Multiple Regression

Reading Data

```
data=(read.csv("rent99.raw", sep=" "))
attach(data) # able to use location instead of data$location
head(data) # prints data header
```

```
      rent   rentsqm area yearc location bath kitchen cheating district
1 120.9744  3.456410   35  1939        1    0       0        0     1112
2 436.9743  4.201676  104  1939        1    1       0        1     1112
3 355.7436 12.267021   29  1971        2    0       0        1     2114
4 282.9231  7.254436   39  1972        2    0       0        1     2148
5 807.2308  8.321964   97  1985        1    0       0        1     2222
6 482.8205  7.787426   62  1962        1    0       0        1     2222
```

```
data$location=as.factor(data$location) # treats location as a categorical variable (no linear
levels(data$location)=c("avg","good","top") # names the categorical variable's values
```

basic description and scatter plot

```
library(dplyr)
```

```
Attaching package: 'dplyr'

The following objects are masked from 'package:stats':

    filter, lag
```

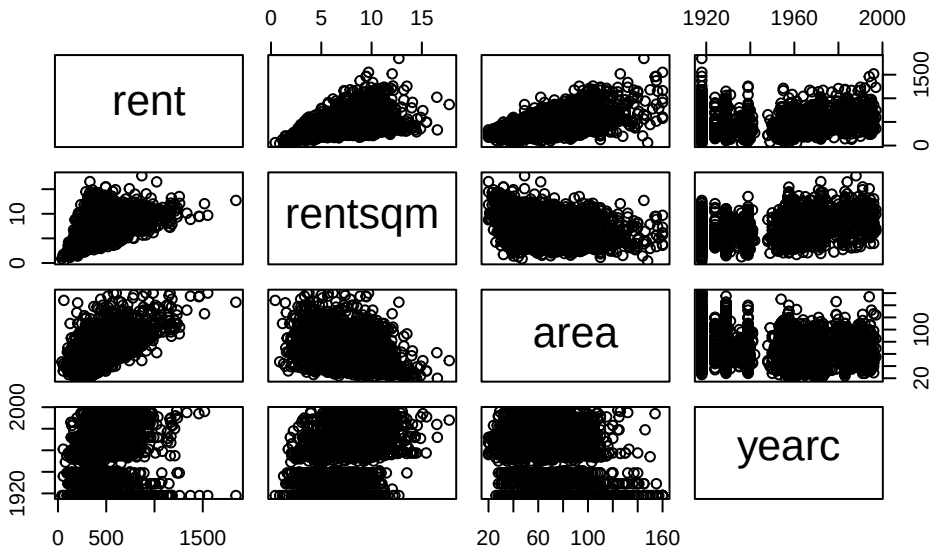
```
The following objects are masked from 'package:base':

    intersect, setdiff, setequal, union
```

```
library(tableone)
CreateTableOne(factorVars=c("location", "bath", "kitchen", "cheating"), # makes a descriptio
               data=data%>%select(-district)) # syntactic "sugar" for select(data, -district)
```

```
                     Overall
  n                     3082
  rent (mean (SD))     459.44 (195.66)
  rentsqm (mean (SD))    7.11 (2.44)
  area (mean (SD))      67.37 (23.72)
  yearc (mean (SD))   1956.31 (22.31)
  location (%)
     avg                1794 (58.2)
     good               1210 (39.3)
     top                  78 ( 2.5)
  bath = 1 (%)           191 ( 6.2)
  kitchen = 1 (%)        131 ( 4.3)
  cheating = 1 (%)      2761 (89.6)
```

```
plot(data[,1:4]) # plots all rows and first 4 columns of data (the 12 scatterplots)
```



