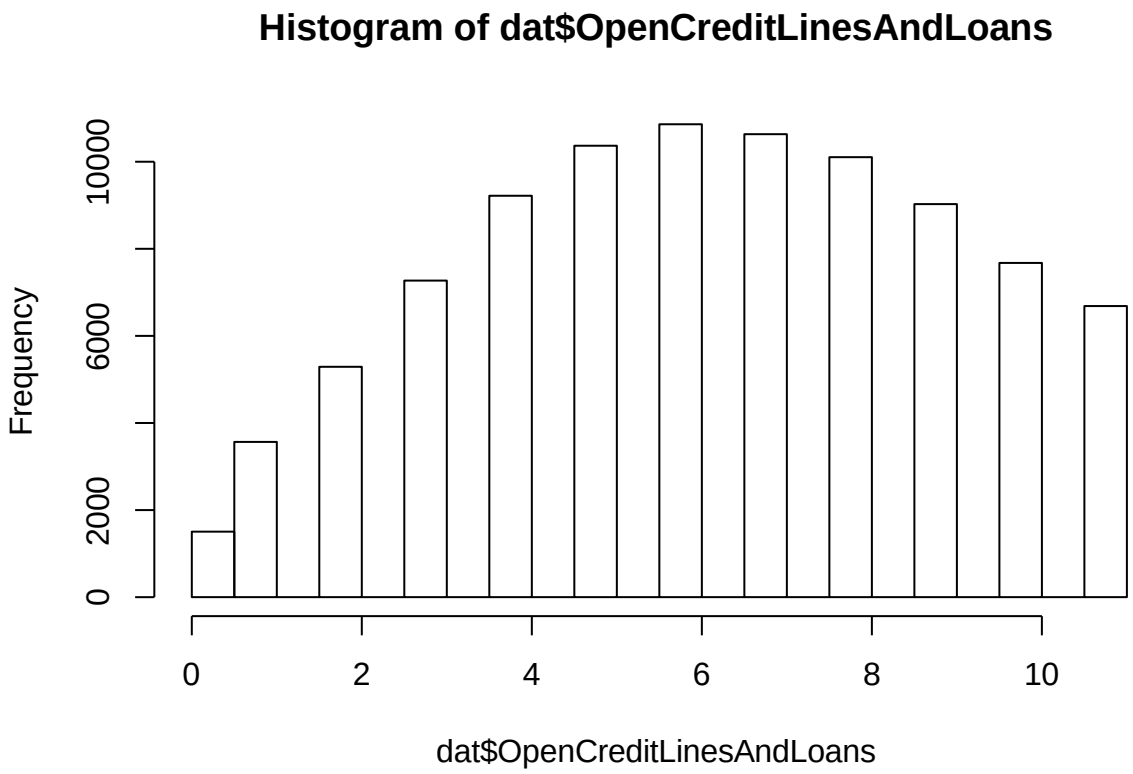

```
hist(dat$DebtRatio)
```



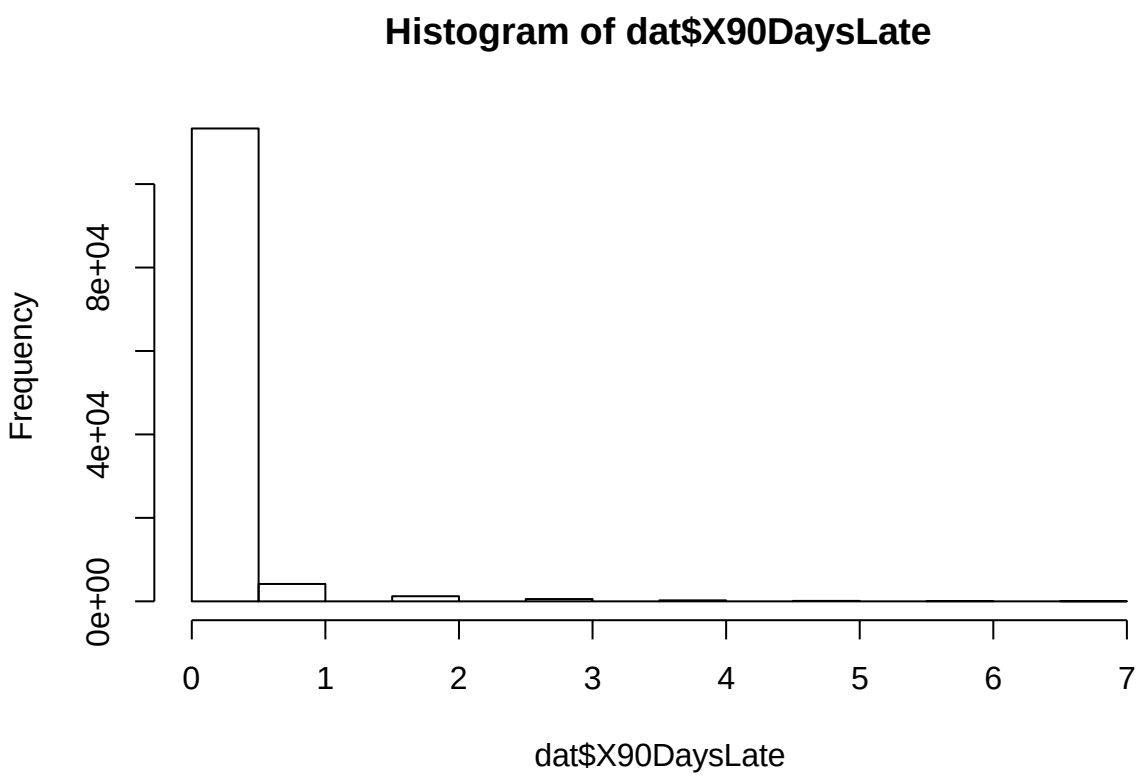

```
hist(dat$MonthlyIncome)
```



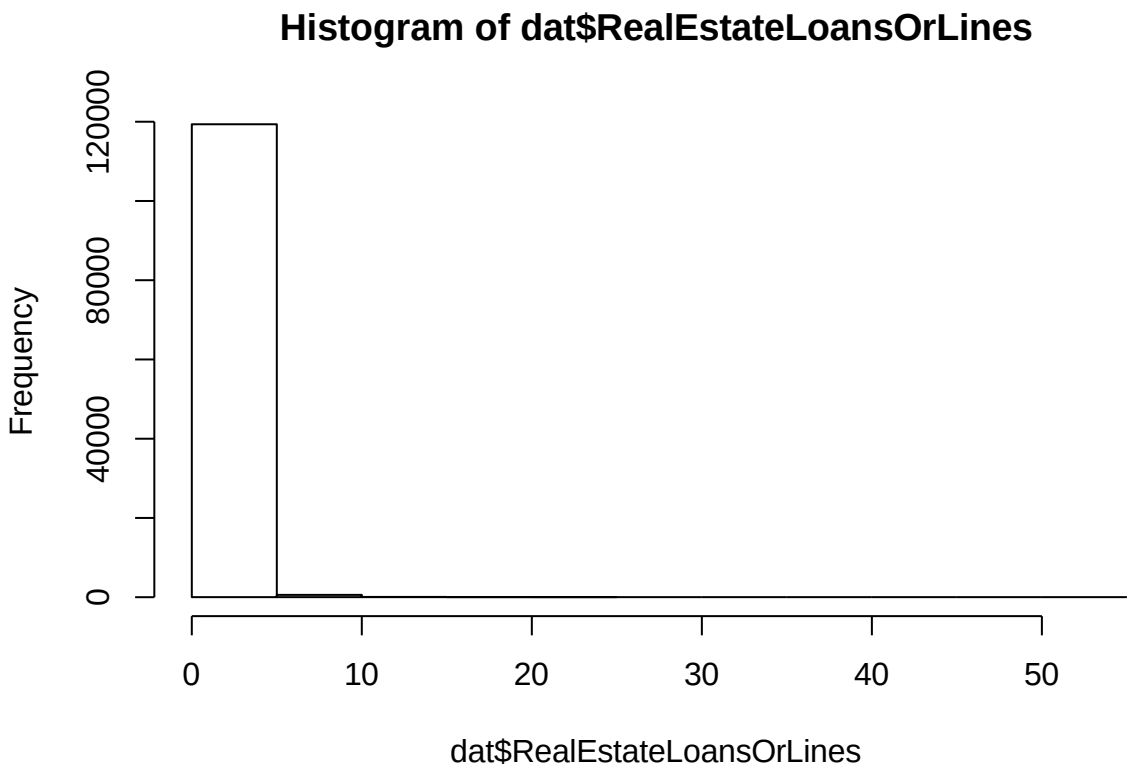

```
hist(dat$OpenCreditLinesAndLoans)
```



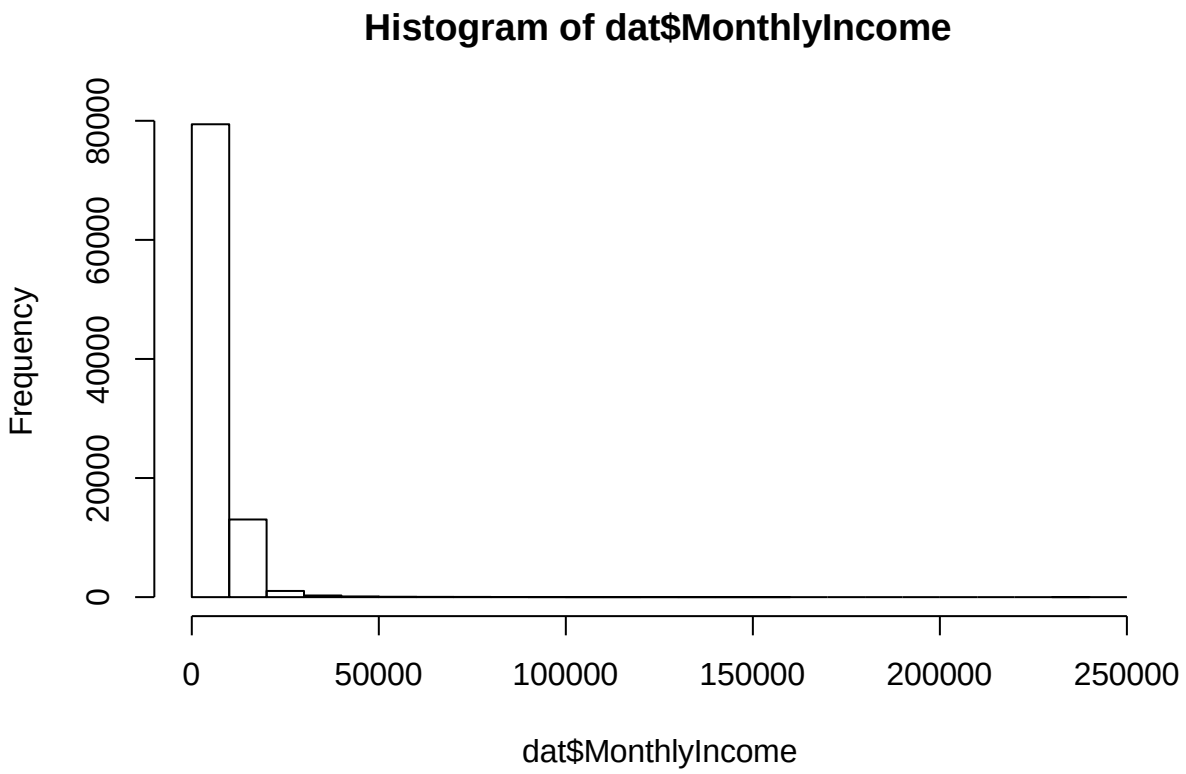

```
hist(dat$X90DaysLate)
```



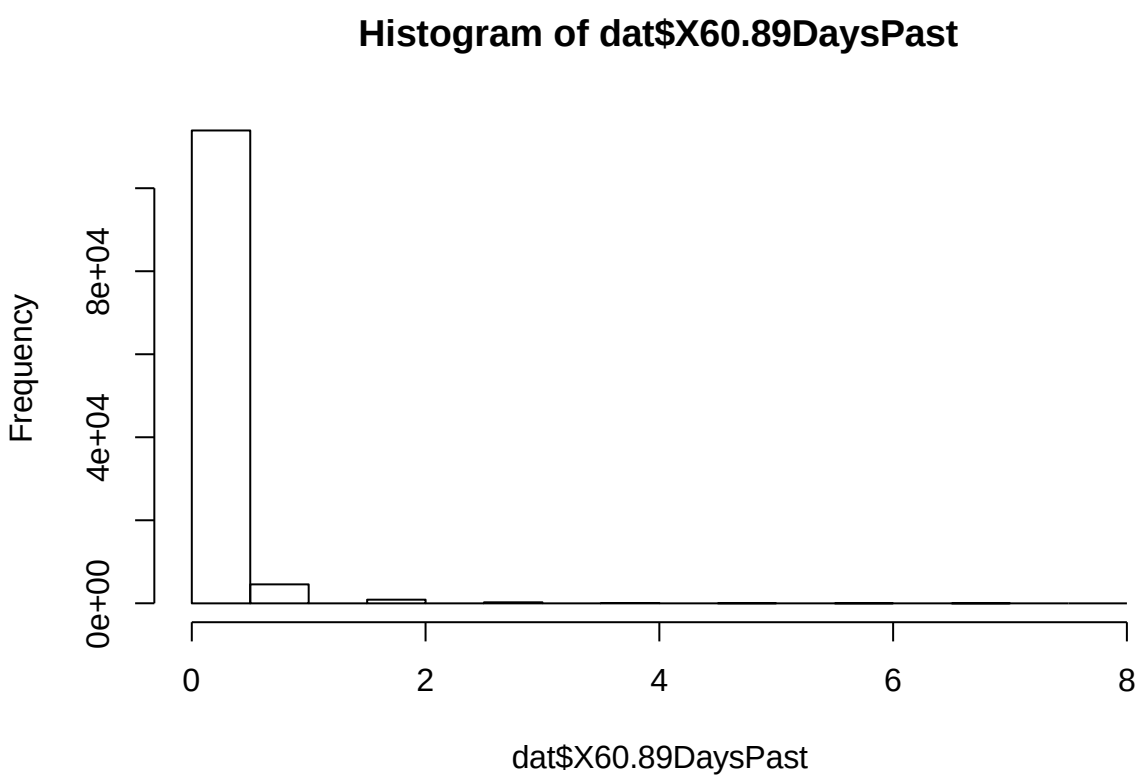

```
hist(dat$RealEstateLoansOrLines)
```




```
hist(dat$MonthlyIncome)
```




```
hist(dat$X60.89DaysPast)
```




```
dat$ProportionOfUnsecuredLines[is.na(dat$ProportionOfUnsecuredLines)]=median(dat$ProportionOfUnsecure
