sta210 project

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loading packages & dataset

```
library(tidyverse)
library(tidymodels)
library(readxl)
library(MASS)
library(leaps)
library(caret)
library(glmnet)
library(Stat2Data)
#library(statnnet)
library(lme4)
library(UpSetR)
library(nlme)
library(sjstats)
set.seed(8)
soccer <- read_excel("AllTimeRankingByClub.xlsx")
```

Introduction and data

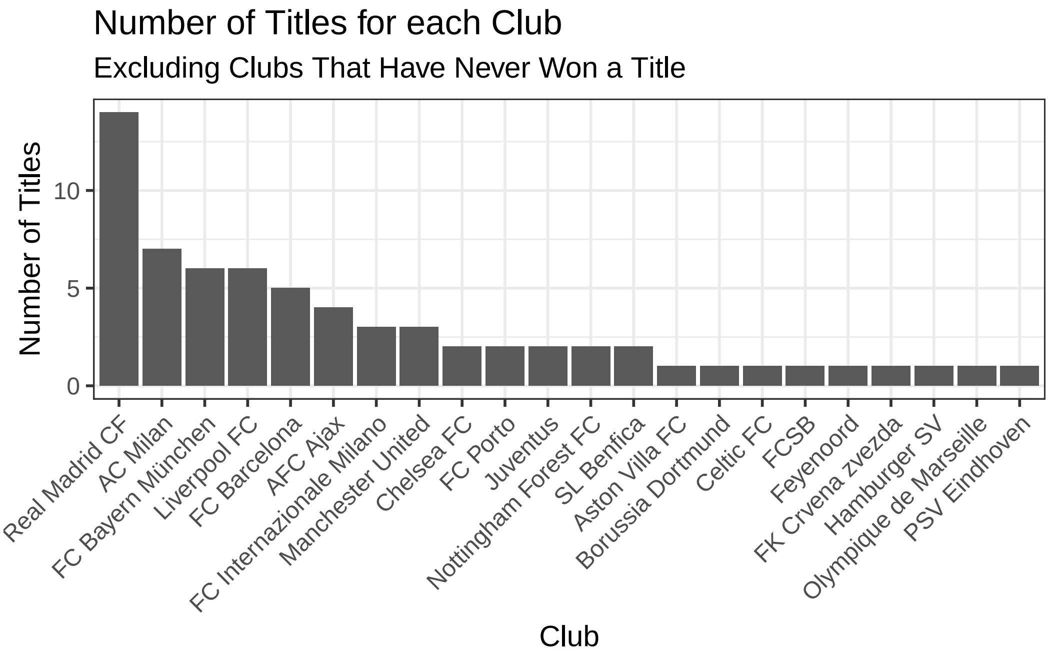
Data Cleaning

```
soccer = soccer %>%
  rename(goals_for = `Goals For`,
         goals_against = `Goals Against`,
         goal_diff = `Goal Diff`)

soccer = soccer %>%
  mutate(winspermatch = Win/Played,
         pointspermatch = Pts/Played,
         goalspermatch = goals_for/Played,
         goalsagainstpermatch = goals_against/Played,
         goalmarginpermatch = goal_diff/Played)

soccer = soccer %>%
  mutate(topfiveleague = ifelse(Country == 'ESP' | Country == 'ENG' | Country == 'GER' | C
```

EDA

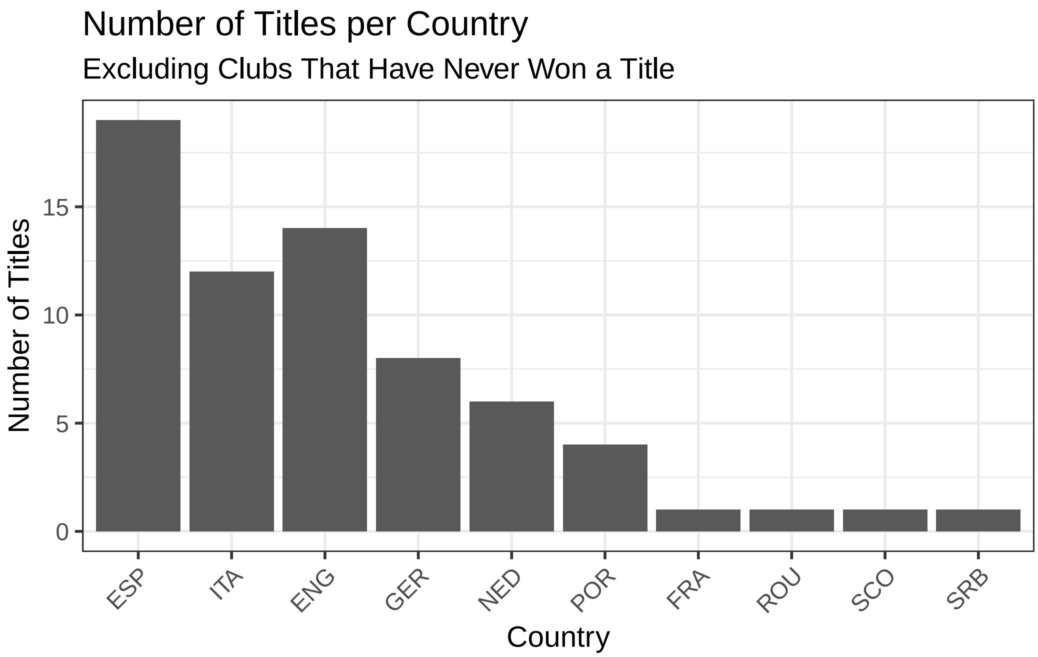
Plot 1:

```
soccer %>%
  filter(Titles > 0) %>%
  ggplot(aes(x = reorder(Club, (-Titles)), y = Titles)) +
  geom_bar(stat = 'identity') +
  labs(x = 'Club', y = 'Number of Titles', title = 'Number of Titles for each Club',
       subtitle = 'Excluding Clubs That Have Never Won a Title') +
  theme_bw() +
  scale_x_discrete(guide = guide_axis(angle = 45))
```



Plot 2:

