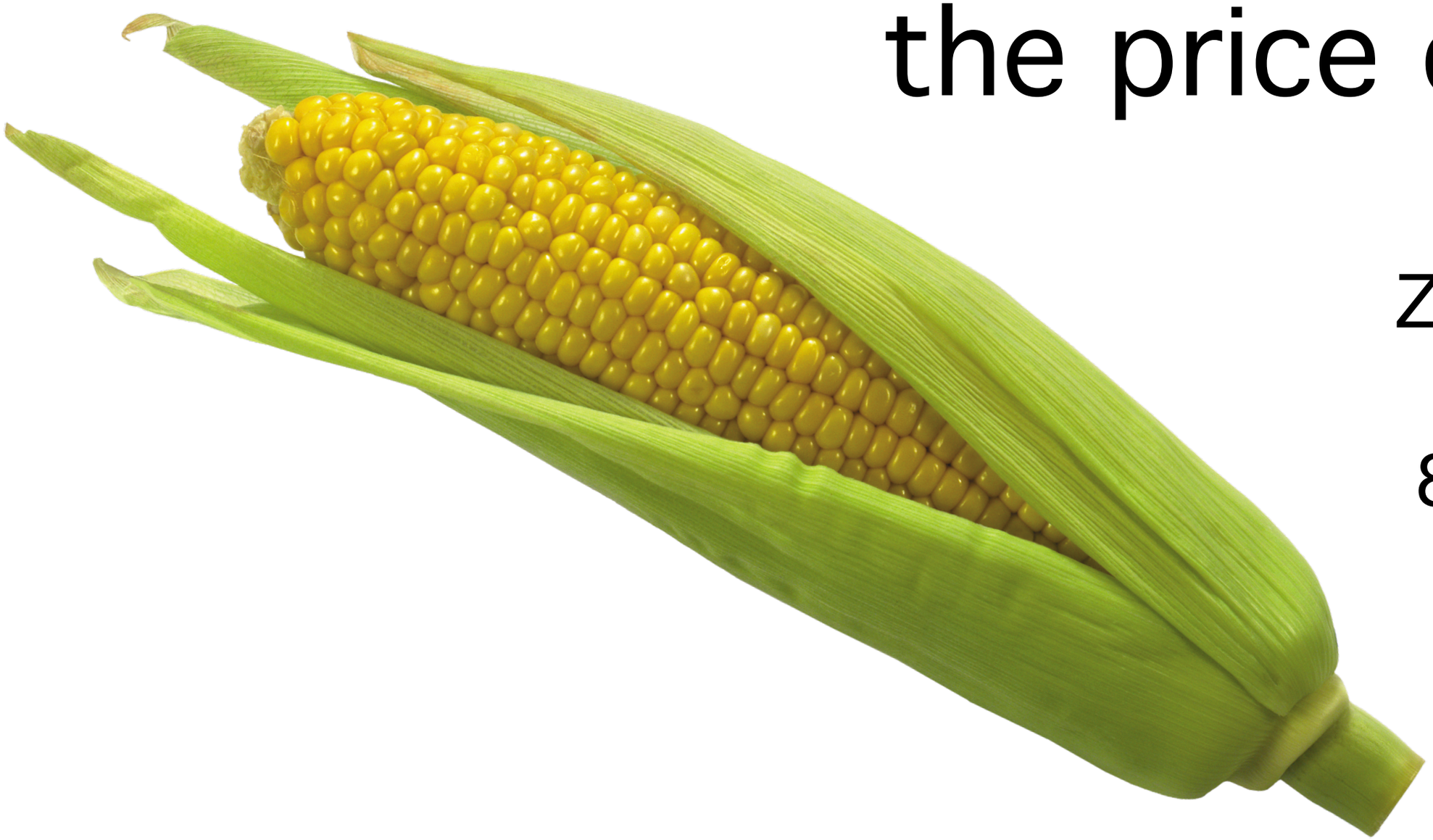
Analysis of USDA feed grains database to predict the price of corn