dat$Age[is.na(dat$Age)] = mean(dat$Age[!is.na(dat$Age)])
dat$DebtRatio[is.na(dat$DebtRatio)] = mean(dat$DebtRatio[!is.na(dat$DebtRatio)])
dat$OpenCreditLinesAndLoans[is.na(dat$OpenCreditLinesAndLoans)]=mean(dat$OpenCreditLinesAndLoans[!is.
dat$X90DaysLate[is.na(dat$X90DaysLate)] = median(dat$X90DaysLate[!is.na(dat$X90DaysLate)])
dat$NumberOfTime30.59DaysPast[is.na(dat$NumberOfTime30.59DaysPast)]=median(dat$NumberOfTime30.59DaysP
dat$RealEstateLoansOrLines[is.na(dat$RealEstateLoansOrLines)]=median(dat$RealEstateLoansOrLines[!is.n
dat$X60.89DaysPast[is.na(dat$X60.89DaysPast)] = median(dat$X60.89DaysPast[!is.na(dat$X60.89DaysPast)])
dat$Dependents[is.na(dat$Dependents)] = median(dat$Dependents[!is.na(dat$Dependents)])
dat$MonthlyIncome[is.na(dat$MonthlyIncome)] = median(dat$MonthlyIncome[!is.na(dat$MonthlyIncome)])

#Regressions Baum, nur wenn MonthlyIncome noch NAs hat

dataset=na.omit(dat) set.seed(1)
train =  sample_frac(dataset, 0.7)
sid = as.numeric(rownames(train)) # weil rownames() character zurückliefert
test = dataset[-sid,]

#Modeln des Baums
mod_rpart = rpart(MonthlyIncome ~ .-DefaultLast2Years, data = train, method = "anova", control = rpart.