Linear regression models

multiple regression of rent onto area and yearc

```
fit=lm(rent~area+I(yearc-1956),data=data) # I() - idiot function - treat arithmetics literal
summary(fit)
```

```
Call:
lm(formula = rent ~ area + I(yearc - 1956), data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-734.76  -94.75  -10.87   82.55 1063.17

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      97.4225     8.3079   11.73   <2e-16 ***
area              5.3618     0.1165   46.01   <2e-16 ***
I(yearc - 1956)   2.4913     0.1239   20.11   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 149.3 on 3079 degrees of freedom
Multiple R-squared:  0.4181,    Adjusted R-squared:  0.4177
F-statistic:  1106 on 2 and 3079 DF,  p-value: < 2.2e-16
```

polynomial regression / quadratic effects

```
fit.2=lm(rent~area+I(yearc-1956)+I((yearc-1956)^2),data=data)
summary(fit.2)
```

```
Call:
lm(formula = rent ~ area + I(yearc - 1956) + I((yearc - 1956)^2),
    data = data)

Residuals:
```

```
    Min      1Q  Median      3Q     Max
-757.99  -88.89   -8.39   83.52 1039.27

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)         81.607327   8.237114   9.907   <2e-16 ***
area                 5.136457   0.115594  44.435   <2e-16 ***
I(yearc - 1956)      2.942822   0.127113  23.151   <2e-16 ***
I((yearc - 1956)^2)  0.062017   0.005255  11.802   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 146.1 on 3078 degrees of freedom
Multiple R-squared:  0.4433,    Adjusted R-squared:  0.4427
F-statistic: 816.9 on 3 and 3078 DF,  p-value: < 2.2e-16
```

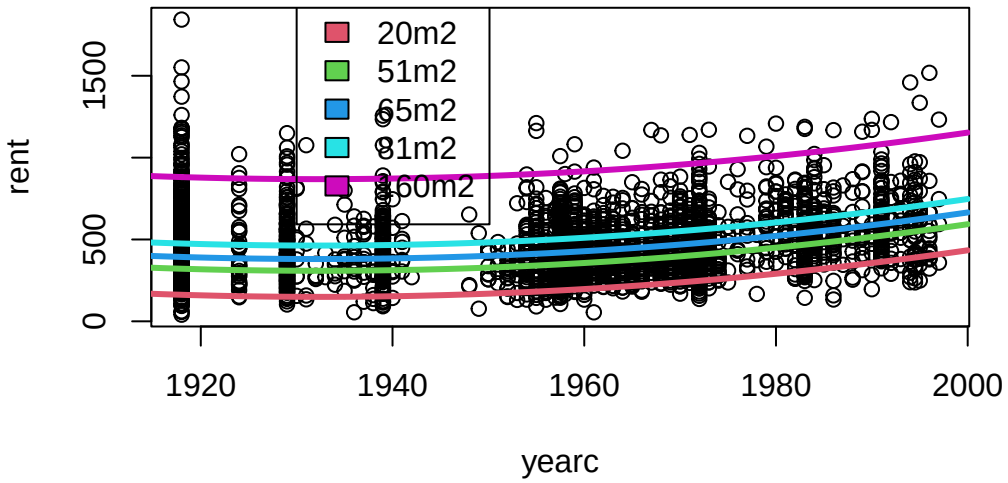
plotting model estimates with basic plotting tools

```
summary(data$area)
```

```
   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
  20.00   51.00   65.00   67.37   81.00  160.00
```

```
with(data,plot(rent~yearc)) # with() - syntactic sugar for plot(data$rent~data$yearc)

H=predict(fit.2, newdata= # uses fit.2 lm to predict rent for new data frame (90 x 5 new data
            data.frame(expand.grid(yearc=1911:2000, area=c(20,51,65,81,160))))
for (i in 0:4){ # plots a line for each area (5 of them)
lines(1911:2000,H[i*90+1:90], lwd=3, col=i+2) # predicted rent vs yearc
} # lwd - line thickness, col - color
legend(1930,2000, legend=c("20m2","51m2","65m2","81m2","160m2"), fill=c(2:6))
```