Zane Billings

MATH 375

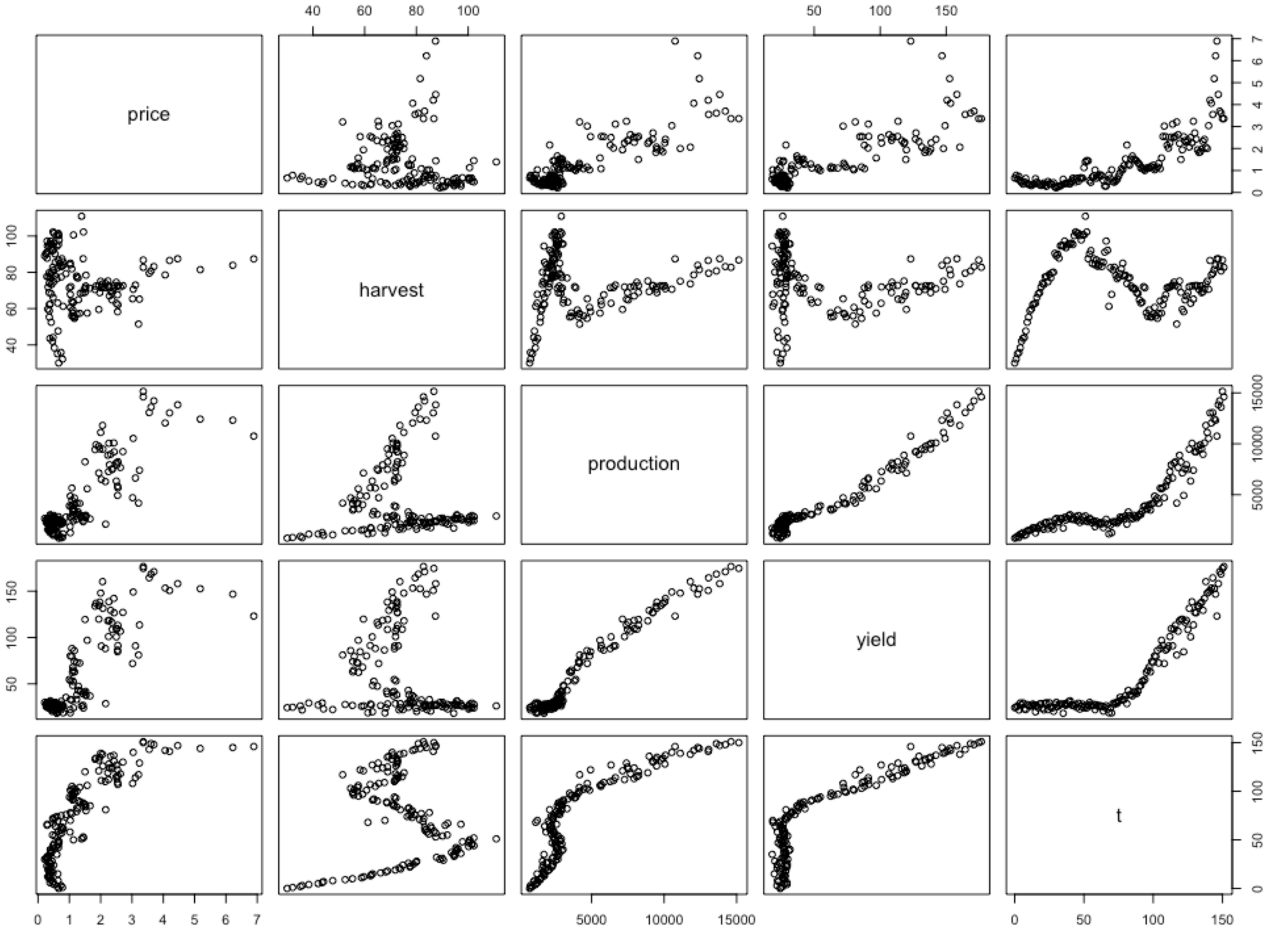
8 May, 2019

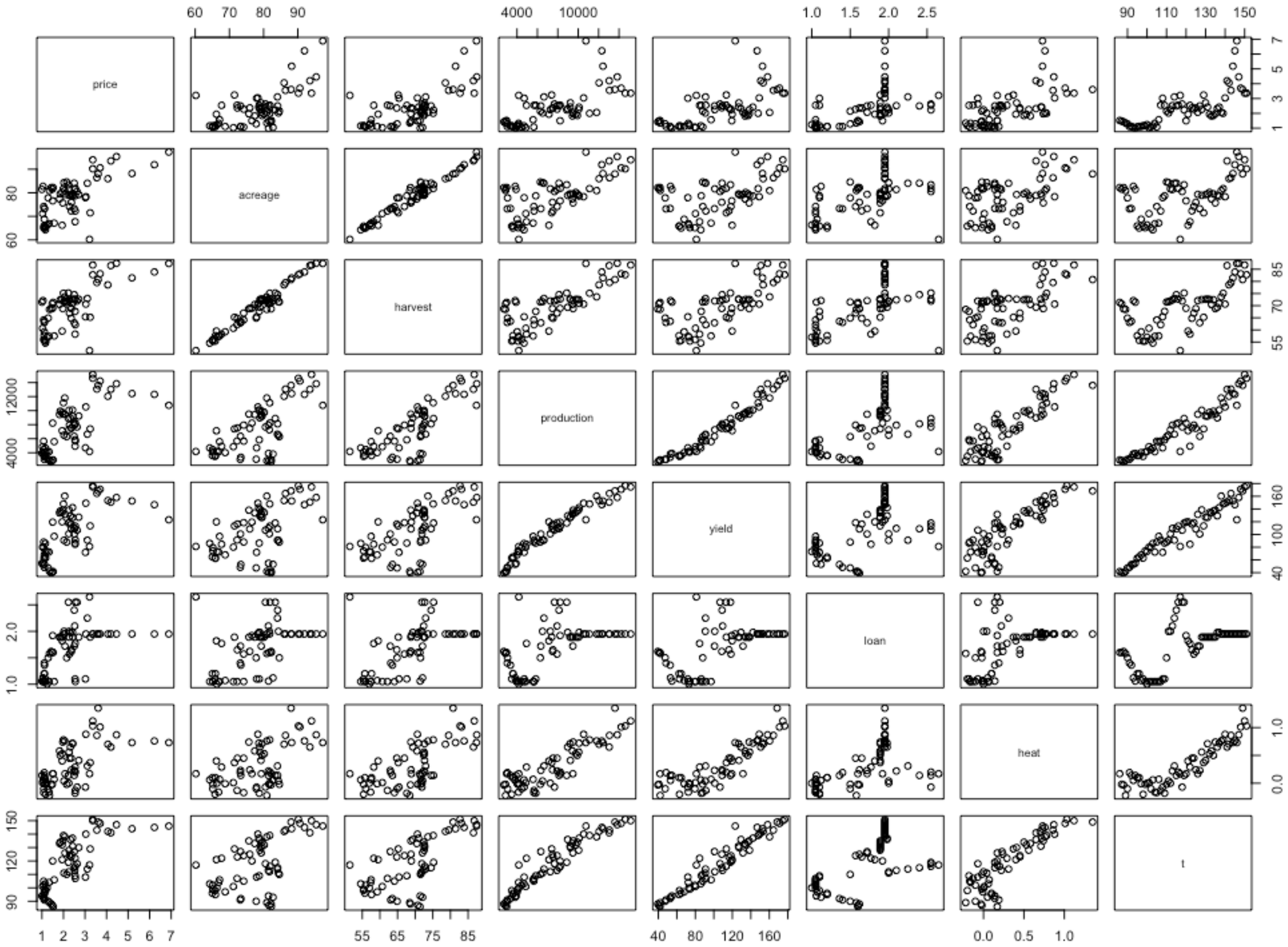
Introduction

- USDA Feed Grains database records a lot of data on corn, wheat, sorghum, and oats.

- All of the data is time series data, but not all of the different variables recorded start at the same year.

- Used price received by farmers as the response.


price
harvest
production
yield
t
40
60
80
100
50
100
150
0
1
2
3
4
5
6
7
40
60
80
100
5000
10000
15000
50
100
150
0
50
100
150


price
acreage
harvest
production
yield
loan
heat
t

Stepwise Regression

$$\text{price} = \beta_0 + \beta_1(\text{time}) + \beta_2(\text{acerage}) + \beta_3(\text{harvest}) + \beta_4(\text{production}) + \beta_5(\text{yield}) + \beta_6(\text{loan}) + \beta_7(\text{heat})$$

vs.

$$\text{price} = \beta_0$$

Forward:

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.65876 -0.24846 -0.08864  0.19155  1.05809

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -4.547122   0.954369  -4.765 1.86e-05 ***
t            0.065546   0.013239   4.951 9.93e-06 ***
loan         0.609355   0.142711   4.270 9.43e-05 ***
yield       -0.018167   0.005991  -3.032  0.00394 **
heat        -0.943429   0.337792  -2.793  0.00753 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.3948 on 47 degrees of freedom
Multiple R-squared:  0.6757,    Adjusted R-squared:  0.6481
F-statistic: 24.48 on 4 and 47 DF,  p-value: 5.44e-11
```

Reverse:

```
Residuals:
     Min       1Q   Median       3Q      Max
-0.64112 -0.27448 -0.03946  0.22948  0.95797