#https://stats.stackexchange.com/questions/5792/r-square-from-rpart-model?utm_medium=organic&utm_source
```

```
tmp = printcp(mod_rpart)
```

```
##
## Regression tree:
## rpart(formula = MonthlyIncome ~ . - DefaultLast2Years, data = train, ##       method =
"anova", control = rpart.control(minsplit = 30,
##                 minbucket = 1, cp = 0.001)) ##
## Variables actually used in tree construction: ## [1] Age
                                                  DebtRatio
## [3] Dependents                                OpenCreditLinesAndLoans ##
[5] ProportionOfUnsecuredLines RealEstateLoansOrLines ##
## Root node error: 2.4638e+12/84000 = 29330812 ##
## n= 84000 ##
##                CP nsplit rel error  xerror                xstd
## 1  0.0515622      0      1.00000  1.00003  0.053921
## 2  0.0371207      2      0.89688  0.91633  0.047815
## 3  0.0221266      3      0.85976  0.86880  0.045113
## 4  0.0162101      6      0.79025  0.80383  0.042294
## 5  0.0135838      7      0.77404  0.81730  0.045408
## 6  0.0120987      8      0.76045  0.79738  0.045926
## 7  0.0114635      9      0.74835  0.79788  0.045943
## 8  0.0108191     10      0.73689  0.79135  0.045840
## 9  0.0103505     11      0.72607  0.77751  0.045276
## 10 0.0067923     12      0.71572  0.76376  0.043908
## 11 0.0065242     13      0.70893  0.75875  0.043845
## 12 0.0055887     14      0.70240  0.75372  0.043749
## 13 0.0046241     15      0.69682  0.75871  0.044040
## 14 0.0045460     17      0.68757  0.75725  0.044103
## 15 0.0044450     18      0.68302  0.75359  0.043997
## 16 0.0041852     19      0.67858  0.75103  0.043934
## 17 0.0041412     20      0.67439  0.75144  0.043947
## 18 0.0035383     21      0.67025  0.74494  0.043759
## 19 0.0030656     22      0.66671  0.74543  0.044142
## 20 0.0026309     23      0.66365  0.74007  0.043844
## 21 0.0024194     24      0.66102  0.73972  0.043817
## 22 0.0023609     25      0.65860  0.74033  0.043830
## 23 0.0023134     26      0.65624  0.73929  0.043802
## 24 0.0022853     28      0.65161  0.73750  0.043719
## 25 0.0022060     29      0.64932  0.73537  0.043667
## 26 0.0021818     30      0.64712  0.73558  0.043669
## 27 0.0021748     36      0.63403  0.73512  0.043664
## 28 0.0020532     37      0.63185  0.73719  0.043986
## 29 0.0020065     38      0.62980  0.73652  0.043984
## 30 0.0019715     39      0.62779  0.73364  0.043991
## 31 0.0017096     41      0.62385  0.73193  0.044095
## 32 0.0016560     42      0.62214  0.72817  0.044036
## 33 0.0015713     43      0.62048  0.72782  0.043956
## 34 0.0015013     44      0.61891  0.72824  0.043964
## 35 0.0014334     45      0.61741  0.72850  0.043945
## 36 0.0014215     46      0.61598  0.72684  0.043931
```

