testprojekt

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```
library("car")
```

```
## Warning: package 'car' was built under R version 4.4.3
```

```
## Loading required package: carData
```

```
## Warning: package 'carData' was built under R version 4.4.3
```

```
library("lmtest")
```

```
## Warning: package 'lmtest' was built under R version 4.4.3
```

```
## Loading required package: zoo
```

```
## Warning: package 'zoo' was built under R version 4.4.3
```

```
##
## Attaching package: 'zoo'
```

```
## The following objects are masked from 'package:base':
##
##     as.Date, as.Date.numeric
```

```
baltic_data <- read.csv("A8_baltic_DIN.csv")
# Ändrar datatyp för variabeln land från char till factor så att R sedan automatiskt dummykodar den vid
baltic_data$x20 <- as.factor(baltic_data$x20)
# Sätt Sverige som referens.
baltic_data$x20 <- relevel(baltic_data$x20, ref = "SWEDEN")
```

Testar full regressionsmodell:

```
full_model <- lm(y ~ x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 +
                     x12 + x13 + x14 + x15 + x16 + x17 + x18 + x19 +x20,
                     data = baltic_data)

model_1 <- step(full_model, direction = "both")
```

```
## Start:  AIC=1599.13
## y ~ x1 + x2 + x3 + x4 + x5 + x6 + x7 + x8 + x9 + x10 + x11 +
##     x12 + x13 + x14 + x15 + x16 + x17 + x18 + x19 + x20
##
##
## Step:  AIC=1599.13
## y ~ x1 + x2 + x3 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12 +
##     x13 + x14 + x15 + x16 + x17 + x18 + x19 + x20
##
##        Df Sum of Sq       RSS    AIC
## - x3    1    405369 263634827 1597.3
## - x5    1   2336050 265565508 1598.1
## <none>              263229458 1599.1
## - x14   1   6540703 269770161 1599.7
## - x6    1   6541220 269770678 1599.7
## - x7    1   6541242 269770700 1599.7
## - x13   1   6541245 269770703 1599.7
## - x1    1   6541245 269770703 1599.7
## - x11   1   6541246 269770704 1599.7
## - x10   1   6541248 269770705 1599.7
## - x8    1   6541248 269770706 1599.7
## - x9    1   6541254 269770711 1599.7
## - x15   1   6541283 269770741 1599.7
## - x12   1   6541296 269770753 1599.7
## - x2    1  35897987 299127444 1610.5
## - x16   1  42504449 305733907 1612.8
## - x18   1  52312500 315541957 1616.2
## - x20   7  96662889 359892347 1618.0
## - x19   1  62511580 325741038 1619.5
## - x17   1 208820094 472049552 1658.5
##
## Step:  AIC=1597.29
## y ~ x1 + x2 + x5 + x6 + x7 + x8 + x9 + x10 + x11 + x12 + x13 +
##     x14 + x15 + x16 + x17 + x18 + x19 + x20
##
##        Df Sum of Sq       RSS    AIC
## - x5    1   4273221 267908048 1597.0
## <none>              263634827 1597.3
## - x14   1   6215642 269850469 1597.7
## - x6    1   6216145 269850971 1597.7
## - x7    1   6216166 269850993 1597.7
## - x1    1   6216169 269850996 1597.7
## - x13   1   6216169 269850996 1597.7
## - x11   1   6216170 269850997 1597.7
## - x10   1   6216172 269850998 1597.7
## - x8    1   6216172 269850999 1597.7
## - x9    1   6216177 269851004 1597.7
## - x15   1   6216206 269851033 1597.7
## - x12   1   6216218 269851045 1597.7
## + x3    1    405369 263229458 1599.1
## + x4    1    405369 263229458 1599.1
## - x2    1  35963195 299598022 1608.7
## - x16   1  44314204 307949031 1611.6
## - x18   1  52070793 315705620 1614.2
```

```
## - x20   7  96327907 359962734 1616.0
## - x19   1  62475311 326110138 1617.6
## - x17   1 209001233 472636060 1656.6
##
## Step:  AIC=1596.98
## y ~ x1 + x2 + x6 + x7 + x8 + x9 + x10 + x11 + x12 + x13 + x14 +
##     x15 + x16 + x17 + x18 + x19 + x20
##
##        Df Sum of Sq       RSS    AIC
## <none>              267908048 1597.0
## + x5    1   4273221 263634827 1597.3
## - x14   1   6460210 274368258 1597.5
## - x6    1   6460710 274368758 1597.5
## - x7    1   6460732 274368780 1597.5
## - x13   1   6460735 274368782 1597.5
## - x1    1   6460735 274368783 1597.5
## - x11   1   6460736 274368784 1597.5
## - x10   1   6460737 274368785 1597.5
## - x8    1   6460738 274368786 1597.5
## - x9    1   6460745 274368793 1597.5
## - x15   1   6460768 274368815 1597.5
## - x12   1   6460784 274368832 1597.5
## + x3    1   2342539 265565508 1598.1
## + x4    1   2342539 265565508 1598.1
## - x2    1  32321331 300229379 1606.9
## - x16   1  44864433 312772481 1611.2
## - x20   7  92363997 360272044 1614.1
## - x18   1  54721138 322629186 1614.5
## - x19   1  62038293 329946341 1616.8
## - x17   1 205309945 473217993 1654.7
```

```
summary(model_1)
```

```
##
## Call:
## lm(formula = y ~ x1 + x2 + x6 + x7 + x8 + x9 + x10 + x11 + x12 +
##     x13 + x14 + x15 + x16 + x17 + x18 + x19 + x20, data = baltic_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4406.8  -792.1    -2.2   658.1  8106.4
##
## Coefficients:
##                Estimate Std. Error t value Pr(>|t|)
## (Intercept)   6.346e+03  2.015e+03   3.149 0.002293 **
## x1            1.082e+04  7.738e+03   1.398 0.166042
## x2           -2.525e-03  8.078e-04  -3.126 0.002460 **
## x6           -1.082e+04  7.738e+03  -1.398 0.166043
## x7           -1.082e+04  7.738e+03  -1.398 0.166042
## x8           -1.082e+04  7.738e+03  -1.398 0.166042
## x9           -1.082e+04  7.738e+03  -1.398 0.166042
## x10          -1.082e+04  7.738e+03  -1.398 0.166042
## x11          -1.082e+04  7.738e+03  -1.398 0.166042
## x12          -1.082e+04  7.738e+03  -1.398 0.166040
```