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -6.8769347  1.5093377  -4.556 3.83e-05 ***
t            0.0674920  0.0122647   5.503 1.60e-06 ***
acreage      0.0285022  0.0114826   2.482 0.016769 *
production  -0.0002656  0.0000763  -3.481 0.001107 **
loan         0.5585764  0.1568908   3.560 0.000874 ***
heat        -0.8922684  0.3314695  -2.692 0.009876 **
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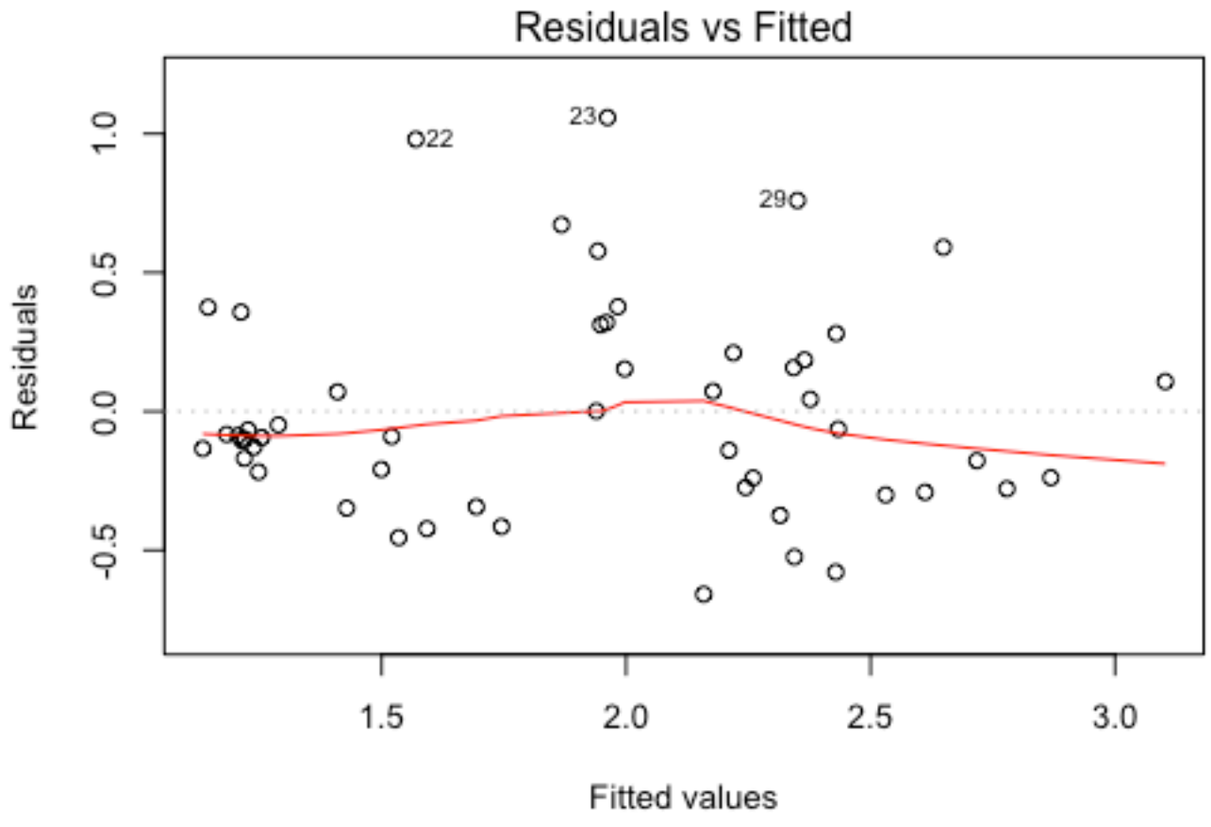
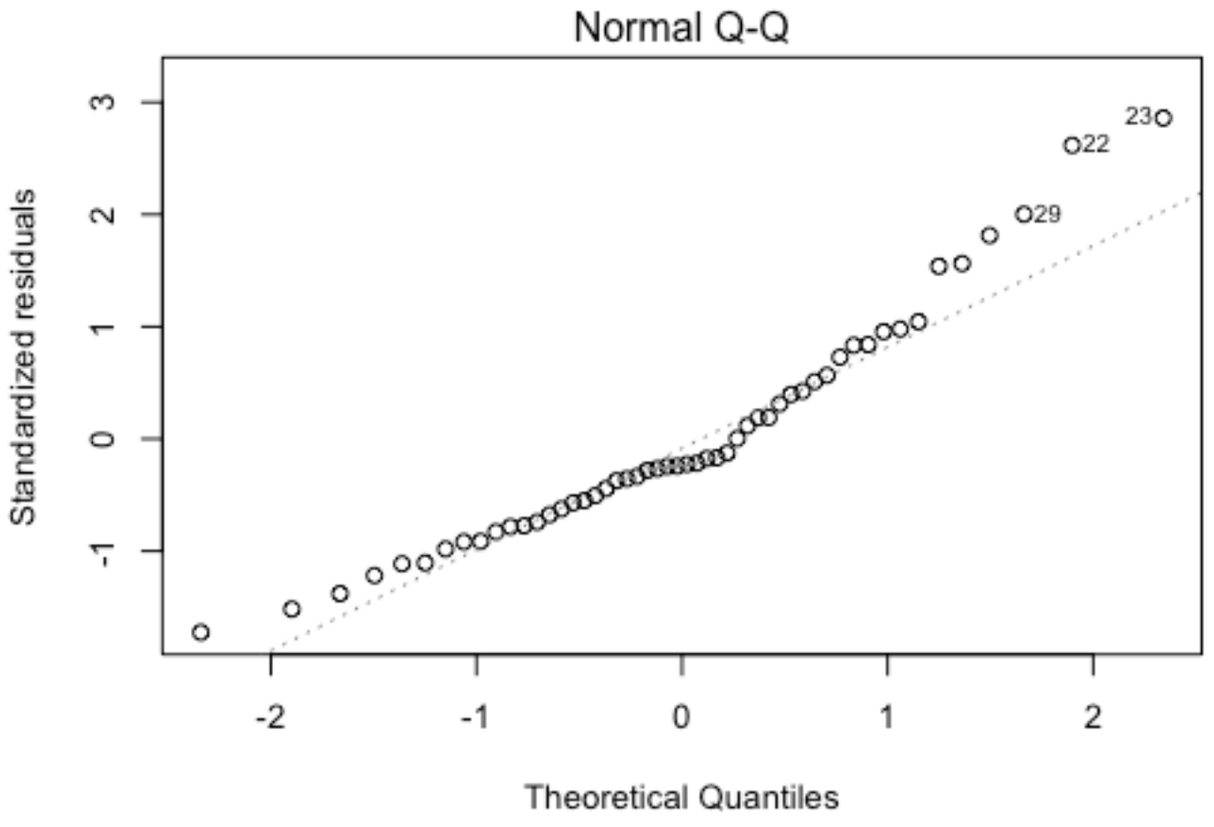
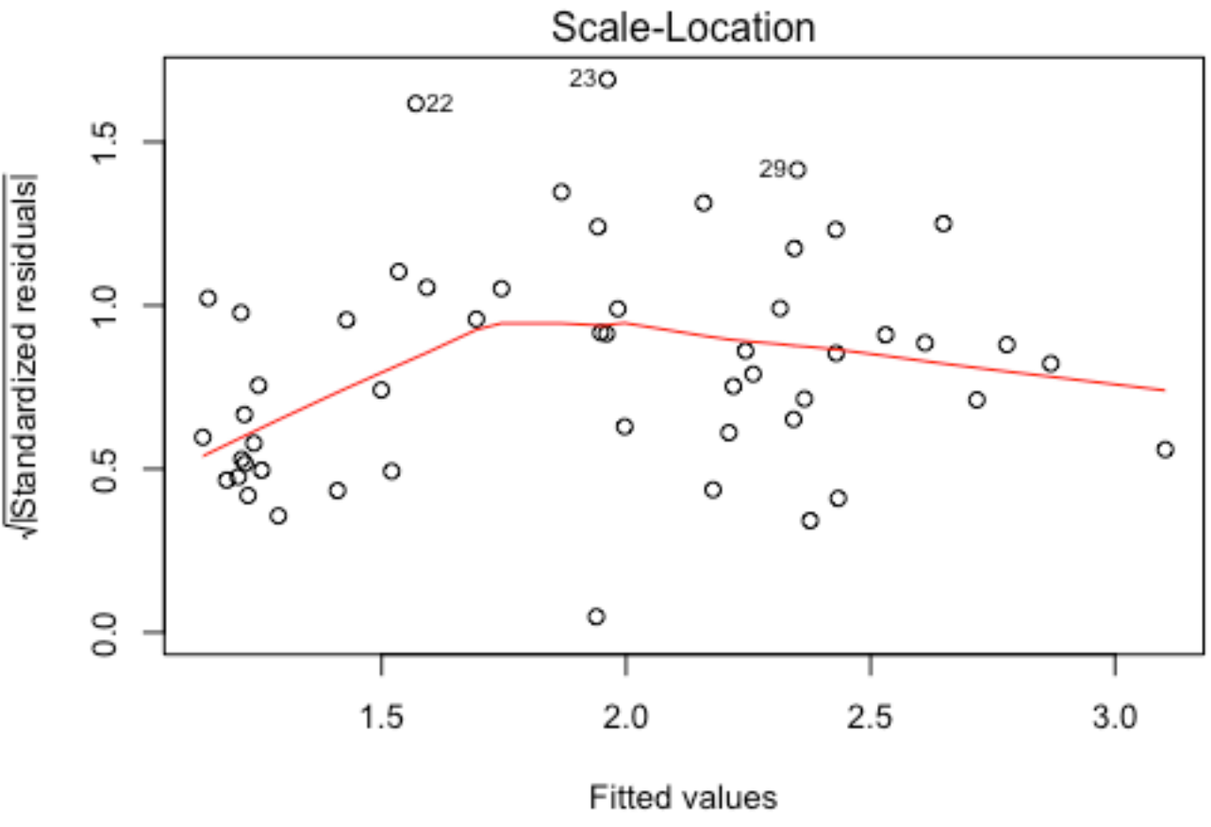
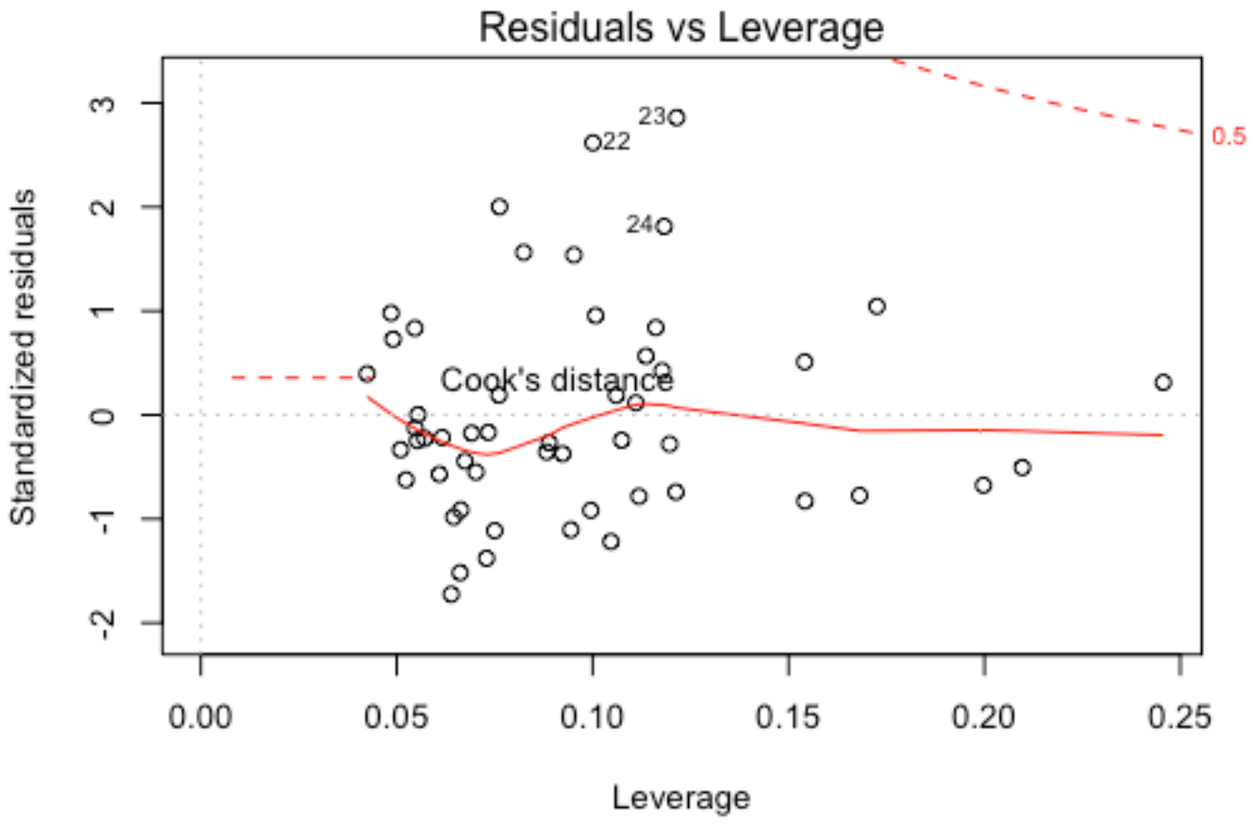
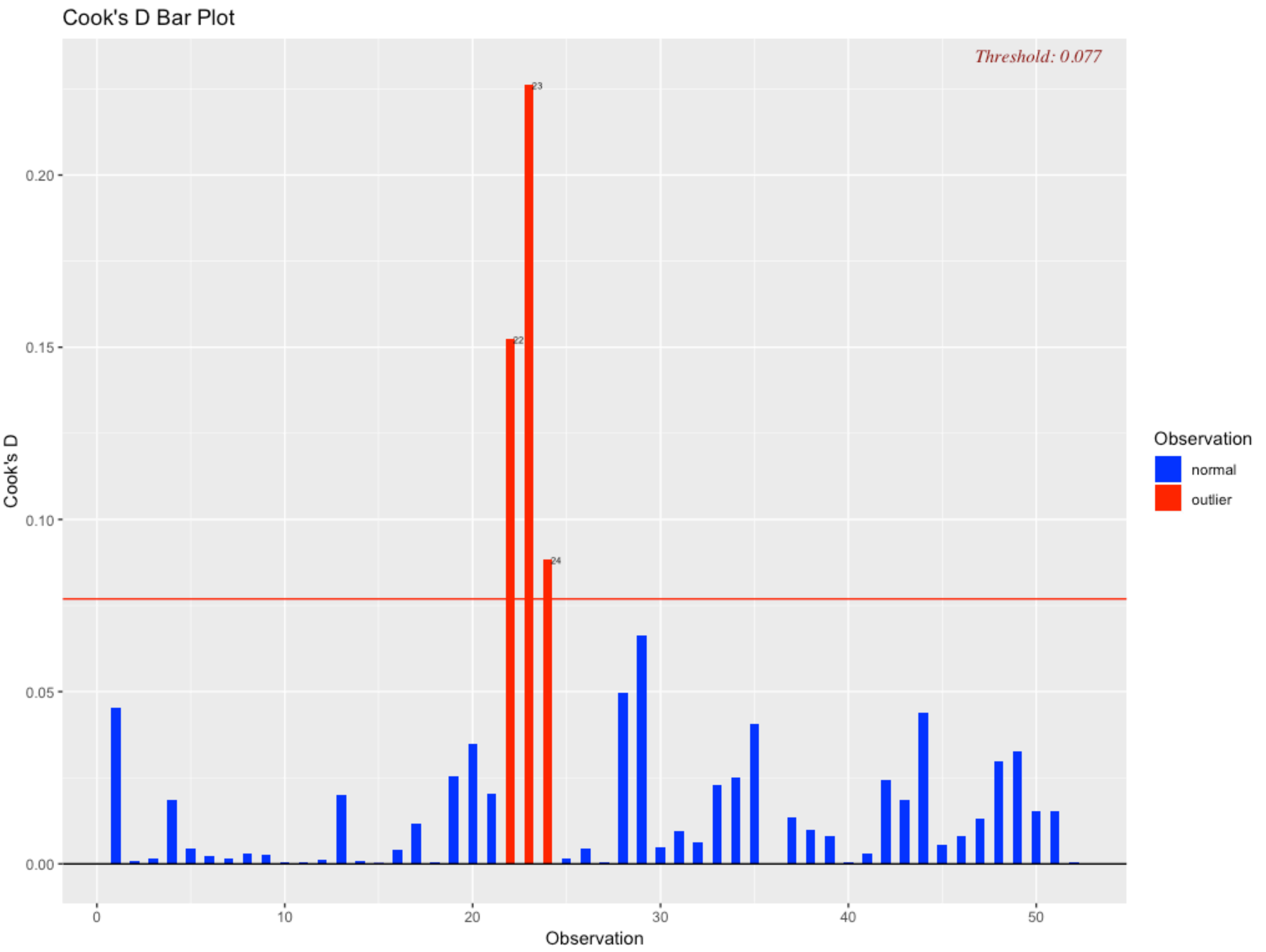