```
##  37 0.0013588        47      0.61456 0.72627 0.043933
##  38 0.0012858        50      0.61048 0.72933 0.044016
##  39 0.0012313        51      0.60919 0.72844 0.043955
##  40 0.0011729        52      0.60796 0.72601 0.043389
##  41 0.0011559        53      0.60679 0.72643 0.043388
##  42 0.0011411        54      0.60563 0.72715 0.043604
##  43 0.0011373        60      0.59785 0.73064 0.043756
##  44 0.0011123        63      0.59444 0.73023 0.043749
##  45 0.0011104        64      0.59333 0.72950 0.043729
##  46 0.0010912        65      0.59222 0.72880 0.043722
##  47 0.0010747        66      0.59113 0.72854 0.043722
##  48 0.0010405        67      0.59005 0.72830 0.043790
##  49 0.0010162        68      0.58901 0.72773 0.043789
##  50 0.0010000        69      0.58800 0.72624 0.043739
```

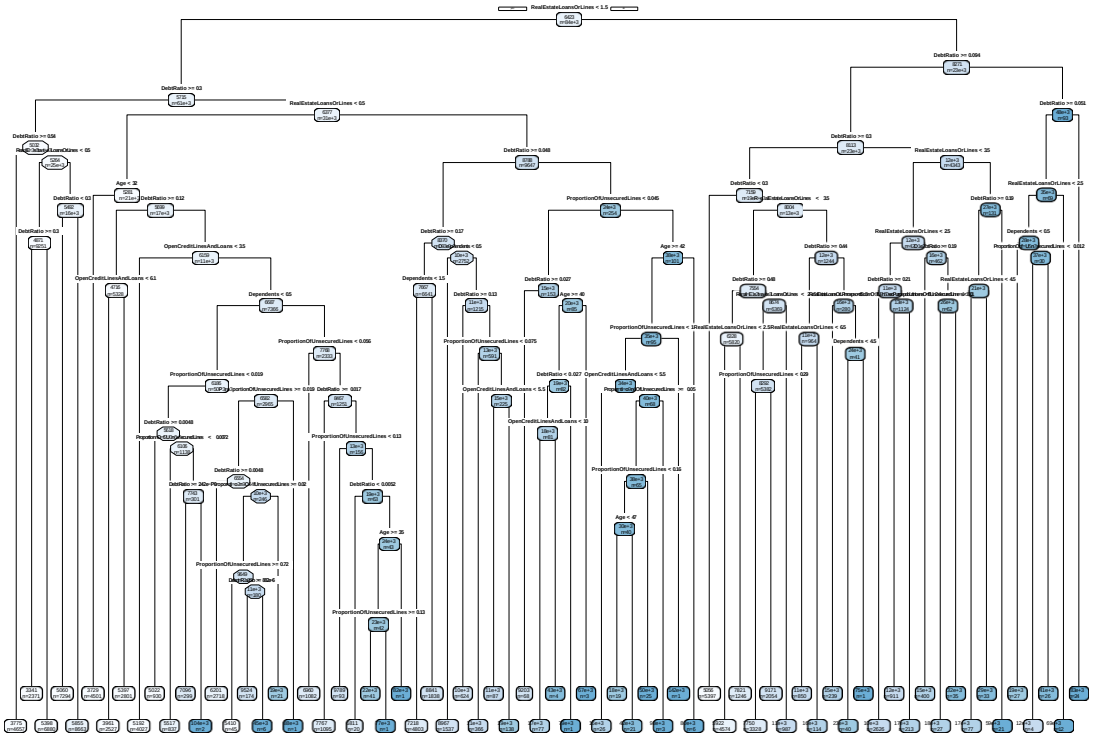
```
rsq.val = 1-tmp[,c(3,4)]
rsq.val # r³ pro Anzahl der Splits = 1 - relativer Error am Split
```

```
##          rel error    xerror
##  1    1.110223e-16 -2.552655e-05
##  2    1.031243e-01  8.367174e-02
##  3    1.402450e-01  1.311988e-01
##  4    2.097531e-01  1.961669e-01
##  5    2.259631e-01  1.827049e-01
##  6    2.395469e-01  2.026220e-01
##  7    2.516457e-01  2.021178e-01
##  8    2.631092e-01  2.086538e-01
##  9    2.739282e-01  2.224928e-01
##  10   2.842787e-01  2.362441e-01
##  11   2.910710e-01  2.412528e-01
##  12   2.975952e-01  2.462811e-01
##  13   3.031839e-01  2.412888e-01
##  14   3.124321e-01  2.427475e-01
##  15   3.169781e-01  2.464093e-01
##  16   3.214231e-01  2.489744e-01
##  17   3.256083e-01  2.485620e-01
##  18   3.297495e-01  2.550604e-01
##  19   3.332878e-01  2.545743e-01
##  20   3.363534e-01  2.599256e-01
##  21   3.389843e-01  2.602779e-01
##  22   3.414037e-01  2.596678e-01
##  23   3.437646e-01  2.607052e-01
##  24   3.483914e-01  2.624996e-01
##  25   3.506766e-01  2.646289e-01
##  26   3.528827e-01  2.644231e-01
##  27   3.659732e-01  2.648831e-01
##  28   3.681480e-01  2.628084e-01
##  29   3.702012e-01  2.634789e-01
##  30   3.722077e-01  2.663614e-01
##  31   3.761506e-01  2.680731e-01
##  32   3.778603e-01  2.718259e-01
##  33   3.795162e-01  2.721758e-01
##  34   3.810875e-01  2.717610e-01
##  35   3.825888e-01  2.714982e-01
##  36   3.840222e-01  2.731563e-01
```

```