```
## x13          -1.082e+04  7.738e+03  -1.398 0.166042
## x14          -1.081e+04  7.738e+03  -1.398 0.166059
## x15          -1.082e+04  7.738e+03  -1.398 0.166041
## x16           5.036e+00  1.367e+00   3.683 0.000415 ***
## x17           6.519e-03  8.275e-04   7.879 1.30e-11 ***
## x18           2.397e-02  5.894e-03   4.067 0.000110 ***
## x19          -9.253e+01  2.137e+01  -4.331 4.22e-05 ***
## x20ESTONIA   -1.662e+03  1.151e+03  -1.444 0.152537
## x20FINLAND   -7.719e+02  5.631e+02  -1.371 0.174281
## x20LATVIA     1.891e+03  1.153e+03   1.640 0.104939
## x20LITHUANIA -3.283e+03  3.378e+03  -0.972 0.334088
## x20MISSING    7.963e+02  7.174e+02   1.110 0.270323
## x20POLAND     1.024e+04  7.264e+03   1.410 0.162277
## x20RUSSIA    -4.655e+03  2.151e+03  -2.164 0.033404 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1819 on 81 degrees of freedom
## Multiple R-squared:  0.977,  Adjusted R-squared:  0.9705
## F-statistic: 149.9 on 23 and 81 DF,  p-value: < 2.2e-16
```

Step tar bort x3, x4 och x5 som alla beskriver befolkning, x3, x4 andelar av samma, därav perfekt kolinearitet. Skattningsvärden på parametrar x1, x6-x15 är exakt samma vilket är högst orimligt -> tecken på stark kolinearitet då modellen har svårt att särskilja deras effekter. Lägger till x6-x15 i en ny variabel total_area som visar sig få samma värden som x1. Alltså har vi perfekt kolinearitet då x1 = x6+x7+x8+x9+x10+x11+x12+x13+x14+x15.

Provar göra om de till andelar för bättre tolkning och tar bort x14 (bara 3 observationer) för att simplifiera modellen och pga dess låga relevans för helhetsbilden.

```r
baltic_data$andel_lövskog <- baltic_data$x6 / baltic_data$x1
baltic_data$andel_barrskog <- baltic_data$x7 / baltic_data$x1
baltic_data$andel_blandskog <- baltic_data$x8 / baltic_data$x1
baltic_data$andel_buskveg <- baltic_data$x9 / baltic_data$x1
baltic_data$andel_våtmark <- baltic_data$x10 / baltic_data$x1
baltic_data$andel_jordbruk <- baltic_data$x11 / baltic_data$x1
baltic_data$andel_kala_ytor <- baltic_data$x12 / baltic_data$x1
baltic_data$andel_vatten <- baltic_data$x13 / baltic_data$x1
baltic_data$andel_artif_ytor <- baltic_data$x15 / baltic_data$x1

model_2 <- lm(y ~ x1 + x2 + andel_lövskog + andel_barrskog + andel_blandskog + andel_buskveg + andel_vå

summary(model_2)
```

```
##
## Call:
## lm(formula = y ~ x1 + x2 + andel_lövskog + andel_barrskog +
##     andel_blandskog + andel_buskveg + andel_våtmark + andel_jordbruk +
##     andel_kala_ytor + andel_vatten + andel_artif_ytor + x16 +
##     x17 + x18 + x19 + x20, data = baltic_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4338.6  -821.5    72.8   682.8  9028.9
```

```
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       1.061e+05  4.165e+05   0.255  0.79954
## x1                1.151e-03  1.598e-04   7.202 2.59e-10 ***
## x2               -2.349e-03  7.566e-04  -3.105  0.00261 **
## andel_lövskog    -1.103e+05  4.147e+05  -0.266  0.79101
## andel_barrskog   -1.010e+05  4.166e+05  -0.242  0.80900
## andel_blandskog  -1.027e+05  4.167e+05  -0.246  0.80593
## andel_buskveg    -9.951e+04  4.162e+05  -0.239  0.81165
## andel_våtmark    -1.174e+05  4.150e+05  -0.283  0.77807
## andel_jordbruk   -1.000e+05  4.167e+05  -0.240  0.81084
## andel_kala_ytor  -1.178e+05  4.522e+05  -0.261  0.79508
## andel_vatten     -1.067e+05  4.159e+05  -0.257  0.79816
## andel_artif_ytor -9.517e+04  4.170e+05  -0.228  0.82005
## x16               4.735e+00  1.546e+00   3.062  0.00297 **
## x17               7.321e-03  7.741e-04   9.458 8.84e-15 ***
## x18               6.803e-03  4.065e-03   1.673  0.09805 .
## x19              -6.656e+01  2.063e+01  -3.227  0.00180 **
## x20ESTONIA       -2.294e+03  1.370e+03  -1.674  0.09786 .
## x20FINLAND       -7.703e+02  6.766e+02  -1.139  0.25822
## x20LATVIA         1.585e+03  1.375e+03   1.153  0.25224
## x20LITHUANIA     -5.356e+03  3.130e+03  -1.711  0.09084 .
## x20MISSING        1.138e+03  8.363e+02   1.360  0.17748
## x20POLAND         9.619e+03  6.406e+03   1.502  0.13703
## x20RUSSIA        -3.352e+03  2.410e+03  -1.391  0.16805
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1987 on 82 degrees of freedom
## Multiple R-squared:  0.9722, Adjusted R-squared:  0.9648
## F-statistic: 130.6 on 22 and 82 DF,  p-value: < 2.2e-16
```

```
vif(model_2)
```

```
##                         GVIF Df GVIF^(1/(2*Df))
## x1              9.254079e+00  1        3.042052
## x2              1.245981e+02  1       11.162350
## andel_lövskog   3.168909e+03  1       56.293063
## andel_barrskog  2.552575e+05  1      505.230152
## andel_blandskog 7.081152e+04  1      266.104337
## andel_buskveg   7.847880e+03  1       88.588263
## andel_våtmark   6.835271e+03  1       82.675699
## andel_jordbruk  2.682427e+05  1      517.921529
## andel_kala_ytor 1.281930e+03  1       35.804055
## andel_vatten    8.170902e+03  1       90.393043
## andel_artif_ytor 9.857233e+02  1       31.396231
## x16             1.481031e+00  1        1.216976
## x17             2.499569e+01  1        4.999569
## x18             9.691965e+01  1        9.844778
## x19             3.530511e+00  1        1.878965
## x20             7.664956e+02  7        1.607076
```