Residuals vs Fitted
Residuals
Fitted values
22
23
29
1.5
2.0
2.5
3.0
-0.5
0.0
0.5
1.0

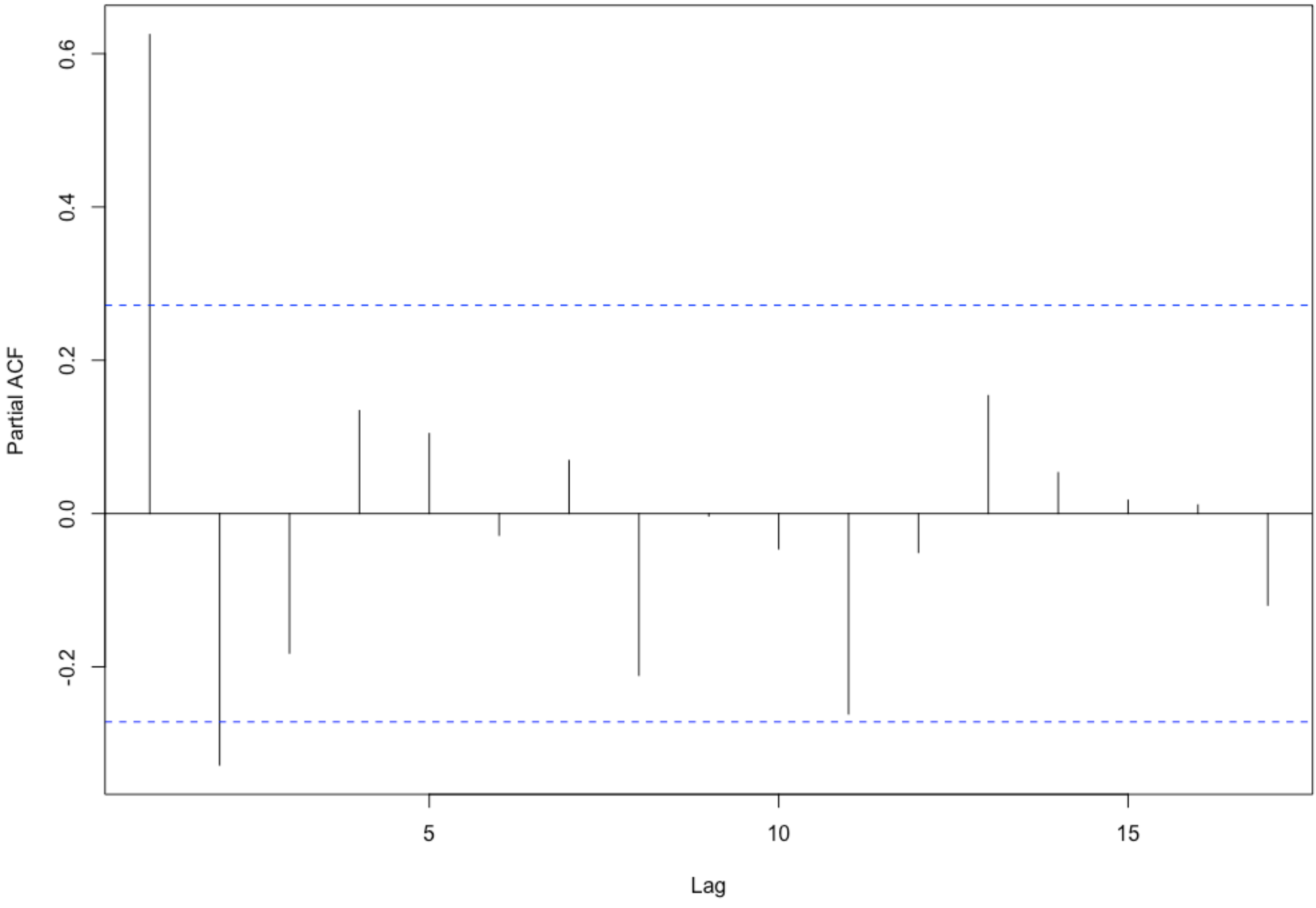

Normal Q-Q
Standardized residuals
Theoretical Quantiles
23
22
29
-2
-1
0
1
2
-1
0
1
2
3


Scale-Location
√|Standardized residuals|
Fitted values
23
22
29
1.5
2.0
2.5
3.0
0.0
0.5
1.0
1.5


Residuals vs Leverage
Standardized residuals
Leverage
Cook's distance
0.5
23
22
24
0.00
0.05
0.10
0.15
0.20
0.25
-2
-1
0
1
2
3


Cook's D Bar Plot
Threshold: 0.077
0.20
0.15
0.10
0.05
0.00
Cook's D
0
10
20
30
40
50
Observation
23
22
24
Observation
normal
outlier

Residual PACF



GLS accommodates correlated residuals

1.

```
Generalized least squares fit by REML
  Model: price ~ t + loan + yield + heat
  Data: Corn1952Training
       AIC      BIC    logLik
  40.31833 53.26936 -13.15916

Correlation Structure: AR(1)
 Formula: ~t
 Parameter estimate(s):
     Phi
0.866462

Coefficients:
                Value Std.Error   t-value p-value
(Intercept) -2.7952969 1.5638059 -1.787496  0.0803
t            0.0514150 0.0148595  3.460085  0.0012
loan         0.3543629 0.2544055  1.392906  0.1702
yield       -0.0178266 0.0028937 -6.160440  0.0000
heat         0.1910170 0.2683956  0.711700  0.4802
```

2.

```
Generalized least squares fit by REML
  Model: price ~ t + loan + yield
  Data: Corn1952Training
       AIC      BIC    logLik
  38.01165 49.23886 -13.00583

Correlation Structure: AR(1)
 Formula: ~t
 Parameter estimate(s):
      Phi
0.8521398

Coefficients:
                Value Std.Error   t-value p-value
(Intercept) -2.9787540 1.4387223 -2.070416  0.0438
t            0.0527077 0.0138949  3.793305  0.0004
loan         0.3773481 0.2495705  1.511990  0.1371
yield       -0.0173434 0.0028113 -6.169096  0.0000
```

3.