##  37  3.854437e-01       2.737268e-01
##  38  3.895199e-01       2.706680e-01
##  39   3.908058e-01       2.715553e-01
##  40   3.920371e-01       2.739888e-01
##  41   3.932100e-01       2.735651e-01
##  42   3.943659e-01       2.728527e-01
##  43   4.021467e-01       2.693619e-01
##  44   4.055587e-01       2.697742e-01
##  45   4.066710e-01       2.705015e-01
##  46   4.077815e-01       2.711973e-01
##  47   4.088726e-01       2.714648e-01
##  48   4.099473e-01       2.716958e-01
##  49   4.109879e-01       2.722733e-01
## 50 4.120041e-01  2.737640e-01
```

```
# Plotten des Regression Baumes
rpart.plot(mod_rpart, type = 1,extra = 1)
```

```
## Warning: labs do not fit even at cex 0.15, there may be some overplotting
```



4 Modeling

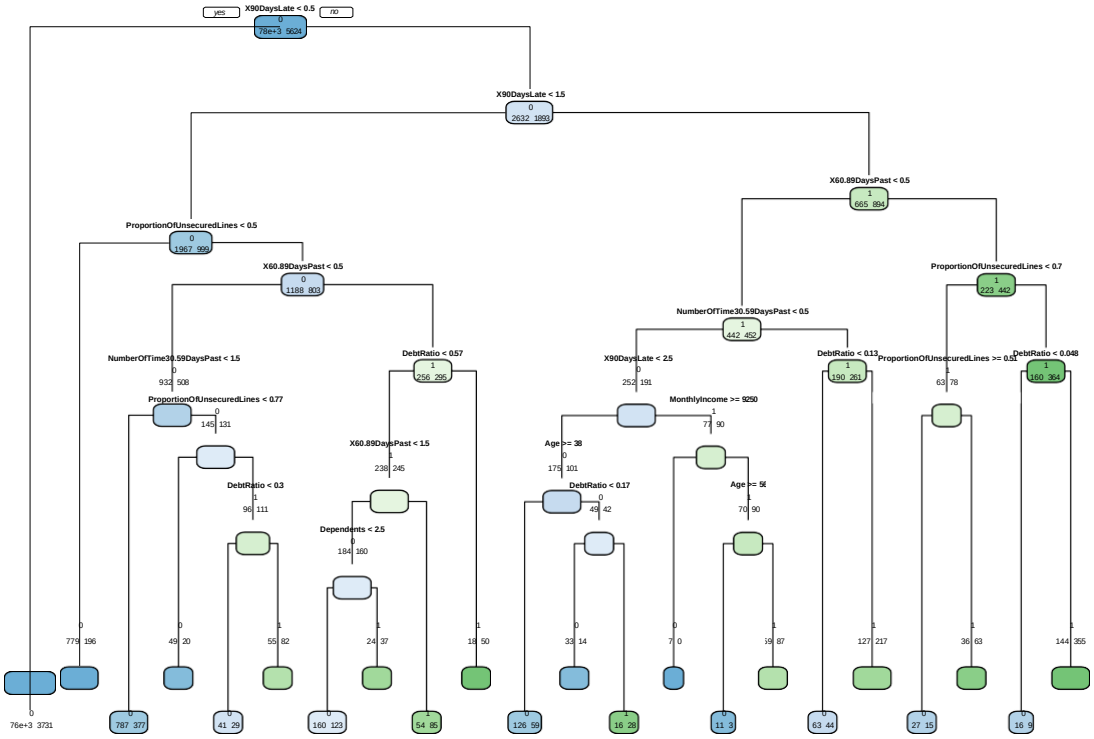
```
#Trainset und Testset mithilfe von Stratified Sampling bilden #install.packages("fifer")
set.seed(1)
```

```r
train = stratified(df = dat, group = "DefaultLast2Years", size = .7, select = NULL) sid =
as.numeric(rownames(train)) # weil rownames() character zurückliefert
test = dat[-sid,]



#CART Baum

#Modeln des Baums
mod_rpart = rpart(DefaultLast2Years ~ ., data = train, method = "class", control = rpart.control(minspl
mod_rpart
```

```
## n= 84000 ##
## node), split, n, loss, yval, (yprob) ##       *
denotes terminal node
##
##      1) root 84000 5624 0 (0.93304762 0.06695238)
##        2) X90DaysLate< 0.5 79475 3731 0 (0.95305442 0.04694558) *
##        3) X90DaysLate>=0.5 4525 1893 0 (0.58165746 0.41834254)
##          6) X90DaysLate< 1.5 2966  999 0 (0.66318274 0.33681726)
##           12) ProportionOfUnsecuredLines< 0.4963137 975  196 0 (0.79897436 0.20102564) *
##           13) ProportionOfUnsecuredLines>=0.4963137 1991  803 0 (0.59668508 0.40331492)
##             26) X60.89DaysPast< 0.5 1440  508 0 (0.64722222 0.35277778)
##               52) NumberOfTime30.59DaysPast< 1.5 1164  377 0 (0.67611684 0.32388316) *
##               53) NumberOfTime30.59DaysPast>=1.5 276  131 0 (0.52536232 0.47463768)
##                 106) ProportionOfUnsecuredLines< 0.7719685 69  20 0 (0.71014493 0.28985507) *
##                 107) ProportionOfUnsecuredLines>=0.7719685 207  96 1 (0.46376812 0.53623188)
##                   214) DebtRatio< 0.302415 70  29 0 (0.58571429 0.41428571) *
##                   215) DebtRatio>=0.302415 137  55 1 (0.40145985 0.59854015) *
##             27) X60.89DaysPast>=0.5 551  256 1 (0.46460980 0.53539020)
##               54) DebtRatio< 0.5694972 483  238 1 (0.49275362 0.50724638)
##                 108) X60.89DaysPast< 1.5 344  160 0 (0.53488372 0.46511628)
##                   216) Dependents< 2.5 