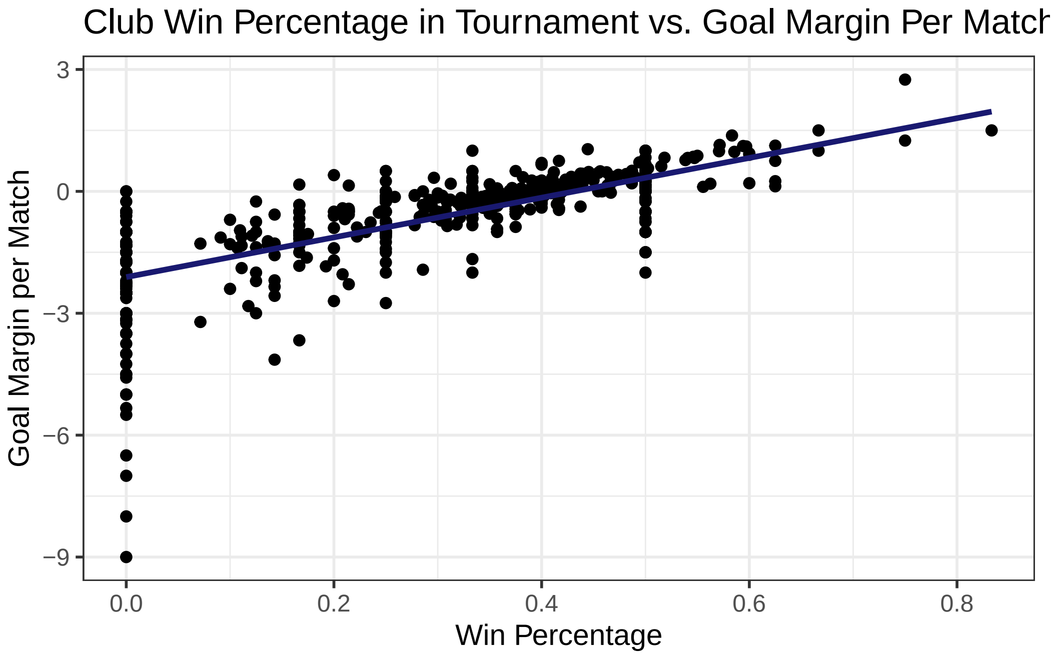
```r
soccer %>%
  filter(Titles > 0) %>%
  ggplot(aes(x = reorder(Country, (-Titles)), y = Titles)) +
  geom_bar(stat = 'identity') +
  labs(x = 'Country', y = 'Number of Titles', title = 'Number of Titles per Country',
       subtitle = 'Excluding Clubs That Have Never Won a Title') +
  theme_bw() +
  scale_x_discrete(guide = guide_axis(angle = 45))
```



Plot 3:

```r
ggplot(data = soccer, aes(x = winspermatch, y = goalmarginpermatch)) +
  geom_point() +
  geom_smooth(method = 'lm', se = F, color = 'midnightblue') +
  labs(x = "Win Percentage", y = 'Goal Margin per Match',
       title = 'Club Win Percentage in Tournament vs. Goal Margin Per Match') +
  theme_bw()
```

```
`geom_smooth()` using formula = 'y ~ x'
```



Methods

Model 1: Linear Regression

Outcome:

- points per match

Predictors:

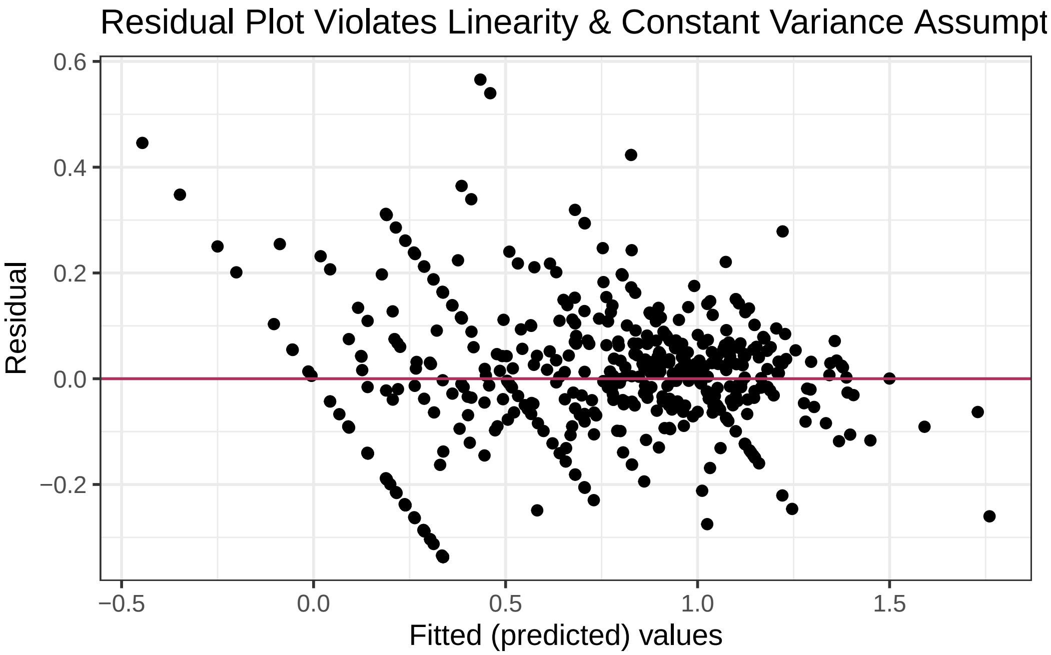
- wins per match
- goals per match
- goals against per match
- goal margin per match
- top five league

```r
model1 = lm(pointspermatch ~ winspermatch + goalspermatch +
               goalsagainstpermatch + goalmarginpermatch + topfiveleague,
               data = soccer)
summary(model1)
```