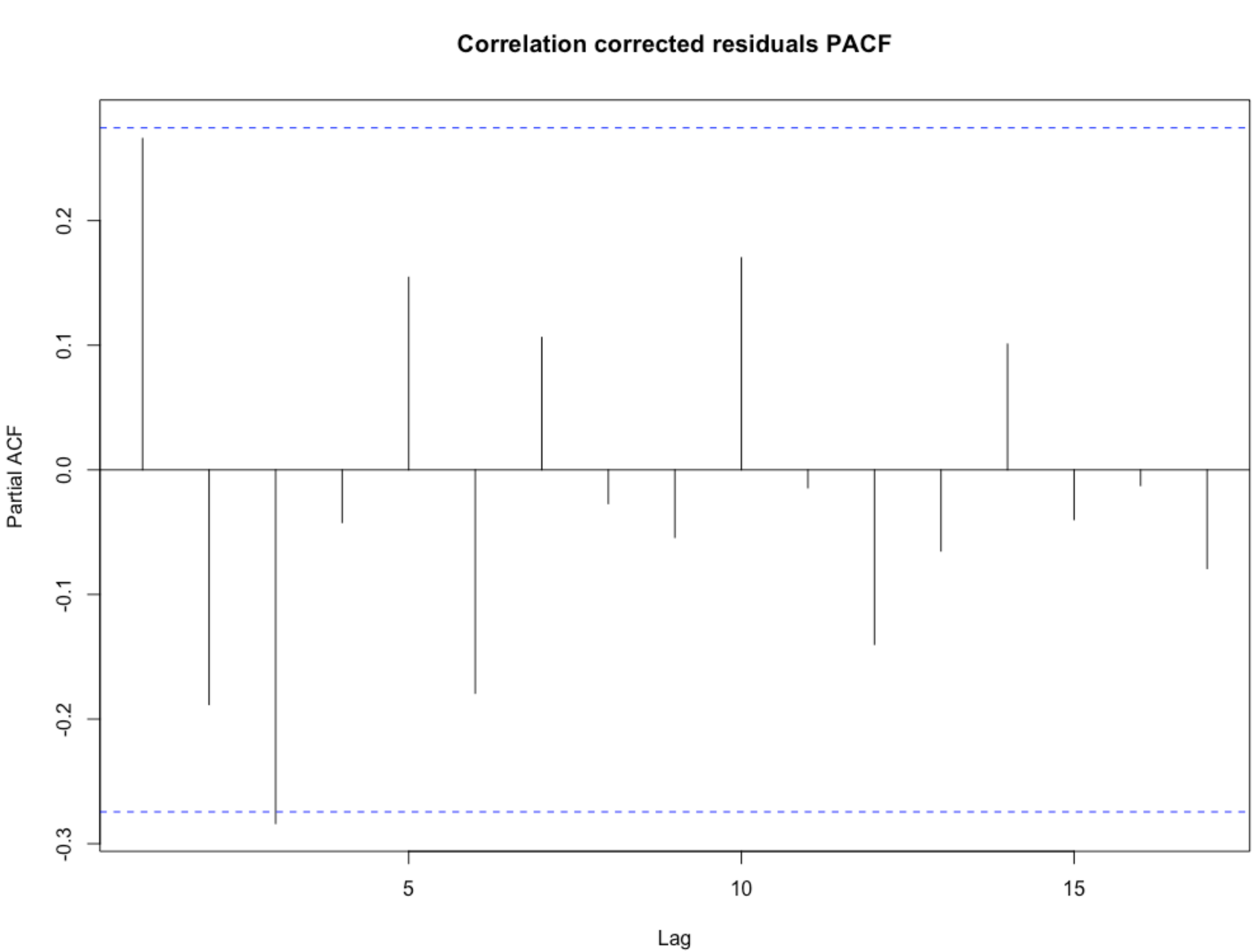
```
Generalized least squares fit by REML
  Model: price ~ t + yield
  Data: Corn1952Training
       AIC      BIC    logLik
  37.20752 46.66662 -13.60376

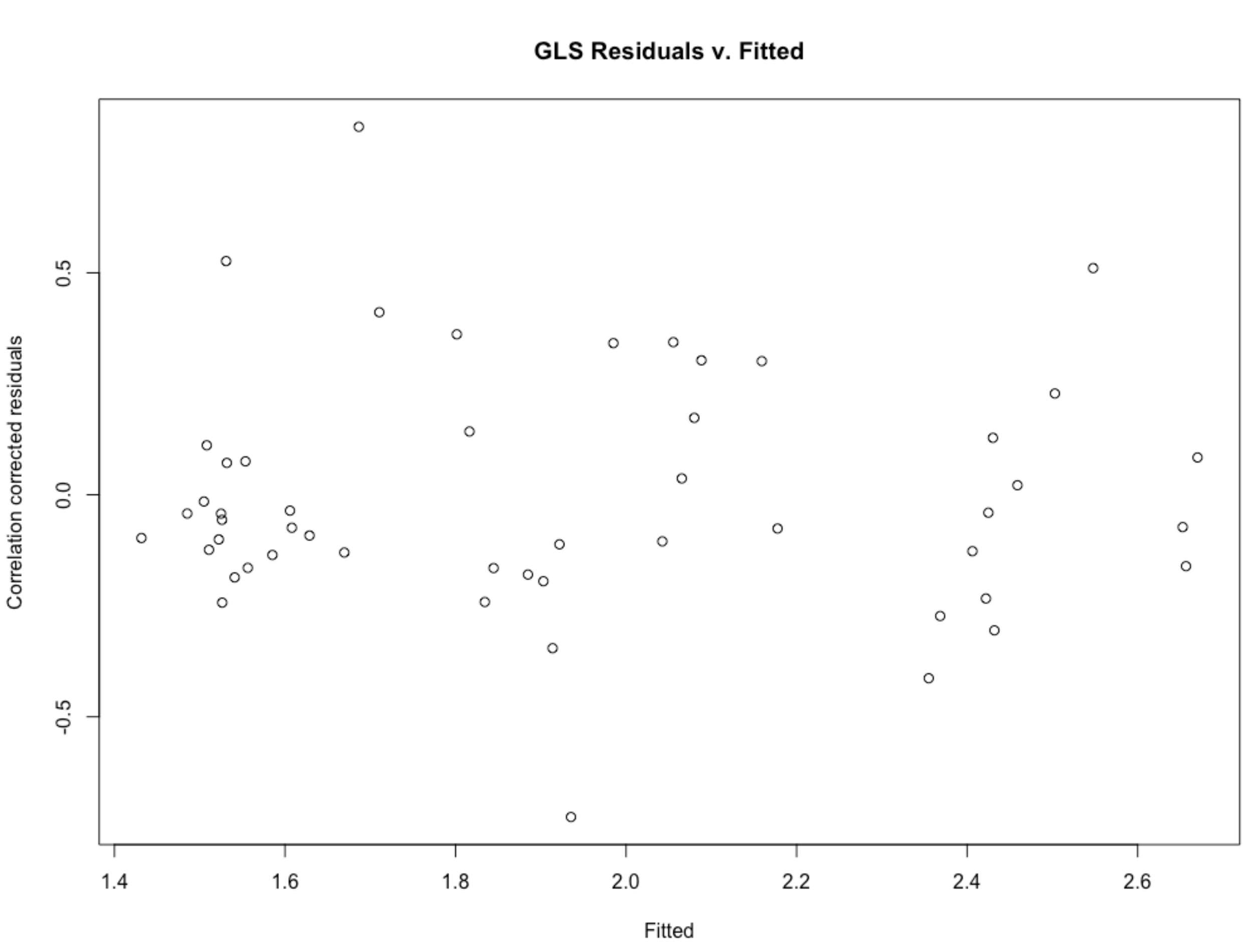
Correlation Structure: AR(1)
 Formula: ~t
 Parameter estimate(s):
      Phi
0.8879908

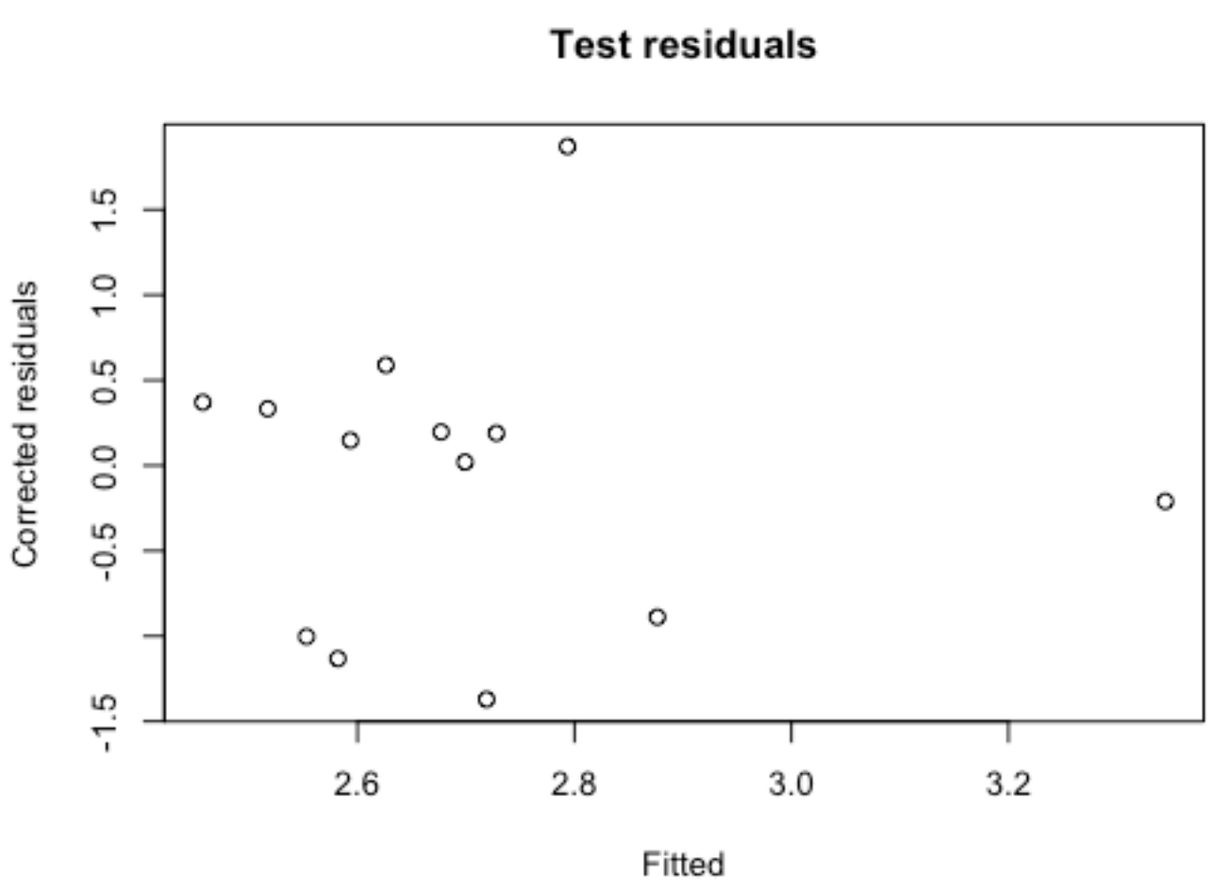
Coefficients:
                Value Std.Error   t-value p-value
(Intercept) -2.7917639 1.7423442 -1.602303  0.1155
t            0.0566660 0.0160393  3.532945  0.0009
yield       -0.0173597 0.0028087 -6.180676  0.0000
```