```r
AIC(model_2)
```

```
## [1] 1914.885
```

```r
model_3 <- update(model_2, .~. - andel_barrskog)
summary(model_3)
```

```
##
## Call:
## lm(formula = y ~ x1 + x2 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + x17 + x18 + x19 +
##     x20, data = baltic_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4339.1  -824.7    55.6   677.6  9026.9
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       5.113e+03  2.143e+03   2.386  0.01929 *
## x1                1.152e-03  1.588e-04   7.254 1.95e-10 ***
## x2               -2.354e-03  7.520e-04  -3.130  0.00241 **
## andel_lövskog    -9.723e+03  9.715e+03  -1.001  0.31981
## andel_blandskog  -1.659e+03  2.193e+03  -0.757  0.45135
## andel_buskveg     1.401e+03  8.796e+03   0.159  0.87383
## andel_våtmark    -1.673e+04  7.654e+03  -2.186  0.03161 *
## andel_jordbruk    9.888e+02  1.837e+03   0.538  0.59180
## andel_kala_ytor  -8.271e+03  1.873e+04  -0.442  0.65991
## andel_vatten     -5.863e+03  5.920e+03  -0.990  0.32494
## andel_artif_ytor  5.868e+03  1.739e+04   0.337  0.73661
## x16               4.696e+00  1.529e+00   3.071  0.00288 **
## x17               7.315e-03  7.692e-04   9.510 6.25e-15 ***
## x18               6.835e-03  4.040e-03   1.692  0.09445 .
## x19              -6.675e+01  2.050e+01  -3.257  0.00163 **
## x20ESTONIA       -2.280e+03  1.361e+03  -1.675  0.09767 .
## x20FINLAND       -7.671e+02  6.726e+02  -1.140  0.25737
## x20LATVIA         1.605e+03  1.365e+03   1.176  0.24297
## x20LITHUANIA     -5.372e+03  3.111e+03  -1.726  0.08798 .
## x20MISSING        1.162e+03  8.256e+02   1.407  0.16313
## x20POLAND         9.644e+03  6.368e+03   1.514  0.13374
## x20RUSSIA        -3.347e+03  2.396e+03  -1.397  0.16618
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1976 on 83 degrees of freedom
## Multiple R-squared:  0.9722, Adjusted R-squared:  0.9652
## F-statistic: 138.4 on 21 and 83 DF,  p-value: < 2.2e-16
```

```r
vif(model_3)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
```

```
## x1                9.245609  1        3.040659
## x2              124.529554  1       11.159281
## andel_lövskog     1.758914  1        1.326240
## andel_blandskog   1.983119  1        1.408233
## andel_buskveg     3.544832  1        1.882772
## andel_våtmark     2.351301  1        1.533395
## andel_jordbruk    5.272912  1        2.296282
## andel_kala_ytor   2.224222  1        1.491382
## andel_vatten      1.674401  1        1.293987
## andel_artif_ytor  1.733242  1        1.316527
## x16               1.464461  1        1.210149
## x17              24.965648  1        4.996564
## x18              96.820193  1        9.839725
## x19               3.525594  1        1.877657
## x20             751.554963  7        1.604818
```

```
bptest(model_3)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_3
## BP = 67.003, df = 21, p-value = 1.054e-06
```

```
AIC(model_3)
```

```
## [1] 1912.96
```

Klart lägre VIF, innan borttag av andel_barrskog hade ingen andel VIF under 31 och 2 st över 500, nu är samtliga under 2.3. Minskad residual error 1987 -> 1976, liten ökning R^2 0.9648 -> 0.9652. Minskade standard errors på koefficienterna dock fortsatt höga p-värden på många.

Kollar korrelation mellan x2 och x18 pga deras VIF-värden kring 10.

```
cor(baltic_data$x2, baltic_data$x18, use = "complete.obs")
```

```
## [1] 0.9763909
```

Väldigt stark korrelation (0.976). Misstänker högre relevans för DIN av antal nötkreatur än befolkning i området, pga gödsel osv... (är ju inte mitt expertisområde direkt)

Provar därför ta bort x2 (befolkningen i området).

```
model_4 <- update(model_3, .~. - x2)
summary(model_4)
```

```
##
## Call:
## lm(formula = y ~ x1 + andel_lövskog + andel_blandskog + andel_buskveg +
##     andel_våtmark + andel_jordbruk + andel_kala_ytor + andel_vatten +
##     andel_artif_ytor + x16 + x17 + x18 + x19 + x20, data = baltic_data)
##
```

```
## Residuals:
##     Min      1Q  Median      3Q     Max
## -4469.8  -796.3     8.0   637.6 10990.9
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.736e+03  2.106e+03   1.300 0.197320
## x1                8.468e-04  1.317e-04   6.428 7.45e-09 ***
## andel_lövskog    -1.326e+04  1.014e+04  -1.307 0.194775
## andel_blandskog  -2.146e+03  2.299e+03  -0.934 0.353200
## andel_buskveg     6.639e+03  9.076e+03   0.731 0.466521
## andel_våtmark    -1.236e+04  7.910e+03  -1.563 0.121787
## andel_jordbruk    3.412e+03  1.751e+03   1.949 0.054605 .
## andel_kala_ytor  -1.740e+04  1.945e+04  -0.895 0.373483
## andel_vatten     -1.993e+03  6.085e+03  -0.328 0.744054
## andel_artif_ytor -1.357e+04  1.707e+04  -0.795 0.428934
## x16               5.561e+00  1.580e+00   3.519 0.000703 ***
## x17               6.856e-03  7.936e-04   8.638 3.17e-13 ***
## x18              -1.441e-03  3.210e-03  -0.449 0.654692
## x19              -4.395e+01  2.014e+01  -2.183 0.031843 *
## x20ESTONIA       -2.198e+03  1.430e+03  -1.536 0.128175
## x20FINLAND       -5.950e+02  7.046e+02  -0.844 0.400827
## x20LATVIA         1.942e+03  1.430e+03   1.358 0.178141
## x20LITHUANIA     -3.934e+03  3.234e+03  -1.216 0.227341
## x20MISSING        5.939e+02  8.465e+02   0.702 0.484911
## x20POLAND        -2.336e+03  5.350e+03  -0.437 0.663531
## x20RUSSIA        -4.982e+03  2.458e+03  -2.027 0.045851 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2077 on 84 degrees of freedom
## Multiple R-squared:  0.969,  Adjusted R-squared:  0.9616
## F-statistic: 131.1 on 20 and 84 DF,  p-value: < 2.2e-16
```

```
vif(model_4)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                5.756749  1        2.399323
## andel_lövskog     1.735175  1        1.317260
## andel_blandskog   1.973140  1        1.404685
## andel_buskveg     3.416505  1        1.848379
## andel_våtmark     2.273046  1        1.507662
## andel_jordbruk    4.335737  1        2.082243
## andel_kala_ytor   2.170297  1        1.473193
## andel_vatten      1.601393  1        1.265462
## andel_artif_ytor  1.512149  1        1.229695
## x16               1.416566  1        1.190196
## x17              24.056675  1        4.904760
## x18              55.346895  1        7.439549
## x19               3.080327  1        1.755086
## x20             327.146513  7        1.512253
```

```r
AIC(model_4)
```

```
## [1] 1922.674
```

Provar istället ta bort x18.