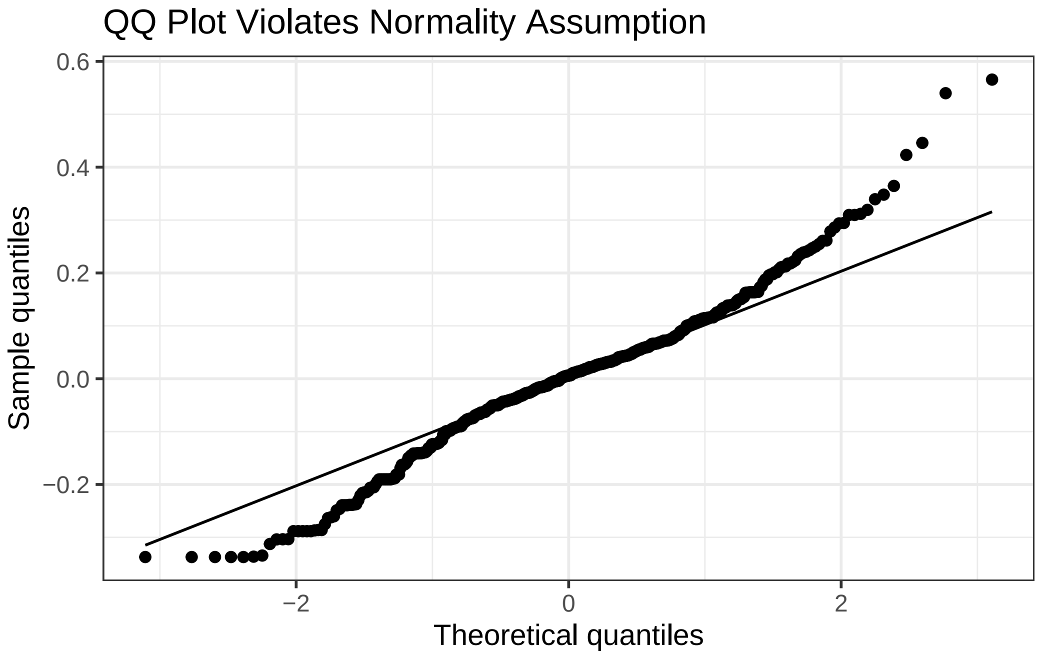
```
Call:
lm(formula = pointspermatch ~ winspermatch + goalspermatch +
    goalsagainstpermatch + goalmarginpermatch + topfiveleague,
    data = soccer)

Residuals:
     Min       1Q   Median       3Q      Max
-0.33721 -0.06803  0.00581  0.06882  0.56561

Coefficients: (1 not defined because of singularities)
                       Estimate Std. Error t value Pr(>|t|)
(Intercept)            0.435103   0.020395  21.334  < 2e-16 ***
winspermatch           1.381209   0.049182  28.084  < 2e-16 ***
goalspermatch          0.096467   0.014703   6.561 1.28e-10 ***
goalsagainstpermatch  -0.097891   0.006649 -14.723  < 2e-16 ***
goalmarginpermatch           NA         NA      NA       NA
topfiveleaguetop five  0.025705   0.016498   1.558     0.12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1355 on 525 degrees of freedom
Multiple R-squared:  0.8845,    Adjusted R-squared:  0.8836
F-statistic:  1005 on 4 and 525 DF,  p-value: < 2.2e-16
```

Conditions for Model 1: Violated linearity, constant variance, and normality

```
model1aug = augment(model1)

ggplot(model1aug, aes(x = .fitted, y = .resid)) +
  geom_point() +
  geom_hline(yintercept = 0, color = 'maroon') +
  labs(x = "Fitted (predicted) values", y = 'Residual') +
  ggtitle('Residual Plot Violates Linearity & Constant Variance Assumptions') +
  theme_bw()
```



```r
ggplot(model1aug, aes(sample = .resid)) +
  stat_qq() +
  stat_qq_line() +
  theme_bw() +
  labs(x = 'Theoretical quantiles',
       y = 'Sample quantiles',
       title = 'QQ Plot Violates Normality Assumption')
```



testing correlations because something is weird

```
test = soccer %>%
  dplyr::select(pointspermatch, winspermatch, goalspermatch, goalsagainstpermatch, goalmar

cor(test)
```

```
                     pointspermatch winspermatch goalspermatch
pointspermatch            1.0000000    0.9103634     0.7085198
winspermatch              0.9103634    1.0000000     0.7213852
goalspermatch             0.7085198    0.7213852     1.0000000
goalsagainstpermatch     -0.6382465   -0.4996595    -0.2858228
goalmarginpermatch        0.8108285    0.7085429     0.6652299
                     goalsagainstpermatch goalmarginpermatch
pointspermatch                 -0.6382465          0.8108285
winspermatch                   -0.4996595          0.7085429
goalspermatch                  -0.2858228          0.6652299
goalsagainstpermatch            1.0000000         -0.9056286
goalmarginpermatch             -0.9056286          1.0000000
```

Model 2: Linear Regression

Outcome:

- points per match

Predictors:

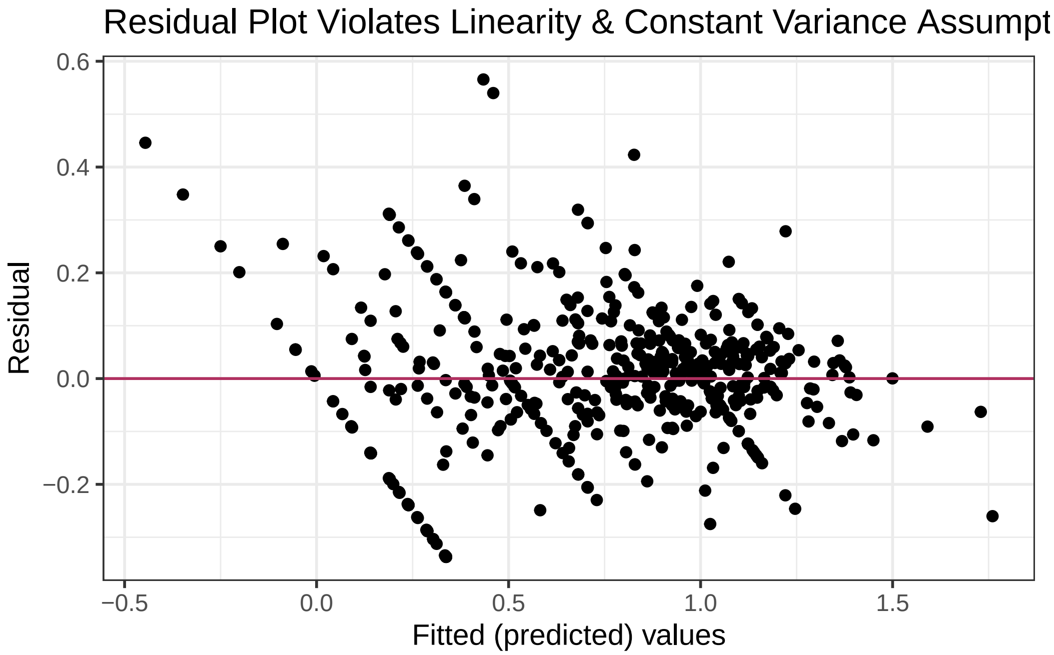
- wins per match
- goals per match
- goals against per match
- top five league

```
model2 = lm(pointspermatch ~ winspermatch + goalspermatch +
               goalsagainstpermatch + topfiveleague,
               data = soccer)
summary(model2)
```