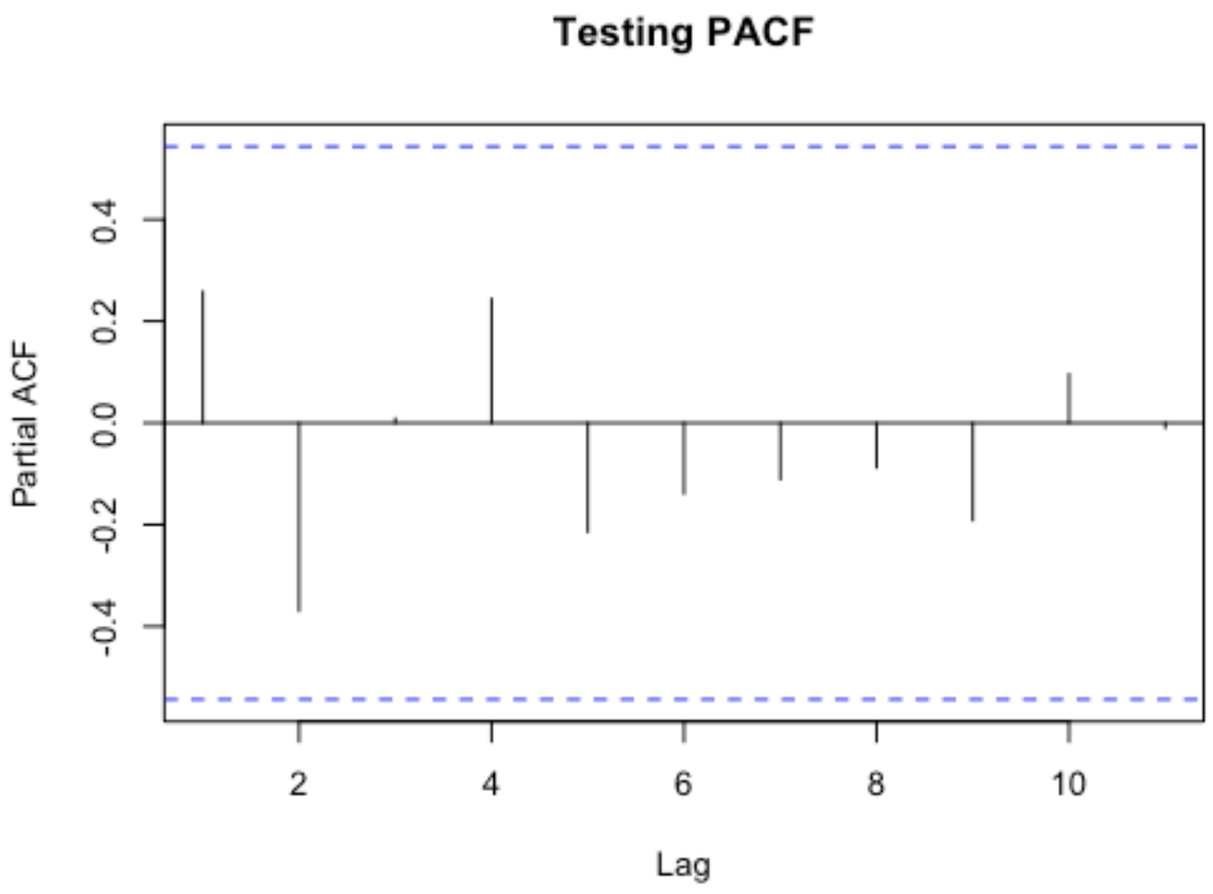
Given that residuals violate OLS assumptions, generate new model.
In the new model, only two parameters are significant.