283  123 0 (0.56537102 0.43462898) *
##                   217) Dependents>=2.5 61  24 1 (0.39344262 0.60655738) *
##                 109) X60.89DaysPast>=1.5 139  54 1 (0.38848921 0.61151079) *
##               55) DebtRatio>=0.5694972 68  18 1 (0.26470588 0.73529412) *
##          7) X90DaysLate>=1.5 1559  665 1 (0.42655548 0.57344452)
##           14) X60.89DaysPast< 0.5 894  442 1 (0.49440716 0.50559284)
##             28) NumberOfTime30.59DaysPast< 0.5 443  191 0 (0.56884876 0.43115124)
##               56) X90DaysLate< 2.5 276  101 0 (0.63405797 0.36594203)
##                 112) Age>=37.5 185  59 0 (0.68108108 0.31891892) *
##                 113) Age< 37.5 91  42 0 (0.53846154 0.46153846)
##                   226) DebtRatio< 0.1735258 47  14 0 (0.70212766 0.29787234) *
##                   227) DebtRatio>=0.1735258 44  16 1 (0.36363636 0.63636364) *
##               57) X90DaysLate>=2.5 167  77 1 (0.46107784 0.53892216)
##                 114) MonthlyIncome>=9250 7  0 0 (1.00000000 0.00000000) *
##                 115) MonthlyIncome< 9250 160  70 1 (0.43750000 0.56250000)
##                   230) Age>=55.5 14  3 0 (0.78571429 0.21428571) *
##                   231) Age< 55.5 146  59 1 (0.40410959 0.59589041) *
##             29) NumberOfTime30.59DaysPast>=0.5 451  190 1 (0.42128603 0.57871397)
##               58) DebtRatio< 0.131328 107  44 0 (0.58878505 0.41121495) *
##               59) DebtRatio>=0.131328 344  127 1 (0.36918605 0.63081395) *
##           15) X60.89DaysPast>=0.5 665  223 1 (0.33533835 0.66466165)
```

```
##                 30) ProportionOfUnsecuredLines< 0.6968037 141                 63 1 (0.44680851 0.55319149)
##                   60) ProportionOfUnsecuredLines>=0.507118442                  15 0 (0.64285714 0.35714286) *
##                   61) ProportionOfUnsecuredLines< 0.507118499                  36 1 (0.36363636 0.63636364) *
##                 31) ProportionOfUnsecuredLines>=0.6968037 524  160 1 (0.30534351 0.69465649)
##                   62) DebtRatio< 0.04798866 25                  9 0 (0.64000000 0.36000000) *
##                   63) DebtRatio>=0.04798866 499  144 1 (0.28857715 0.71142285) *
```

```
# Plotten des CART Baumes
rpart.plot(mod_rpart, type = 1,extra = 1)
```




```
# Modell auf Testmenge anwenden
prediction = as.character(predict(mod_rpart, test[,-1], type = "class"))
predicted = cbind.data.frame(observed = test$DefaultLast2Years, prediction = prediction)

# Confusion Matrix fÃ¼r Testmenge erstellen
cm=table(predicted$observed,predicted$prediction) cm