```r
model_5 <- update(model_3, .~. - x18)
summary(model_5)
```

```
##
## Call:
## lm(formula = y ~ x1 + x2 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + x17 + x19 + x20,
##     data = baltic_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -5121.4  -851.1     0.0   592.9  9187.9
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.671e+03  2.150e+03   2.173  0.03263 *
## x1                1.134e-03  1.602e-04   7.080 4.06e-10 ***
## x2               -1.521e-03  5.749e-04  -2.646  0.00972 **
## andel_lövskog    -1.314e+04  9.608e+03  -1.368  0.17506
## andel_blandskog  -1.823e+03  2.215e+03  -0.823  0.41288
## andel_buskveg     6.677e+03  8.315e+03   0.803  0.42420
## andel_våtmark    -1.676e+04  7.738e+03  -2.166  0.03318 *
## andel_jordbruk    2.168e+03  1.718e+03   1.262  0.21042
## andel_kala_ytor  -1.388e+04  1.864e+04  -0.745  0.45863
## andel_vatten     -4.589e+03  5.937e+03  -0.773  0.44174
## andel_artif_ytor -6.907e+02  1.714e+04  -0.040  0.96795
## x16               4.694e+00  1.546e+00   3.037  0.00318 **
## x17               7.913e-03  6.908e-04  11.455  < 2e-16 ***
## x19              -6.156e+01  2.049e+01  -3.005  0.00350 **
## x20ESTONIA       -2.521e+03  1.368e+03  -1.843  0.06892 .
## x20FINLAND       -7.985e+02  6.798e+02  -1.175  0.24346
## x20LATVIA         1.736e+03  1.378e+03   1.260  0.21109
## x20LITHUANIA     -2.602e+03  2.675e+03  -0.973  0.33346
## x20MISSING        8.331e+02  8.113e+02   1.027  0.30740
## x20POLAND         9.487e+03  6.438e+03   1.474  0.14432
## x20RUSSIA        -4.786e+03  2.265e+03  -2.113  0.03760 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 1998 on 84 degrees of freedom
## Multiple R-squared:  0.9713, Adjusted R-squared:  0.9644
## F-statistic:   142 on 20 and 84 DF,  p-value: < 2.2e-16
```

```r
vif(model_5)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                9.205478  1        3.034053
## x2               71.186846  1        8.437230
## andel_lövskog     1.682892  1        1.297263
## andel_blandskog   1.979277  1        1.406868
## andel_buskveg     3.099113  1        1.760430
## andel_våtmark     2.351293  1        1.533393
## andel_jordbruk    4.513124  1        2.124411
## andel_kala_ytor   2.154621  1        1.467863
## andel_vatten      1.647320  1        1.283480
## andel_artif_ytor  1.647073  1        1.283383
## x16               1.464461  1        1.210149
## x17              19.697720  1        4.438211
## x19               3.446607  1        1.856504
## x20             356.407975  7        1.521535
```

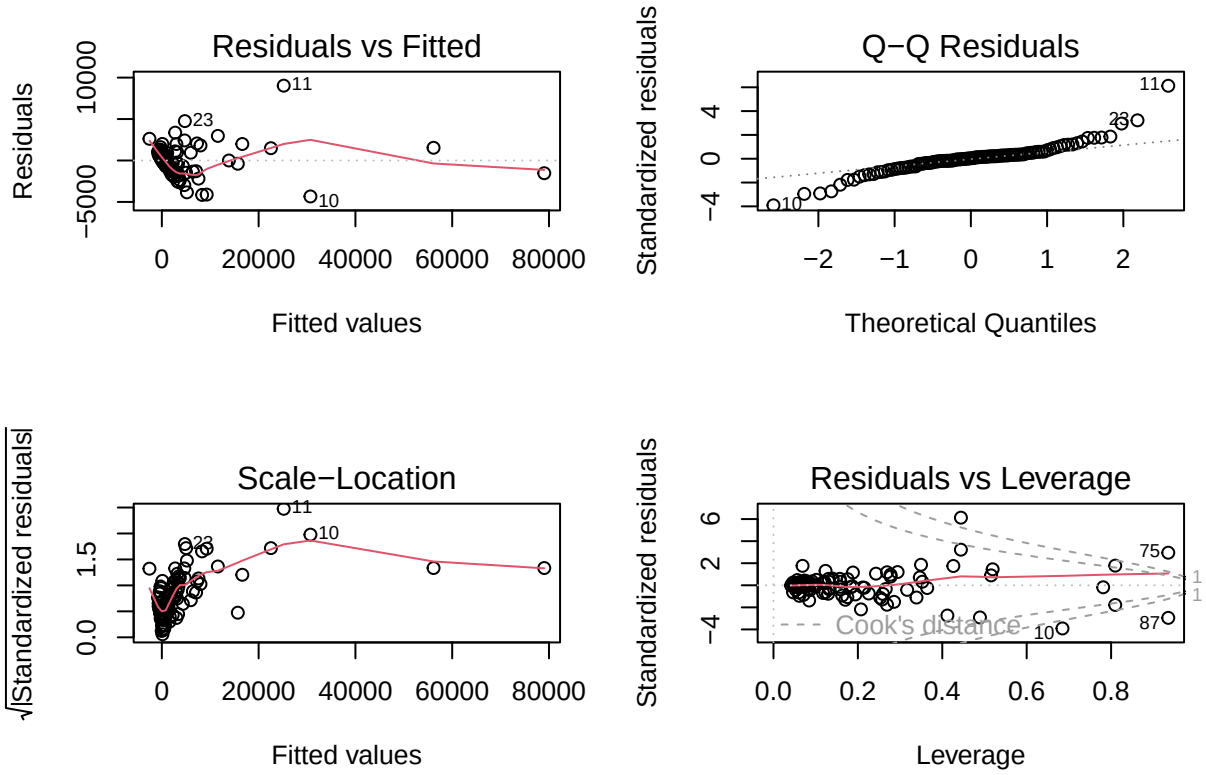
```r
AIC(model_5)
```

```
## [1] 1914.52
```

Påbörjar residualdiagnostik för fortsatt analys av modellen.

```r
par(mfrow = c(2, 2))
plot(model_3) # modell med både x2 och x18
```

```
## Warning: not plotting observations with leverage one:
##   74
```



Residuals vs fitted visar misstänkt linearitet och Scale-Location visar misstänkt heteroskedasticitet. Provar därför logaritmera y.

```
model_log <- lm(log(y) ~ x1 + x2 + andel_lövskog + andel_blandskog +  andel_buskveg + andel_våtmark + a
summary(model_log)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + x2 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + x17 + x18 + x19 +
##     x20, data = baltic_data)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.5228 -0.5809 -0.0093  0.5846  1.8964
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       5.297e+00  9.928e-01   5.335 8.12e-07 ***
## x1                2.268e-07  7.360e-08   3.081  0.00280 **
## x2               -7.680e-07  3.485e-07  -2.204  0.03030 *
## andel_lövskog     7.431e+00  4.502e+00   1.651  0.10258
## andel_blandskog  -5.429e-01  1.016e+00  -0.534  0.59458
## andel_buskveg     4.092e+00  4.076e+00   1.004  0.31831
## andel_våtmark     4.666e-01  3.547e+00   0.132  0.89565
```

```
## andel_jordbruk    1.415e+00  8.511e-01   1.663  0.10007
## andel_kala_ytor  -5.316e+00  8.679e+00  -0.613  0.54184
## andel_vatten      8.689e+00  2.743e+00   3.167  0.00215 **
## andel_artif_ytor  2.600e+01  8.057e+00   3.227  0.00179 **
## x16               2.038e-03  7.084e-04   2.876  0.00511 **
## x17               2.071e-07  3.564e-07   0.581  0.56277
## x18               3.839e-06  1.872e-06   2.051  0.04343 *
## x19              -1.764e-02  9.497e-03  -1.857  0.06681 .
## x20ESTONIA        6.086e-01  6.307e-01   0.965  0.33733
## x20FINLAND        7.232e-01  3.117e-01   2.320  0.02278 *
## x20LATVIA         1.285e+00  6.324e-01   2.032  0.04533 *
## x20LITHUANIA     -2.471e-01  1.442e+00  -0.171  0.86436
## x20MISSING        1.242e+00  3.826e-01   3.246  0.00169 **
## x20POLAND         1.970e+00  2.951e+00   0.668  0.50622
## x20RUSSIA         2.864e-01  1.110e+00   0.258  0.79713
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9157 on 83 degrees of freedom
## Multiple R-squared:  0.7963, Adjusted R-squared:  0.7447
## F-statistic: 15.45 on 21 and 83 DF,  p-value: < 2.2e-16
```