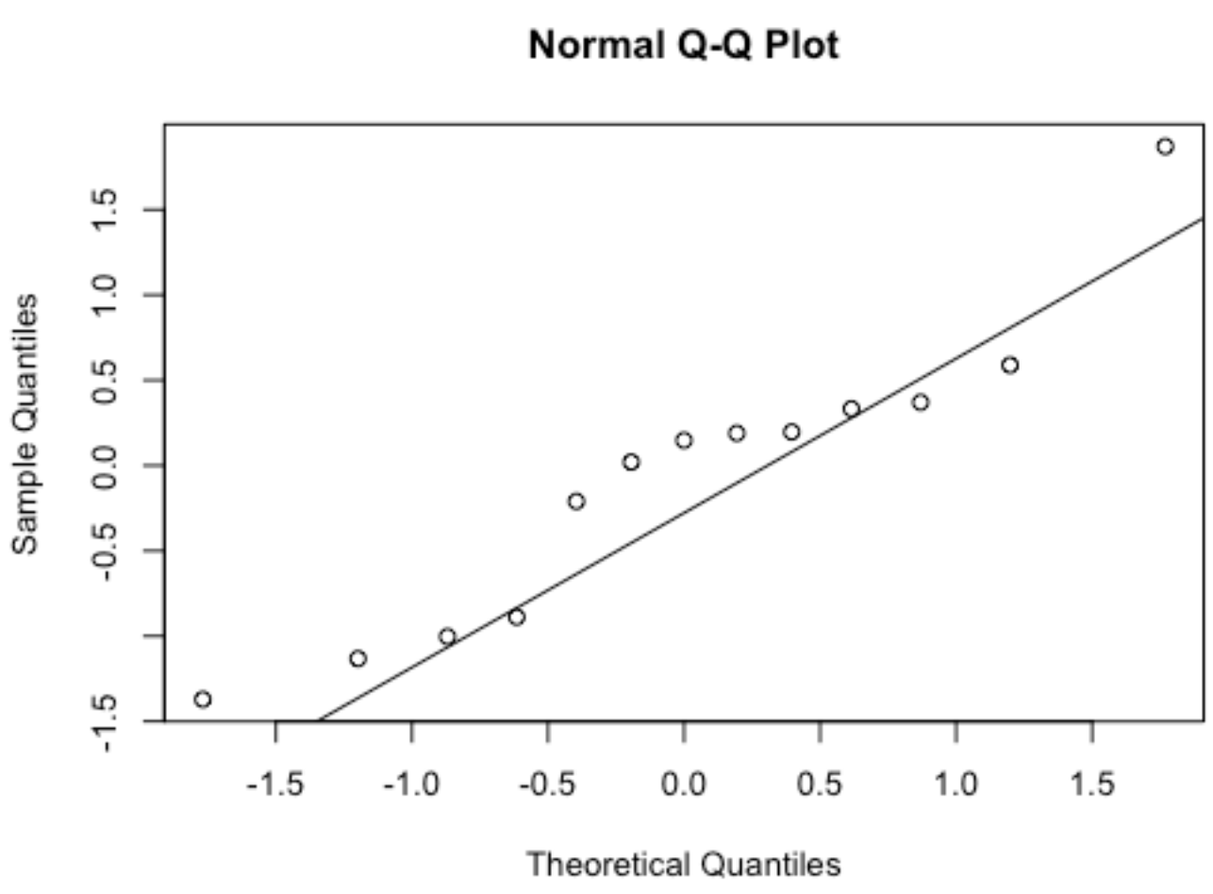
$$\text{price} = \beta_0 + \beta_1 t + \beta_2(\text{yield})$$

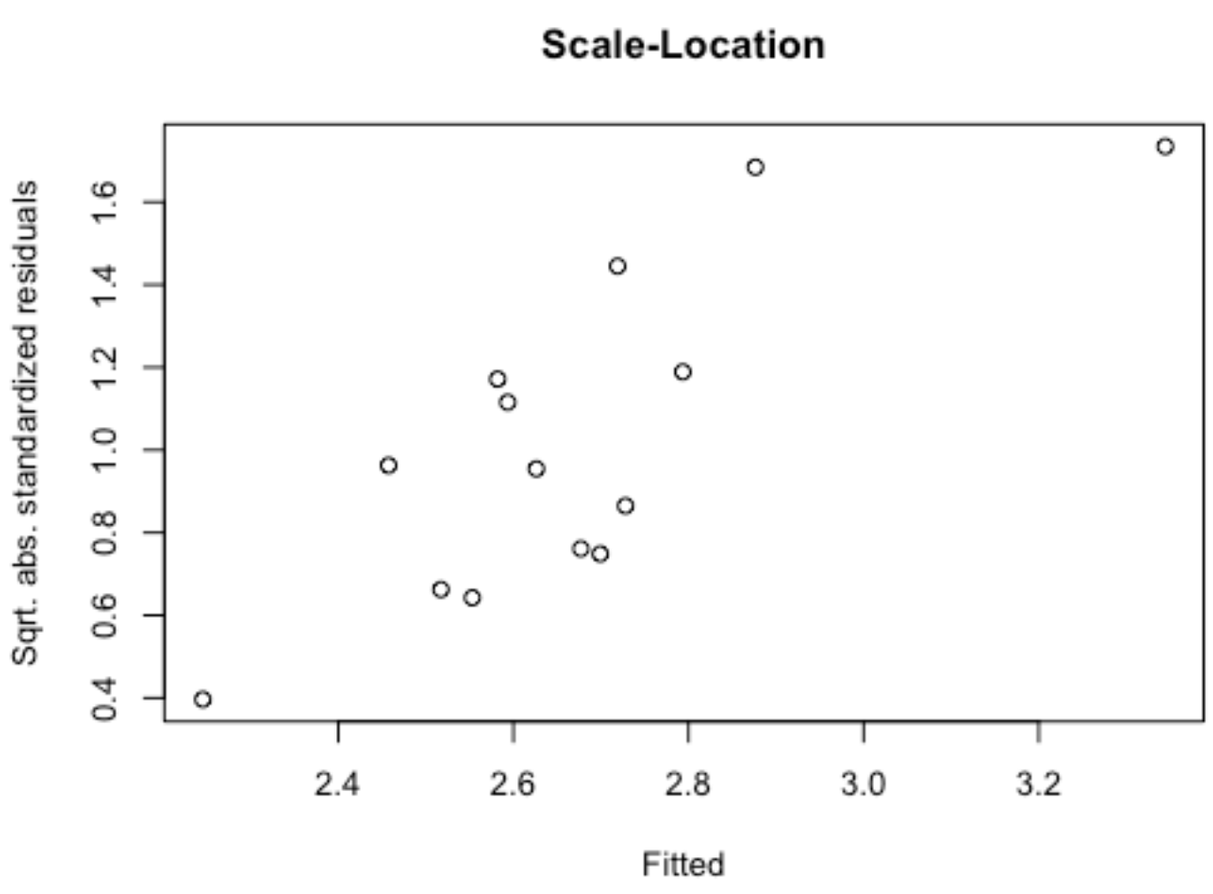

Correlation corrected residuals PACF
Partial ACF
0.2
0.1
0.0
-0.1
-0.2
-0.3
5
10
15
Lag


GLS Residuals v. Fitted
Correlation corrected residuals
0.5
0.0
-0.5
1.4
1.6
1.8
2.0
2.2
2.4
2.6
Fitted


Test residuals
Corrected residuals
Fitted
-1.5
-0.5
0.0
0.5
1.0
1.5
2.6
2.8
3.0
3.2


Testing PACF
Partial ACF
Lag
-0.4
-0.2
0.0
0.2
0.4
2
4
6
8
10


Normal Q-Q Plot
Sample Quantiles
Theoretical Quantiles
-1.5
-0.5
0.0
0.5
1.0
1.5


Scale-Location
Sqrt. abs. standardized residuals
Fitted
0.4
0.6
0.8
1.0
1.2
1.4
1.6
2.4
2.6
2.8
3.0
3.2

Conclusions

- Further considerations could be made to correct minimal NCV, such as taking log(price) and using WGLS.

- Since only yield/time were significant, refit using 1866 data set to see if still significant. This would give higher *n* and possibly better predictions.

- Assuming the United States exists in its current form in several hundred years, repeating analysis with more data points would be useful.