R^2 depends on range of X

previous model

```
fit=lm(rent~area+I(yearc-1956),data=data)
S=summary(fit)
S
```

```
Call:
lm(formula = rent ~ area + I(yearc - 1956), data = data)

Residuals:
    Min      1Q  Median      3Q     Max
-734.76  -94.75  -10.87   82.55 1063.17

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)      97.4225     8.3079   11.73   <2e-16 ***
area              5.3618     0.1165   46.01   <2e-16 ***
I(yearc - 1956)   2.4913     0.1239   20.11   <2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 149.3 on 3079 degrees of freedom
```

```
Multiple R-squared:  0.4181,    Adjusted R-squared:  0.4177
F-statistic:  1106 on 2 and 3079 DF,  p-value: < 2.2e-16
```

regression on subset with medium areas only

```
fit.3=lm(rent~area+I(yearc-1956) ,data=data%>% filter(area>51, area<81)) # only picking data
S.3=summary(fit.3)
S.3
```

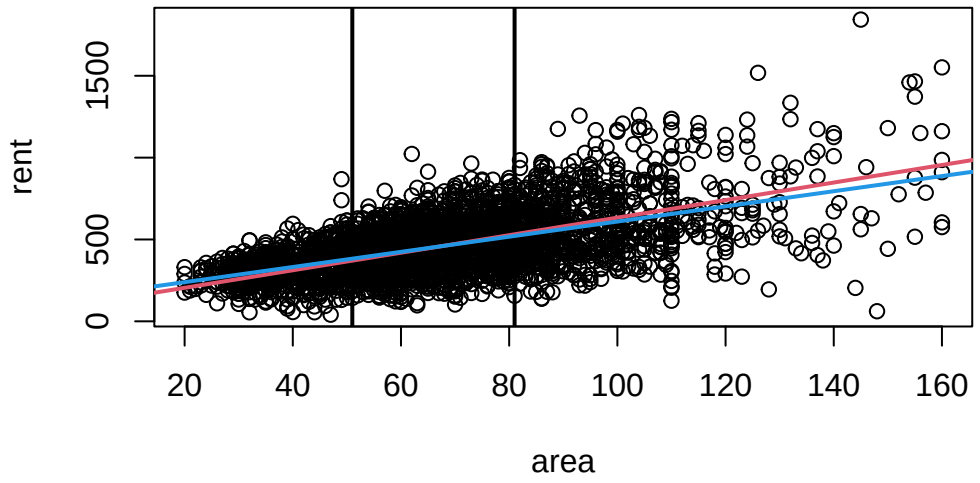
```
Call:
lm(formula = rent ~ area + I(yearc - 1956), data = data %>% filter(area >
    51, area < 81))

Residuals:
    Min      1Q  Median      3Q     Max
-373.56  -96.17   -8.46   90.30  528.87

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     146.5575    27.6437   5.302 1.32e-07 ***
area              4.6265     0.4173  11.086  < 2e-16 ***
I(yearc - 1956)   2.1478     0.1602  13.411  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 135 on 1520 degrees of freedom
Multiple R-squared:  0.1626,    Adjusted R-squared:  0.1614
F-statistic: 147.5 on 2 and 1520 DF,  p-value: < 2.2e-16
```

```
with(data,plot(area, rent))
abline(v=c(51,81), lwd=2, col=1) # two vertical lines
abline(c(97.42, 5.36), lwd=2, col=2) # linear function w/ intercept 97, slope 5
abline(c(146.56, 4.63), lwd=2, col=4)
```



We can observe that limiting data subset has a high impact on the model and how well it will fit.

residual SE = sigma

```
round(S$sigma,2)
```

```
[1] 149.3
```

```
round(S.3$sigma,2)
```

```
[1] 134.99
```

R^2

```
round(S$r.squared,2)
```

```
[1] 0.42
```

```
round(S.3$r.squared,2)
```

```
[1] 0.16
```

estimated beta's

```
round(coef(fit),2)
```

```
    (Intercept)            area I(yearc - 1956)
          97.42            5.36            2.49
```

```
round(coef(fit.3),2)
```

```
    (Intercept)            area I(yearc - 1956)
         146.56            4.63            2.15
```