```
vif(model_log)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                9.245609  1        3.040659
## x2              124.529554  1       11.159281
## andel_lövskog     1.758914  1        1.326240
## andel_blandskog   1.983119  1        1.408233
## andel_buskveg     3.544832  1        1.882772
## andel_våtmark     2.351301  1        1.533395
## andel_jordbruk    5.272912  1        2.296282
## andel_kala_ytor   2.224222  1        1.491382
## andel_vatten      1.674401  1        1.293987
## andel_artif_ytor  1.733242  1        1.316527
## x16               1.464461  1        1.210149
## x17              24.965648  1        4.996564
## x18              96.820193  1        9.839725
## x19               3.525594  1        1.877657
## x20             751.554963  7        1.604818
```

```
bptest(model_log)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_log
## BP = 15.478, df = 21, p-value = 0.7982
```

```
resettest(model_log)
```

```
##
```

```
##  RESET test
##
## data:  model_log
## RESET = 24.223, df1 = 2, df2 = 81, p-value = 5.676e-09
```

```
AIC(model_log)
```

```
## [1] 300.7951
```

Kollar korrelationer mellan förklarande variabler.

```
cor(baltic_data[, c("x1", "x2", "andel_lövskog", "andel_blandskog", "andel_buskveg", "andel_våtmark", "a
```

```
##                          x1          x2 andel_lövskog andel_blandskog
## x1                1.00000000  0.73823236    0.11688894     -0.20601103
## x2                0.73823236  1.00000000    0.02554011     -0.24435355
## andel_lövskog     0.11688894  0.02554011    1.00000000     -0.17073280
## andel_blandskog  -0.20601103 -0.24435355   -0.17073280      1.00000000
## andel_buskveg     0.23286539  0.28372954    0.51942630     -0.36168112
## andel_våtmark     0.05199178 -0.08026152    0.15720303     -0.06732014
## andel_jordbruk    0.13893686  0.32543770    0.27316372     -0.34717934
## andel_kala_ytor   0.03374788 -0.05631930    0.18995969     -0.14363658
## andel_vatten      0.22393964 -0.05314982   -0.04424842     -0.10928690
## andel_artif_ytor -0.01594683  0.13609123   -0.03341781     -0.13232850
## x16              -0.14988632 -0.19631863    0.03741963      0.11352601
## x17               0.54544669  0.93276738   -0.01131147     -0.27993497
## x18               0.65703045  0.97639094    0.03257076     -0.27977706
## x19              -0.49670940 -0.39140253   -0.25478259      0.11906859
##                  andel_buskveg andel_våtmark andel_jordbruk andel_kala_ytor
## x1                  0.23286539    0.05199178      0.1389369      0.03374788
## x2                  0.28372954   -0.08026152      0.3254377     -0.05631930
## andel_lövskog       0.51942630    0.15720303      0.2731637      0.18995969
## andel_blandskog    -0.36168112   -0.06732014     -0.3471793     -0.14363658
## andel_buskveg       1.00000000    0.33214337      0.4307362      0.39890585
## andel_våtmark       0.33214337    1.00000000     -0.3155564      0.64283937
## andel_jordbruk      0.43073623   -0.31555635      1.0000000     -0.20812391
## andel_kala_ytor     0.39890585    0.64283937     -0.2081239      1.00000000
## andel_vatten       -0.12769711    0.03424421     -0.3046832      0.11156620
## andel_artif_ytor   -0.04628347   -0.20474945      0.3454442     -0.12357007
## x16                 0.14009713    0.26646128     -0.1904815      0.31925282
## x17                 0.29289132   -0.07423739      0.4131103     -0.05270375
## x18                 0.34796186   -0.08495323      0.4098365     -0.06154134
## x19                -0.29155925    0.21356381     -0.4959010      0.16218436
##                  andel_vatten andel_artif_ytor         x16         x17
## x1                 0.22393964      -0.01594683 -0.14988632  0.54544669
## x2                -0.05314982       0.13609123 -0.19631863  0.93276738
## andel_lövskog     -0.04424842      -0.03341781  0.03741963 -0.01131147
## andel_blandskog   -0.10928690      -0.13232850  0.11352601 -0.27993497
## andel_buskveg     -0.12769711      -0.04628347  0.14009713  0.29289132
## andel_våtmark      0.03424421      -0.20474945  0.26646128 -0.07423739
## andel_jordbruk    -0.30468321       0.34544418 -0.19048146  0.41311028
## andel_kala_ytor    0.11156620      -0.12357007  0.31925282 -0.05270375
```

```
## andel_vatten       1.00000000      -0.04028571 -0.03890626 -0.11658826
## andel_artif_ytor  -0.04028571       1.00000000 -0.06432461  0.20718432
## x16               -0.03890626      -0.06432461  1.00000000 -0.14891009
## x17               -0.11658826       0.20718432 -0.14891009  1.00000000
## x18               -0.10477959       0.14204687 -0.19830987  0.95580852
## x19                0.12211829       0.08892486  0.12969710 -0.24433975
##                         x18         x19
## x1                0.65703045 -0.49670940
## x2                0.97639094 -0.39140253
## andel_lövskog     0.03257076 -0.25478259
## andel_blandskog  -0.27977706  0.11906859
## andel_buskveg     0.34796186 -0.29155925
## andel_våtmark    -0.08495323  0.21356381
## andel_jordbruk    0.40983650 -0.49590100
## andel_kala_ytor  -0.06154134  0.16218436
## andel_vatten     -0.10477959  0.12211829
## andel_artif_ytor  0.14204687  0.08892486
## x16              -0.19830987  0.12969710
## x17               0.95580852 -0.24433975
## x18               1.00000000 -0.35943372
## x19              -0.35943372  1.00000000
```

Provar ta bort x18.