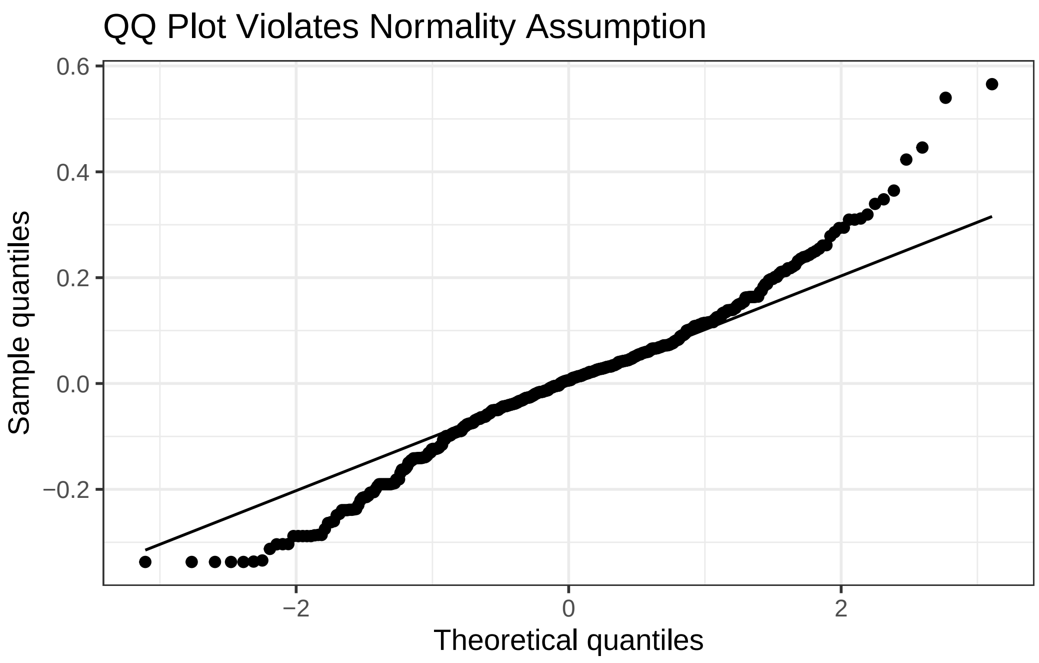
```

Call:
lm(formula = pointspermatch ~ winspermatch + goalspermatch +
    goalsagainstpermatch + topfiveleague, data = soccer)

Residuals:
     Min       1Q   Median       3Q      Max
-0.33721 -0.06803  0.00581  0.06882  0.56561

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)
(Intercept)           0.435103   0.020395  21.334  < 2e-16 ***
winspermatch          1.381209   0.049182  28.084  < 2e-16 ***
goalspermatch         0.096467   0.014703   6.561 1.28e-10 ***
goalsagainstpermatch -0.097891   0.006649 -14.723  < 2e-16 ***
topfiveleaguetop five 0.025705   0.016498   1.558     0.12
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1355 on 525 degrees of freedom
Multiple R-squared:  0.8845,    Adjusted R-squared:  0.8836
F-statistic:  1005 on 4 and 525 DF,  p-value: < 2.2e-16
```

Check Assumptions for Model 2 still all violated

```r
model2aug = augment(model2)

ggplot(model2aug, aes(x = .fitted, y = .resid)) +
  geom_point() +
  geom_hline(yintercept = 0, color = 'maroon') +
  labs(x = "Fitted (predicted) values", y = 'Residual') +
  ggtitle('Residual Plot Violates Linearity & Constant Variance Assumptions') +
  theme_bw()
```



```r
ggplot(model2aug, aes(sample = .resid)) +
  stat_qq() +
  stat_qq_line() +
  theme_bw() +
  labs(x = 'Theoretical quantiles',
       y = 'Sample quantiles',
       title = 'QQ Plot Violates Normality Assumption')
```



Model 3: Linear Regression

Outcome:

- points per match

Predictors:

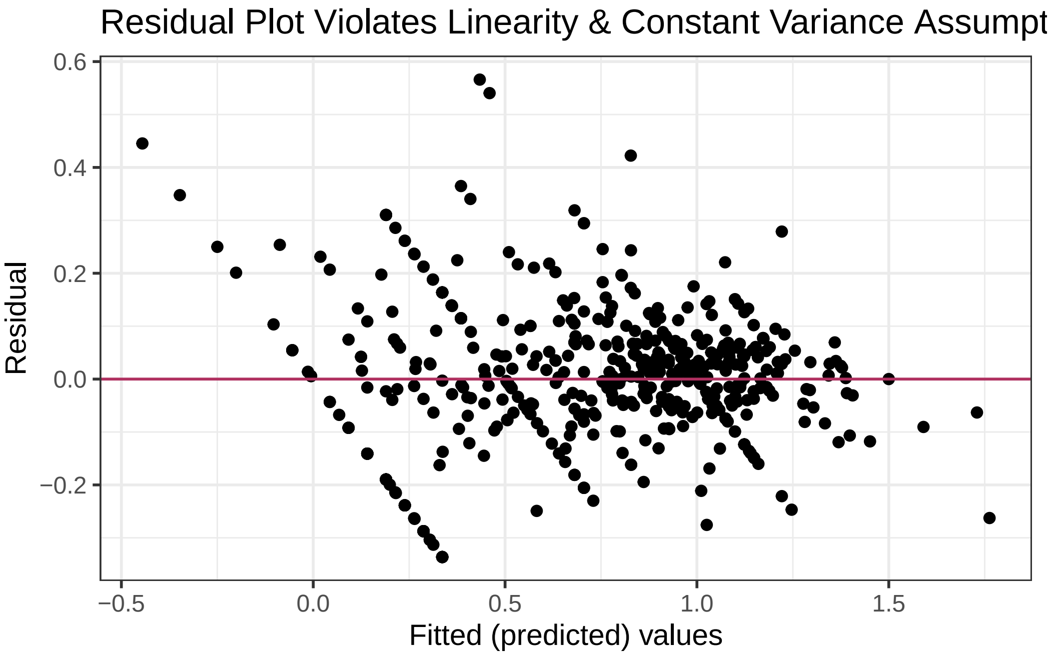
- wins per match
- goal margin per match
- top five league

```
model3 = lm(pointspermatch ~ winspermatch + goalmarginpermatch + topfiveleague,
              data = soccer)
summary(model3)
```