```

```
##
##              0       1
##       0 48748     382
##       1  3027     597
```

```
# Berechnen der Accuracy auf Basis der Confusion Matrix (cm)
accuracy = (cm[1,1] + cm[2,2]) / sum(cm) accuracy
```

```
## [1] 0.9353793
```

```
#Random Forest

rf = randomForest(DefaultLast2Years ~., data=train, ntree=50, nodesize=10, maxnodes=NULL,                    importance =

# Modell auf Testmenge anwenden
prediction = as.character(predict(rf, test[,-1], type = "class"))
predicted = cbind.data.frame(observed = test$DefaultLast2Years, prediction = prediction)


# Confusion Matrix fÃ¼r Testmenge erstellen
cm=table(predicted$observed,predicted$prediction) cm
```

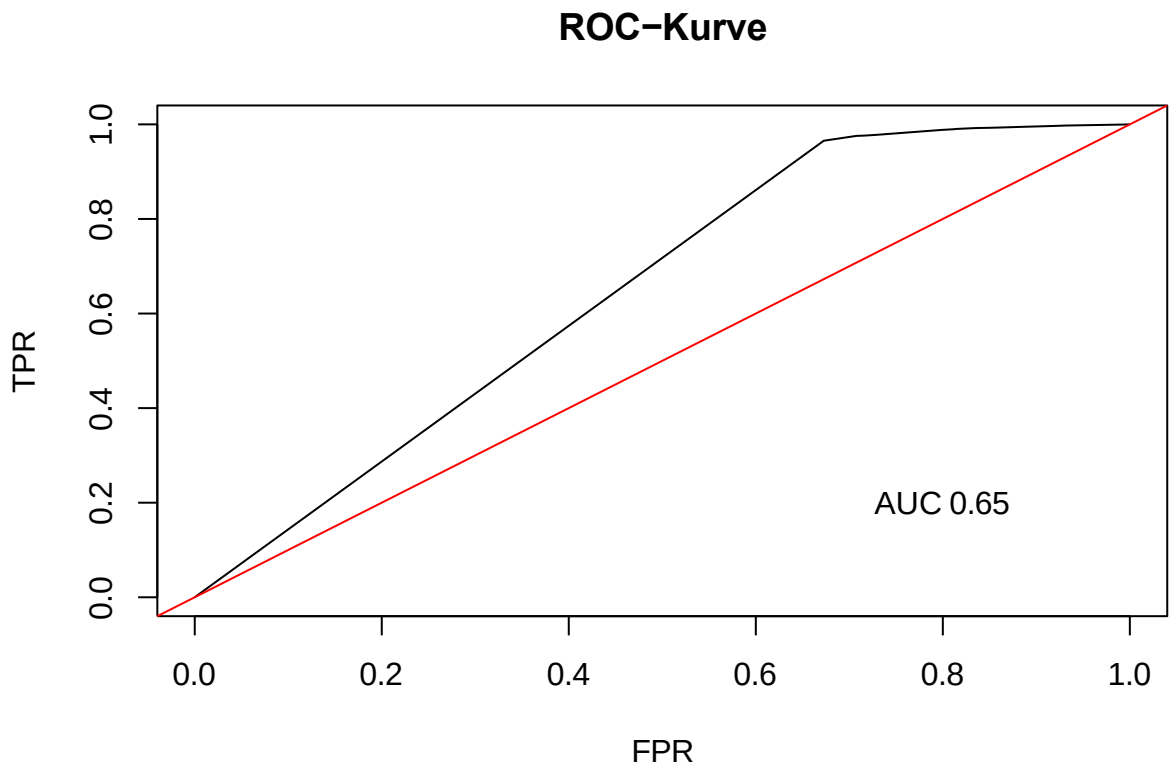
```
##
##              0         1
##      0 48908       222
##      1   2306   1318
```

```
# Berechnen der Accuracy auf Basis der Confusion Matrix (cm)
accuracy = (cm[1,1] + cm[2,2]) / sum(cm) accuracy
```

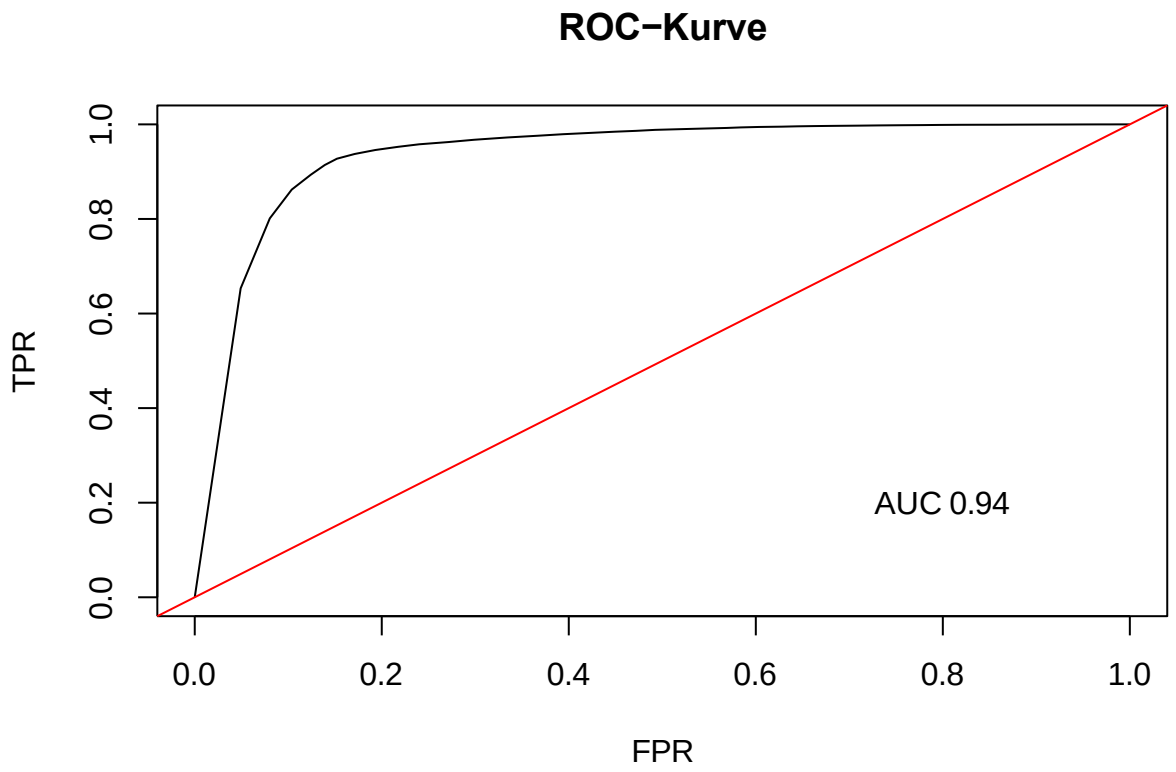
```
## [1] 0.9520795
```

5 Evaluation

```
#ROC und AUC für cart baum

prognose = predict(mod_rpart, newdata = test, type="prob") test$PD = prognose[,
which(colnames(prognose) == 0)]

dat_copy = test
data_roc = prediction(dat_copy$PD, dat_copy$DefaultLast2Years == 0)

roc_curve = performance(data_roc, measure = "tpr", x.measure = "fpr") AUC =
performance(data_roc, measure = "auc")@y.values[[1]]

plot(roc_curve, xlab = "FPR", ylab = "TPR", main ="ROC-Kurve")
abline(a = 0, b = 1, col="red")
text(0.8, 0.2, paste("AUC", toString(round(AUC, digits = 2)), sep = " "))
```




```r
#ROC und AUC für randomForest

prognose = predict(rf, newdata = test, type="prob") test$PD =
prognose[, which(colnames(prognose) == 0)]

dat_copy = test
data_roc = prediction(dat_copy$PD, dat_copy$DefaultLast2Years == 0)

roc_curve = performance(data_roc, measure = "tpr", x.measure = "fpr") AUC =
performance(data_roc, measure = "auc")@y.values[[1]]

plot(roc_curve, xlab = "FPR", ylab = "TPR", main ="ROC-Kurve")
abline(a = 0, b = 1, col="red")
text(0.8, 0.2, paste("AUC", toString(round(AUC, digits = 2)), sep = " "))
```




```
# bei AUC und accuracy ist randomforest besser.
```

6 Deployment

```
#XML bauen
#install.packages("pmml")

#rf_pmml = pmml(rf)
#saveXML(rf_pmml, "C:/Users/Lenovo/Downloads/rf_pmml.xml")
#rpart_pmml=pmml(mod_rpart)
#saveXML(rpart_pmml, "C:/Users/Lenovo/Downloads/cart_pmml.xml")
```

7 Ergebnisse Cart: Accuracy = 0.9354, AUC = 0.65

8 Ergebnisse rf: Accuracy = 0.9520 , AUC = 0.94

Wir würden den Random Forest empfehlen, weil sowohl die Accuracy als auch der AUC höher sind.