```
model_log_reduced_x18 <- lm(log(y) ~ x1 + x2 + andel_lövskog + andel_blandskog +  andel_buskveg + andel_
summary(model_log_reduced_x18)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + x2 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + x17 + x19 + x20,
##     data = baltic_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.52034 -0.58375  0.03557  0.54223  1.93123
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       5.048e+00  1.004e+00   5.028 2.76e-06 ***
## x1                2.168e-07  7.482e-08   2.898  0.00479 **
## x2               -3.002e-07  2.685e-07  -1.118  0.26658
## andel_lövskog     5.511e+00  4.487e+00   1.228  0.22272
## andel_blandskog  -6.346e-01  1.034e+00  -0.614  0.54117
## andel_buskveg     7.056e+00  3.883e+00   1.817  0.07276 .
## andel_våtmark     4.532e-01  3.614e+00   0.125  0.90049
## andel_jordbruk    2.078e+00  8.023e-01   2.590  0.01131 *
## andel_kala_ytor  -8.465e+00  8.703e+00  -0.973  0.33355
## andel_vatten      9.405e+00  2.773e+00   3.392  0.00106 **
## andel_artif_ytor  2.231e+01  8.003e+00   2.788  0.00656 **
## x16               2.037e-03  7.218e-04   2.821  0.00596 **
## x17               5.429e-07  3.226e-07   1.683  0.09610 .
```

```
## x19              -1.472e-02  9.568e-03  -1.539  0.12758
## x20ESTONIA        4.729e-01  6.390e-01   0.740  0.46132
## x20FINLAND        7.056e-01  3.174e-01   2.223  0.02893 *
## x20LATVIA         1.359e+00  6.434e-01   2.112  0.03764 *
## x20LITHUANIA      1.309e+00  1.249e+00   1.048  0.29779
## x20MISSING        1.057e+00  3.788e-01   2.791  0.00651 **
## x20POLAND         1.882e+00  3.006e+00   0.626  0.53299
## x20RUSSIA        -5.216e-01  1.058e+00  -0.493  0.62327
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.933 on 84 degrees of freedom
## Multiple R-squared:  0.7859, Adjusted R-squared:  0.735
## F-statistic: 15.42 on 20 and 84 DF,  p-value: < 2.2e-16
```

```
vif(model_log_reduced_x18)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                9.205478  1        3.034053
## x2               71.186846  1        8.437230
## andel_lövskog     1.682892  1        1.297263
## andel_blandskog   1.979277  1        1.406868
## andel_buskveg     3.099113  1        1.760430
## andel_våtmark     2.351293  1        1.533393
## andel_jordbruk    4.513124  1        2.124411
## andel_kala_ytor   2.154621  1        1.467863
## andel_vatten      1.647320  1        1.283480
## andel_artif_ytor  1.647073  1        1.283383
## x16               1.464461  1        1.210149
## x17              19.697720  1        4.438211
## x19               3.446607  1        1.856504
## x20             356.407975  7        1.521535
```

```
bptest(model_log_reduced_x18)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_log_reduced_x18
## BP = 13.188, df = 20, p-value = 0.8692
```

```
resettest(model_log_reduced_x18)
```

```
##
##  RESET test
##
## data:  model_log_reduced_x18
## RESET = 24.287, df1 = 2, df2 = 82, p-value = 5.201e-09
```

```
AIC(model_log_reduced_x18)
```

```
## [1] 303.9857
```

Provar ta bort x2.

```
model_log_reduced_x2 <- lm(log(y) ~ x1 + andel_lövskog + andel_blandskog +  andel_buskveg + andel_våtma
summary(model_log_reduced_x2)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + x17 + x18 + x19 +
##     x20, data = baltic_data)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.51225 -0.52263  0.05679  0.51937  1.84101
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.521e+00  9.494e-01   4.762 7.91e-06 ***
## x1                1.271e-07  5.939e-08   2.141 0.035198 *
## andel_lövskog     6.278e+00  4.573e+00   1.373 0.173411
## andel_blandskog  -7.017e-01  1.037e+00  -0.677 0.500267
## andel_buskveg     5.801e+00  4.092e+00   1.418 0.160007
## andel_våtmark     1.893e+00  3.566e+00   0.531 0.597038
## andel_jordbruk    2.206e+00  7.893e-01   2.795 0.006426 **
## andel_kala_ytor  -8.294e+00  8.767e+00  -0.946 0.346843
## andel_vatten      9.952e+00  2.744e+00   3.627 0.000491 ***
## andel_artif_ytor  1.966e+01  7.697e+00   2.554 0.012464 *
## x16               2.320e-03  7.126e-04   3.256 0.001631 **
## x17               5.722e-08  3.578e-07   0.160 0.873333
## x18               1.139e-06  1.448e-06   0.787 0.433537
## x19              -1.020e-02  9.079e-03  -1.124 0.264371
## x20ESTONIA        6.355e-01  6.448e-01   0.985 0.327233
## x20FINLAND        7.794e-01  3.177e-01   2.453 0.016224 *
## x20LATVIA         1.395e+00  6.448e-01   2.164 0.033323 *
## x20LITHUANIA      2.223e-01  1.458e+00   0.152 0.879228
## x20MISSING        1.057e+00  3.817e-01   2.768 0.006932 **
## x20POLAND        -1.939e+00  2.412e+00  -0.804 0.423835
## x20RUSSIA        -2.471e-01  1.108e+00  -0.223 0.824138
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9365 on 84 degrees of freedom
## Multiple R-squared:  0.7843, Adjusted R-squared:  0.733
## F-statistic: 15.28 on 20 and 84 DF,  p-value: < 2.2e-16
```

```
vif(model_log_reduced_x2)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                5.756749  1        2.399323
## andel_lövskog     1.735175  1        1.317260
## andel_blandskog   1.973140  1        1.404685
## andel_buskveg     3.416505  1        1.848379
```

```
## andel_våtmark      2.273046  1        1.507662
## andel_jordbruk     4.335737  1        2.082243
## andel_kala_ytor    2.170297  1        1.473193
## andel_vatten       1.601393  1        1.265462
## andel_artif_ytor   1.512149  1        1.229695
## x16                1.416566  1        1.190196
## x17               24.056675  1        4.904760
## x18               55.346895  1        7.439549
## x19                3.080327  1        1.755086
## x20              327.146513  7        1.512253
```

```
bptest(model_log_reduced_x2)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_log_reduced_x2
## BP = 14.192, df = 20, p-value = 0.8206
```

```
resettest(model_log_reduced_x2)
```

```
##
##  RESET test
##
## data:  model_log_reduced_x2
## RESET = 27.958, df1 = 2, df2 = 82, p-value = 5.522e-10
```

```
AIC(model_log_reduced_x2)
```

```
## [1] 304.7665
```

Liknande värden vid borttag av antingen x2 eller x18. Lite försämringar på AIC, R^2 men bättre VIF-värden, ingen över 10 längre. Fortfarande vif-värden över minst 7 på den ej borttagna. Väljer att ta bort x2 då jag anser att det är mer relevant att ha kvar x18 som speglar gödselanvändningen (innehåller mycket kväve) och lägger ihop x17 + x18 till total_livestock för att minska kolinearitet.

Tar bort x20:LITHUANIA pga endast 1 observation, orsakar singularitet i mätvärden och har ändå liten relevans för modellen och. Lägger även ihop

```
baltic_data_no_LITHUANIA <- subset(baltic_data, x20 != "LITHUANIA")
baltic_data_no_LITHUANIA$total_livestock <- baltic_data_no_LITHUANIA$x17 + baltic_data_no_LITHUANIA$x18
model_log_livestock <- lm(log(y) ~ x1 + andel_lövskog + andel_blandskog +  andel_buskveg + andel_våtmark
summary(model_log_livestock)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + total_livestock +
##     x19 + x20, data = baltic_data_no_LITHUANIA)
##
```