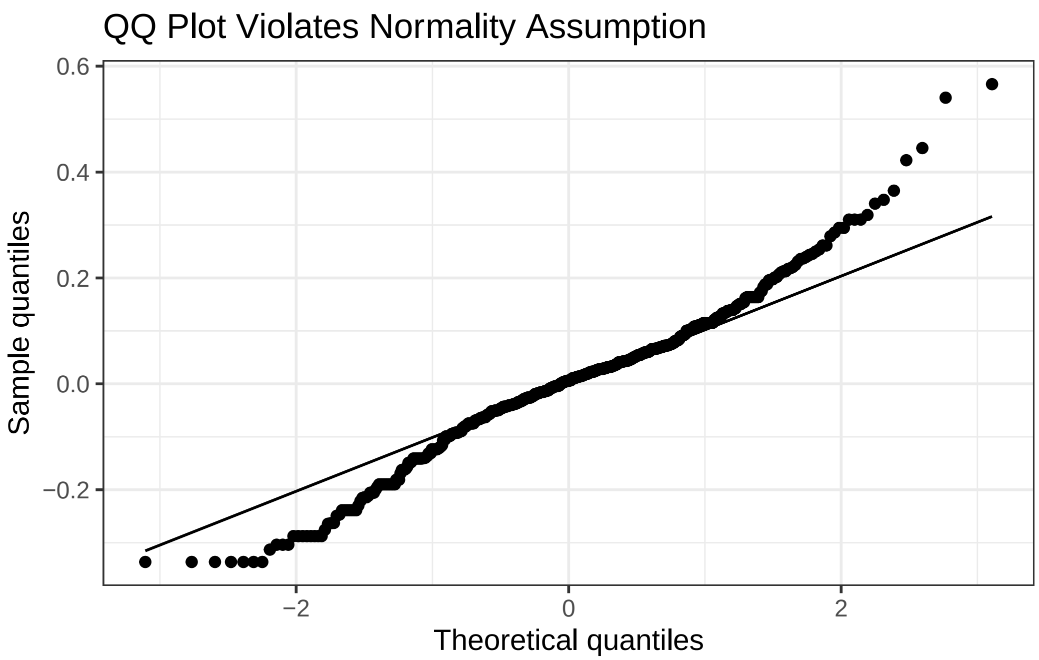
```
Call:
lm(formula = pointspermatch ~ winspermatch + goalmarginpermatch +
    topfiveleague, data = soccer)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.33632 -0.06813  0.00603  0.06892  0.56598 

Coefficients:
                      Estimate Std. Error t value Pr(>|t|)    
(Intercept)           0.434020   0.016755  25.904   <2e-16 ***
winspermatch          1.379068   0.043462  31.731   <2e-16 ***
goalmarginpermatch    0.097704   0.006335  15.423   <2e-16 ***
topfiveleaguetop five 0.025563   0.016412   1.558     0.12    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.1354 on 526 degrees of freedom
Multiple R-squared:  0.8845,	Adjusted R-squared:  0.8838 
F-statistic:  1343 on 3 and 526 DF,  p-value: < 2.2e-16
```

Check Assumptions Model 3

```
model3aug = augment(model3)

ggplot(model3aug, aes(x = .fitted, y = .resid)) +
  geom_point() +
  geom_hline(yintercept = 0, color = 'maroon') +
  labs(x = "Fitted (predicted) values", y = 'Residual') +
  ggtitle('Residual Plot Violates Linearity & Constant Variance Assumptions') +
  theme_bw()
```



```
ggplot(model3aug, aes(sample = .resid)) +
  stat_qq() +
  stat_qq_line() +
  theme_bw() +
  labs(x = 'Theoretical quantiles',
       y = 'Sample quantiles',
       title = 'QQ Plot Violates Normality Assumption')
```



Model 4: Linear Mixed Effects Model (potential violation of independence with topfiveleague)

Outcome:

- points per match

Predictors:

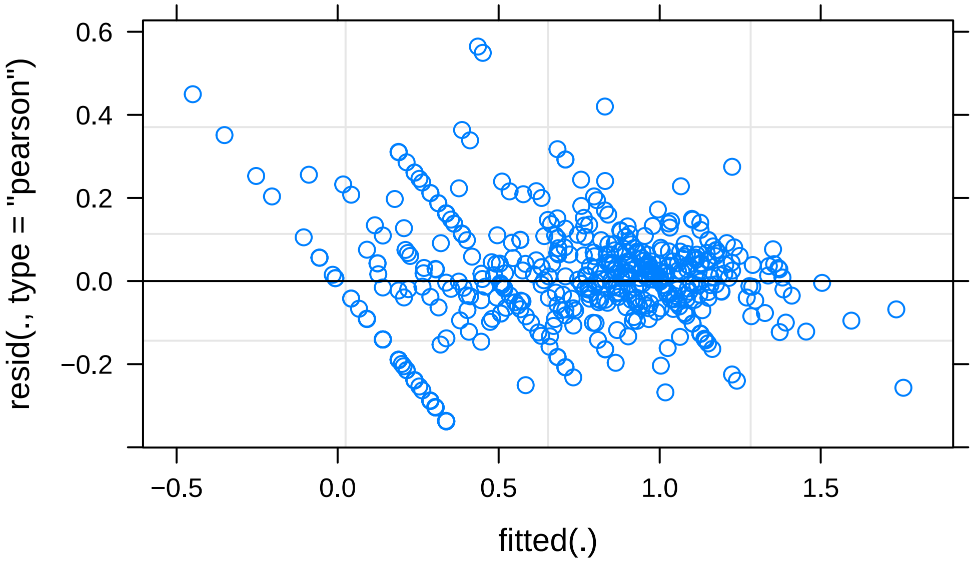
- random intercept for topfiveleague
- goal margin per match
- wins per match
- goals per match

```
model4 = lmer(pointspermatch ~ 1 + goalspermatch + winspermatch + goalsagainstpermatch +
              (1|topfiveleague), data = soccer)
summary(model4)
```

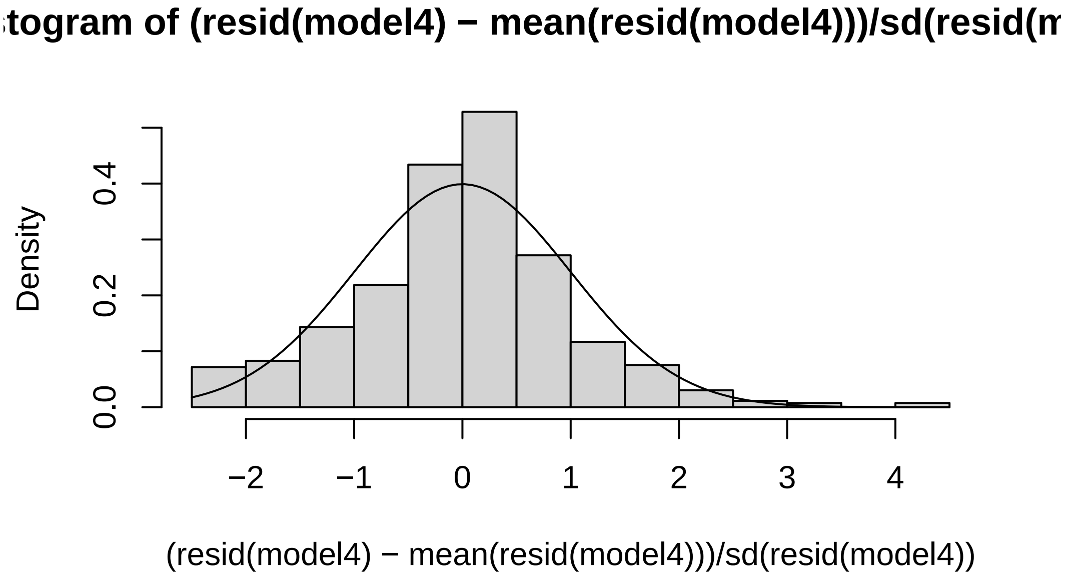
```
Linear mixed model fit by REML ['lmerMod']
Formula:
pointspermatch ~ 1 + goalspermatch + winspermatch + goalsagainstpermatch +
    (1 | topfiveleague)
   Data: soccer

REML criterion at convergence: -589.3

Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.4908 -0.5166  0.0546  0.5113  4.1647

Random effects:
 Groups        Name        Variance  Std.Dev.
 topfiveleague (Intercept) 0.0001943 0.01394
 Residual                  0.0183620 0.13551
Number of obs: 530, groups:  topfiveleague, 2

Fixed effects:
                      Estimate Std. Error t value
(Intercept)           0.443476   0.023240  19.082
goalspermatch         0.097878   0.014635   6.688
winspermatch          1.383025   0.049148  28.140
goalsagainstpermatch -0.098400   0.006629 -14.843

Correlation of Fixed Effects:
            (Intr) glsprm wnsprm
goalsprmtch -0.237
winspermtch -0.342 -0.687
glsgnstprmt -0.676 -0.134  0.436
```

Checking assumptions model 4

```
plot(model4)
```



```
hist((resid(model4) - mean(resid(model4))) / sd(resid(model4)), freq = FALSE); curve(dnorm
```



Model 5: Linear Regression

Outcome:

- points per match

Predictors:

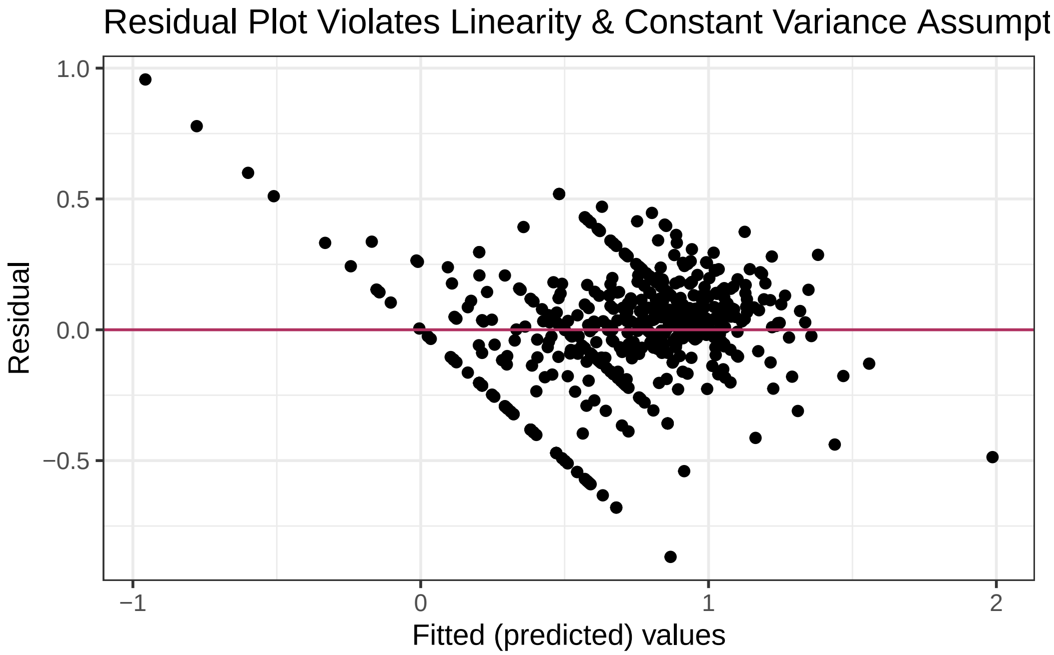
- topfiveleague
- goal margin per match
- goals per match
- goals against per match

```
model5 = lm(pointspermatch ~ goalspermatch + goalsagainstpermatch + goalmarginpermatch +
            topfiveleague, data = soccer)
summary(model5)
```

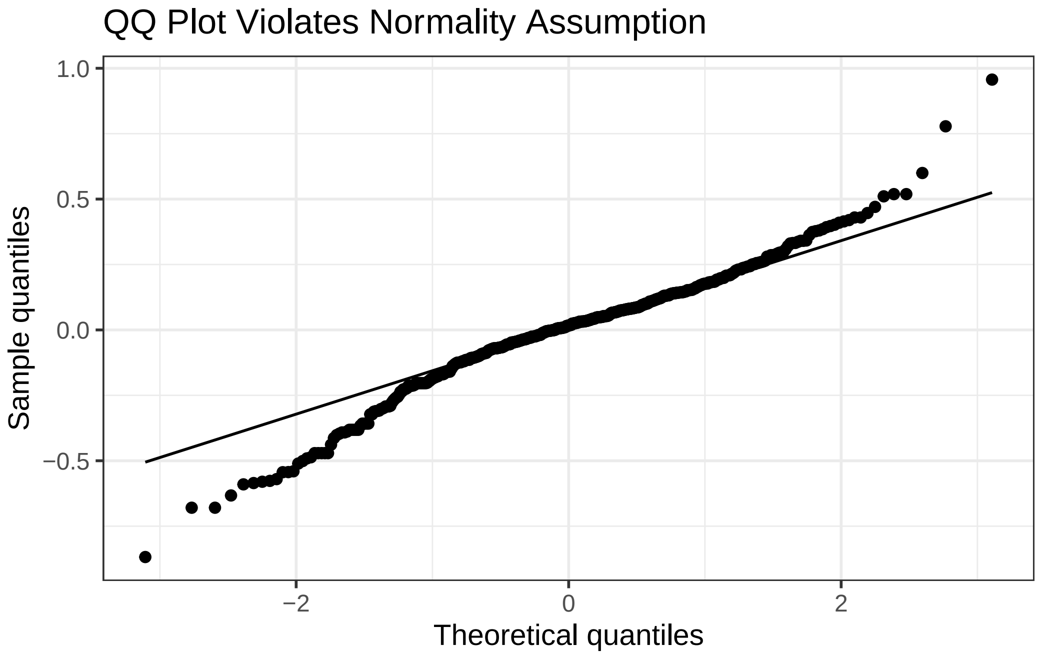
```
Call:
lm(formula = pointspermatch ~ goalspermatch + goalsagainstpermatch +
    goalmarginpermatch + topfiveleague, data = soccer)

Residuals:
     Min       1Q   Median       3Q      Max 
-0.86804 -0.10210  0.01674  0.12150  0.95670 

Coefficients: (1 not defined because of singularities)
                       Estimate Std. Error t value Pr(>|t|)    
(Intercept)            0.649387   0.029890  21.726   <2e-16 ***
goalspermatch          0.377006   0.017049  22.113   <2e-16 ***
goalsagainstpermatch  -0.178454   0.009479 -18.826   <2e-16 ***
goalmarginpermatch           NA         NA      NA       NA    
topfiveleaguetop five  0.052367   0.026029   2.012   0.0447 *  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2141 on 526 degrees of freedom
Multiple R-squared:  0.711, Adjusted R-squared:  0.7093 
F-statistic: 431.3 on 3 and 526 DF,  p-value: < 2.2e-16
```