```
## Residuals:
##      Min       1Q   Median       3Q      Max
## -2.51763 -0.53007  0.02618  0.53626  1.86883
##
## Coefficients:
##                     Estimate Std. Error t value Pr(>|t|)
## (Intercept)       4.626e+00  9.308e-01   4.970 3.43e-06 ***
## x1                1.465e-07  5.039e-08   2.907 0.004659 **
## andel_lövskog     5.833e+00  4.500e+00   1.296 0.198393
## andel_blandskog  -6.903e-01  1.033e+00  -0.668 0.505655
## andel_buskveg     6.584e+00  3.879e+00   1.697 0.093264 .
## andel_våtmark     1.521e+00  3.503e+00   0.434 0.665220
## andel_jordbruk    2.255e+00  7.826e-01   2.881 0.005021 **
## andel_kala_ytor  -8.826e+00  8.694e+00  -1.015 0.312878
## andel_vatten      9.932e+00  2.734e+00   3.633 0.000478 ***
## andel_artif_ytor  1.966e+01  7.669e+00   2.563 0.012138 *
## x16               2.247e-03  7.003e-04   3.209 0.001880 **
## total_livestock   2.480e-07  1.826e-07   1.358 0.178013
## x19              -1.099e-02  8.956e-03  -1.228 0.222981
## x20ESTONIA        5.784e-01  6.359e-01   0.909 0.365677
## x20FINLAND        7.573e-01  3.145e-01   2.408 0.018224 *
## x20LATVIA         1.401e+00  6.424e-01   2.182 0.031898 *
## x20MISSING        1.027e+00  3.772e-01   2.721 0.007887 **
## x20POLAND        -1.125e+00  2.017e+00  -0.558 0.578572
## x20RUSSIA        -4.316e-01  1.064e+00  -0.406 0.685941
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.9331 on 85 degrees of freedom
## Multiple R-squared:  0.7782, Adjusted R-squared:  0.7313
## F-statistic: 16.57 on 18 and 85 DF,  p-value: < 2.2e-16
```

```
vif(model_log_livestock)
```

```
##                       GVIF Df GVIF^(1/(2*Df))
## x1                4.006121  1        2.001530
## andel_lövskog     1.690423  1        1.300163
## andel_blandskog   1.957943  1        1.399265
## andel_buskveg     3.049557  1        1.746298
## andel_våtmark     2.206517  1        1.485435
## andel_jordbruk    4.196043  1        2.048424
## andel_kala_ytor   2.148553  1        1.465794
## andel_vatten      1.589611  1        1.260798
## andel_artif_ytor  1.512077  1        1.229665
## x16               1.360805  1        1.166535
## total_livestock  11.587920  1        3.404103
## x19               2.830556  1        1.682425
## x20             136.389491  6        1.506255
```

```
bptest(model_log_livestock)
```

```
##
##  studentized Breusch-Pagan test
```

```
##
## data:  model_log_livestock
## BP = 12.46, df = 18, p-value = 0.8226
```

```
resettest(model_log_livestock)
```

```
##
##  RESET test
##
## data:  model_log_livestock
## RESET = 27.678, df1 = 2, df2 = 83, p-value = 6.17e-10
```

```
AIC(model_log_livestock)
```

```
## [1] 299.754
```

Mycket bättre VIF-värden samt en sänkning av AIC till den lägsta hittills. R^2 ganska oförändrat.

Provar lägga till interaktion mellan x16 och x20.

```
model_log_livestock_rm_Lithuania_int_x16_x20 <- lm(log(y) ~ x1 + andel_lövskog + andel_blandskog +  ande

summary(model_log_livestock_rm_Lithuania_int_x16_x20)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 * x20 + total_livestock +
##     x19, data = baltic_data_no_LITHUANIA)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.7490 -0.4290  0.0000  0.4644  1.5885
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)       2.782e+00  9.219e-01   3.017 0.003432 **
## x1                3.921e-07  8.713e-08   4.500 2.31e-05 ***
## andel_lövskog     7.762e+00  4.337e+00   1.790 0.077331 .
## andel_blandskog  -6.743e-02  9.273e-01  -0.073 0.942213
## andel_buskveg     4.888e+00  3.578e+00   1.366 0.175713
## andel_våtmark    -2.824e+00  3.217e+00  -0.878 0.382666
## andel_jordbruk    2.162e+00  7.309e-01   2.957 0.004092 **
## andel_kala_ytor  -1.310e+01  8.163e+00  -1.605 0.112567
## andel_vatten      7.248e+00  2.522e+00   2.874 0.005202 **
## andel_artif_ytor  1.505e+01  6.856e+00   2.196 0.031035 *
## x16               4.821e-03  1.227e-03   3.929 0.000181 ***
## x20ESTONIA        2.391e+00  2.567e+00   0.932 0.354356
## x20FINLAND        2.343e+00  5.725e-01   4.093 0.000102 ***
## x20LATVIA         4.140e+00  1.940e+00   2.134 0.035914 *
## x20MISSING        1.748e+00  6.130e-01   2.851 0.005559 **
```

```
## x20POLAND         1.667e+01  6.083e+00   2.741 0.007572 **
## x20RUSSIA         3.620e+01  1.051e+01   3.445 0.000916 ***
## total_livestock   3.163e-07  1.983e-07   1.596 0.114579
## x19              -1.004e-03  8.500e-03  -0.118 0.906313
## x16:x20ESTONIA   -5.977e-03  8.830e-03  -0.677 0.500460
## x16:x20FINLAND   -4.699e-03  1.581e-03  -2.972 0.003916 **
## x16:x20LATVIA    -1.151e-02  7.795e-03  -1.477 0.143699
## x16:x20MISSING   -1.789e-03  1.554e-03  -1.151 0.253247
## x16:x20POLAND    -1.122e-01  3.687e-02  -3.044 0.003168 **
## x16:x20RUSSIA    -1.705e-01  4.936e-02  -3.454 0.000892 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.8229 on 79 degrees of freedom
## Multiple R-squared:  0.8397, Adjusted R-squared:  0.791
## F-statistic: 17.24 on 24 and 79 DF,  p-value: < 2.2e-16
```

```
vif(model_log_livestock_rm_Lithuania_int_x16_x20)
```

```
## there are higher-order terms (interactions) in this model
## consider setting type = 'predictor'; see ?vif

##                          GVIF Df GVIF^(1/(2*Df))
## x1               1.539920e+01  1        3.924182
## andel_lövskog    2.019227e+00  1        1.420995
## andel_blandskog  2.029803e+00  1        1.424711
## andel_buskveg    3.336178e+00  1        1.826521
## andel_våtmark    2.392709e+00  1        1.546838
## andel_jordbruk   4.705078e+00  1        2.169119
## andel_kala_ytor  2.434959e+00  1        1.560436
## andel_vatten     1.739072e+00  1        1.318739
## andel_artif_ytor 1.553583e+00  1        1.246428
## x16              5.369845e+00  1        2.317293
## x20              1.561342e+09  6        5.836129
## total_livestock  1.756721e+01  1        4.191326
## x19              3.278034e+00  1        1.810534
## x16:x20          3.165008e+09  6        6.190103
```

```
bptest(model_log_livestock_rm_Lithuania_int_x16_x20)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_log_livestock_rm_Lithuania_int_x16_x20
## BP = 15.383, df = 24, p-value = 0.909
```

```
resettest(model_log_livestock_rm_Lithuania_int_x16_x20)
```

```
##
##  RESET test
##
## data:  model_log_livestock_rm_Lithuania_int_x16_x20
## RESET = 20.544, df1 = 2, df2 = 77, p-value = 7.08e-08
```

```r
AIC(model_log_livestock_rm_Lithuania_int_x16_x20)
```

```
## [1] 278.0091
```

Provar istället att lägga till interaktion mellan x19 och x20.

```r
model_log_livestock_rm_Lithuania_int_x19_x20 <- lm(log(y) ~ x1 + andel_lövskog + andel_blandskog +  ande

summary(model_log_livestock_rm_Lithuania_int_x19_x20)
```

```
##
## Call:
## lm(formula = log(y) ~ x1 + andel_lövskog + andel_blandskog +
##     andel_buskveg + andel_våtmark + andel_jordbruk + andel_kala_ytor +
##     andel_vatten + andel_artif_ytor + x16 + total_livestock +
##     x19 * x20, data = baltic_data_no_LITHUANIA)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -2.3126 -0.4162 -0.0418  0.4672  1.5430
##
## Coefficients:
##                    Estimate Std. Error t value Pr(>|t|)
## (Intercept)      -3.035e+01  2.143e+01  -1.417 0.160506
## x1                7.708e-07  1.143e-07   6.744 2.30e-09 ***
## andel_lövskog     7.946e+00  3.938e+00   2.018 0.047001 *
## andel_blandskog  -5.817e-01  8.743e-01  -0.665 0.507768
## andel_buskveg     2.725e+00  3.594e+00   0.758 0.450686
## andel_våtmark    -1.212e+00  3.272e+00  -0.370 0.712120
## andel_jordbruk    2.533e+00  6.892e-01   3.676 0.000431 ***
## andel_kala_ytor  -1.048e+01  7.800e+00  -1.343 0.183143
## andel_vatten      4.651e+00  2.483e+00   1.873 0.064723 .
## andel_artif_ytor  1.525e+01  6.569e+00   2.321 0.022883 *
## x16               2.411e-03  5.992e-04   4.023 0.000131 ***
## total_livestock   2.074e-07  1.880e-07   1.103 0.273351
## x19               3.683e-01  2.337e-01   1.576 0.119018
## x20ESTONIA        2.921e+01  2.132e+01   1.370 0.174527
## x20FINLAND       -4.158e+01  3.270e+01  -1.272 0.207264
## x20LATVIA         2.792e+01  2.124e+01   1.315 0.192407
## x20MISSING        3.539e+01  2.135e+01   1.657 0.101447
## x20POLAND        -4.972e+01  2.627e+01  -1.893 0.062084 .
## x20RUSSIA        -4.575e+01  2.379e+01  -1.923 0.058076 .
## x19:x20ESTONIA   -2.901e-01  2.339e-01  -1.240 0.218632
## x19:x20FINLAND    5.973e-01  3.982e-01   1.500 0.137587
## x19:x20LATVIA    -2.558e-01  2.335e-01  -1.096 0.276480
## x19:x20MISSING   -3.759e-01  2.334e-01  -1.610 0.111332
## x19:x20POLAND     1.146e+00  3.884e-01   2.951 0.004172 **
## x19:x20RUSSIA     2.270e+00  4.832e-01   4.698 1.09e-05 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.7863 on 79 degrees of freedom
```

```
## Multiple R-squared:  0.8537, Adjusted R-squared:  0.8092
## F-statistic:  19.2 on 24 and 79 DF,  p-value: < 2.2e-16
```

```
vif(model_log_livestock_rm_Lithuania_int_x19_x20, type ="predictor")
```

```
## GVIFs computed for predictors
```

```
##                        GVIF Df GVIF^(1/(2*Df)) Interacts With
## x1                 29.028518  1        5.387812           --
## andel_lövskog       1.823337  1        1.350310           --
## andel_blandskog     1.976823  1        1.405995           --
## andel_buskveg       3.688424  1        1.920527           --
## andel_våtmark       2.711612  1        1.646697           --
## andel_jordbruk      4.582463  1        2.140669           --
## andel_kala_ytor     2.435878  1        1.560730           --
## andel_vatten        1.846858  1        1.358992           --
## andel_artif_ytor    1.562637  1        1.250055           --
## x16                 1.402875  1        1.184430           --
## total_livestock    17.304063  1        4.159815           --
## x19              3127.661770 13        1.362798           x20
## x20              3127.661770 13        1.362798           x19
##
## x1               andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel_jordbruk, andel
## andel_lövskog              x1, andel_blandskog, andel_buskveg, andel_våtmark, andel_jordbruk, andel
## andel_blandskog              x1, andel_lövskog, andel_buskveg, andel_våtmark, andel_jordbruk, andel
## andel_buskveg              x1, andel_lövskog, andel_blandskog, andel_våtmark, andel_jordbruk, andel
## andel_våtmark              x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_jordbruk, andel
## andel_jordbruk              x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel
## andel_kala_ytor              x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, ande
## andel_vatten               x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel_j
## andel_artif_ytor              x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, and
## x16               x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel_jordbruk, a
## total_livestock              x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, ande
## x19                   x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel_jordbr
## x20                   x1, andel_lövskog, andel_blandskog, andel_buskveg, andel_våtmark, andel_jordbr
```

```
bptest(model_log_livestock_rm_Lithuania_int_x19_x20)
```

```
##
##  studentized Breusch-Pagan test
##
## data:  model_log_livestock_rm_Lithuania_int_x19_x20
## BP = 16.52, df = 24, p-value = 0.8684
```

```
resettest(model_log_livestock_rm_Lithuania_int_x19_x20)
```

```
##
##  RESET test
##
## data:  model_log_livestock_rm_Lithuania_int_x19_x20
## RESET = 14.806, df1 = 2, df2 = 77, p-value = 3.626e-06
```

```
AIC(model_log_livestock_rm_Lithuania_int_x19_x20)
```

```
## [1] 268.5298
```

Får lägre AIC 268 gentemot 278 med interaktionen mellan x16 och x20 och liten förbättring av R^2.

```
par(mfrow = c(2, 2))
plot(model_log_livestock_rm_Lithuania_int_x19_x20)
```

```
## Warning: not plotting observations with leverage one:
##   74, 78, 86, 104
```

```
## Warning in sqrt(crit * p * (1 - hh)/hh): NaNs produced
## Warning in sqrt(crit * p * (1 - hh)/hh): NaNs produced
```