Checking Assumptions

```r
model5aug = augment(model5)

ggplot(model5aug, aes(x = .fitted, y = .resid)) +
  geom_point() +
  geom_hline(yintercept = 0, color = 'maroon') +
  labs(x = "Fitted (predicted) values", y = 'Residual') +
  ggtitle('Residual Plot Violates Linearity & Constant Variance Assumptions') +
  theme_bw()
```



```r
ggplot(model5aug, aes(sample = .resid)) +
  stat_qq() +
  stat_qq_line() +
  theme_bw() +
  labs(x = 'Theoretical quantiles',
       y = 'Sample quantiles',
       title = 'QQ Plot Violates Normality Assumption')
```



Model 6: linear mixed effects (random intercept for topfiveleague)

Outcome:

- points per match

Predictors:

- random intercept for topfiveleague
- goal margin per match
- goals per match

```
model6 = lmer(pointspermatch ~ 1 + goalspermatch + goalsagainstpermatch + goalmarginpermat
              (1|topfiveleague), data = soccer)
```

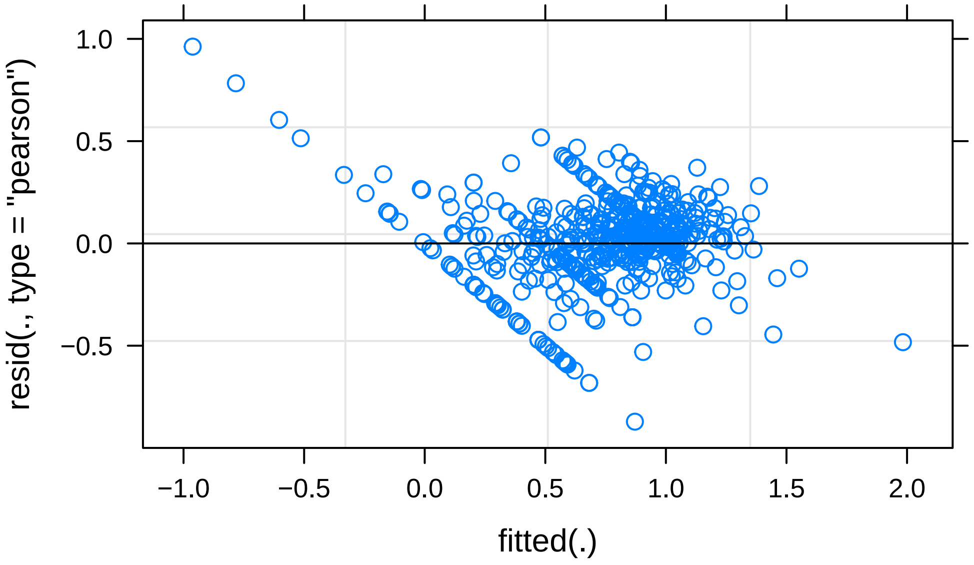
```
fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

```
summary(model6)
```

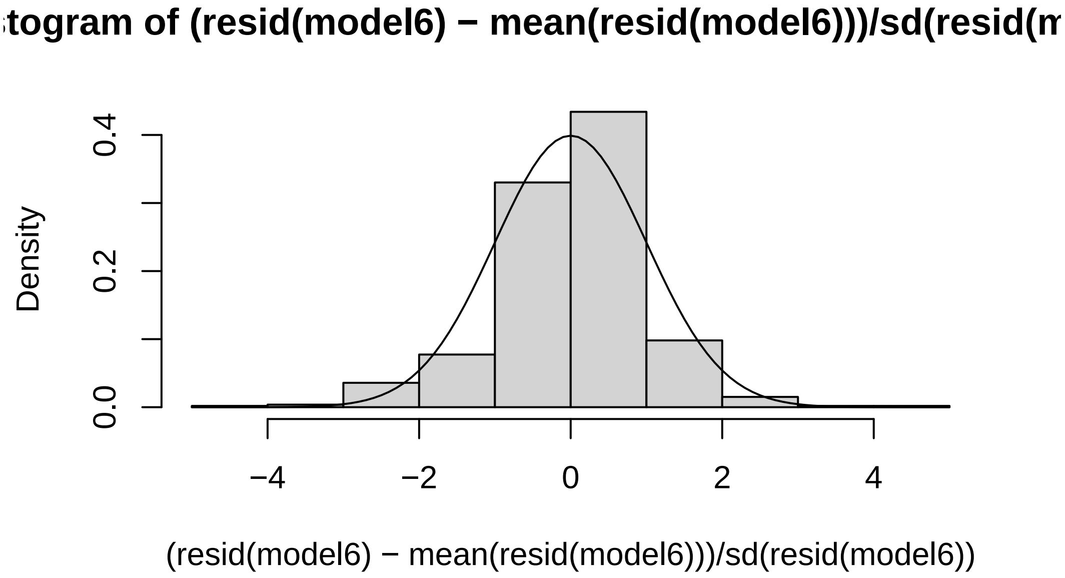
```
Linear mixed model fit by REML ['lmerMod']
Formula:
pointspermatch ~ 1 + goalspermatch + goalsagainstpermatch + goalmarginpermatch +
    (1 | topfiveleague)
   Data: soccer

REML criterion at convergence: -109.6

Scaled residuals:
    Min      1Q  Median      3Q     Max
-4.0695 -0.4806  0.0845  0.5708  4.4929

Random effects:
 Groups        Name        Variance Std.Dev.
 topfiveleague (Intercept) 0.001032 0.03213
 Residual                  0.045860 0.21415
Number of obs: 530, groups:  topfiveleague, 2

Fixed effects:
                      Estimate Std. Error t value
(Intercept)           0.670447   0.038501   17.41
goalspermatch         0.379188   0.016909   22.43
goalsagainstpermatch -0.179209   0.009449  -18.97

Correlation of Fixed Effects:
            (Intr) glsprm
goalsprmtch -0.627
glsgnstprmt -0.550  0.244
fit warnings:
fixed-effect model matrix is rank deficient so dropping 1 column / coefficient
```

Checking assumptions:

```
plot(model6)
```



```
hist((resid(model6) - mean(resid(model6))) / sd(resid(model6)), freq = FALSE); curve(dnorm
```



Variable Selection - LASSO

```
y = soccer$pointspermatch
x = model.matrix(pointspermatch ~ winspermatch + goalspermatch + goalsagainstpermatch +
                goalmarginpermatch + topfiveleague, data = soccer)
m_lasso_cv = cv.glmnet(x, y, alpha = 1)

best_lambda = m_lasso_cv$lambda.min
best_lambda
```

```
[1] 0.003448411
```

```
m_best = glmnet(x, y, alpha = 1, lambda = best_lambda)
m_best$beta
```

```
6 x 1 sparse Matrix of class "dgCMatrix"
                             s0
(Intercept)          .
winspermatch         1.37038572
goalspermatch        .
goalsagainstpermatch .
goalmarginpermatch   0.09659559
topfiveleaguetop five 0.01905888
```

```
bestlasso = lm(pointspermatch ~ winspermatch + goalmarginpermatch + topfiveleague,
               data = soccer)
```

Variable Selection - Stepwise Selection

```
m_none = lm(pointspermatch ~ 1, data = soccer)
m_all = lm(pointspermatch ~ winspermatch + goalspermatch + goalsagainstpermatch +
                goalmarginpermatch + topfiveleague, data = soccer)
```

Forward Selection

```
stepAIC(m_none,
        scope = list(lower = m_none, upper = m_all),
        data = soccer, direction = 'forward')
```

```
Start:  AIC=-977.7
pointspermatch ~ 1

                       Df Sum of Sq    RSS     AIC
+ winspermatch          1    69.170 14.292 -1911.0
+ goalmarginpermatch    1    54.871 28.590 -1543.5
+ goalspermatch         1    41.898 41.564 -1345.2
+ goalsagainstpermatch  1    33.999 49.463 -1253.0
+ topfiveleague         1     9.140 74.322 -1037.2
<none>                              83.462  -977.7

Step:  AIC=-1910.99
pointspermatch ~ winspermatch

                       Df Sum of Sq     RSS     AIC
+ goalmarginpermatch    1    4.6072  9.6847 -2115.2
+ goalsagainstpermatch  1    3.7403 10.5516 -2069.8
+ goalspermatch         1    0.4669 13.8250 -1926.6
+ topfiveleague         1    0.2923 13.9996 -1919.9
<none>                              14.2919 -1911.0

Step:  AIC=-2115.24
pointspermatch ~ winspermatch + goalmarginpermatch

                       Df Sum of Sq    RSS     AIC
+ topfiveleague         1  0.044462 9.6402 -2115.7
<none>                              9.6847 -2115.2
+ goalspermatch         1  0.000047 9.6846 -2113.2
+ goalsagainstpermatch  1  0.000047 9.6846 -2113.2

Step:  AIC=-2115.68
pointspermatch ~ winspermatch + goalmarginpermatch + topfiveleague

                       Df  Sum of Sq    RSS     AIC
<none>                               9.6402 -2115.7
+ goalspermatch         1 0.00015982 9.6400 -2113.7
+ goalsagainstpermatch  1 0.00015982 9.6400 -2113.7


Call:
lm(formula = pointspermatch ~ winspermatch + goalmarginpermatch +
    topfiveleague, data = soccer)
```

```
Coefficients:
          (Intercept)           winspermatch     goalmarginpermatch
              0.43402                1.37907                0.09770
topfiveleaguetop five
              0.02556
```

```
bestforward = lm(pointspermatch ~ winspermatch + goalmarginpermatch +
    topfiveleague, data = soccer)
```

Backward Selection

```
stepAIC(m_all,
        scope = list(lower = m_none, upper = m_all),
        data = soccer, direction = 'backward')
```

```
Start:  AIC=-2113.69
pointspermatch ~ winspermatch + goalspermatch + goalsagainstpermatch +
    goalmarginpermatch + topfiveleague


Step:  AIC=-2113.69
pointspermatch ~ winspermatch + goalspermatch + goalsagainstpermatch +
    topfiveleague

                       Df Sum of Sq     RSS     AIC
<none>                               9.6400 -2113.7
- topfiveleague         1    0.0446  9.6846 -2113.2
- goalspermatch         1    0.7904 10.4305 -2073.9
- goalsagainstpermatch  1    3.9802 13.6203 -1932.5
- winspermatch          1   14.4821 24.1221 -1629.6


Call:
lm(formula = pointspermatch ~ winspermatch + goalspermatch +
    goalsagainstpermatch + topfiveleague, data = soccer)

Coefficients:
          (Intercept)           winspermatch          goalspermatch
              0.43510                1.38121                0.09647
 goalsagainstpermatch  topfiveleaguetop five
             -0.09789                0.02570
```

```
bestbackward = lm(pointspermatch ~ winspermatch + goalspermatch + goalsagainstpermatch +
                    topfiveleague, data = soccer)
```

Both Selection

```
stepAIC(m_none,
        scope = list(lower = m_none, upper = m_all),
        data = soccer, direction = 'both')
```

```
Start:  AIC=-977.7
pointspermatch ~ 1

                       Df Sum of Sq    RSS     AIC
+ winspermatch          1    69.170 14.292 -1911.0
+ goalmarginpermatch    1    54.871 28.590 -1543.5
+ goalspermatch         1    41.898 41.564 -1345.2
+ goalsagainstpermatch  1    33.999 49.463 -1253.0
+ topfiveleague         1     9.140 74.322 -1037.2
<none>                              83.462  -977.7

Step:  AIC=-1910.99
pointspermatch ~ winspermatch

                       Df Sum of Sq    RSS     AIC
+ goalmarginpermatch    1     4.607  9.685 -2115.2
+ goalsagainstpermatch  1     3.740 10.552 -2069.8
+ goalspermatch         1     0.467 13.825 -1926.6
+ topfiveleague         1     0.292 14.000 -1919.9
<none>                              14.292 -1911.0
- winspermatch          1    69.170 83.462  -977.7

Step:  AIC=-2115.24
pointspermatch ~ winspermatch + goalmarginpermatch

                       Df Sum of Sq     RSS     AIC
+ topfiveleague         1    0.0445  9.6402 -2115.7
<none>                               9.6847 -2115.2
+ goalspermatch         1    0.0000  9.6846 -2113.2
+ goalsagainstpermatch  1    0.0000  9.6846 -2113.2
- goalmarginpermatch    1    4.6072 14.2919 -1911.0
- winspermatch          1   18.9058 28.5905 -1543.5
```

```
Step:  AIC=-2115.68
pointspermatch ~ winspermatch + goalmarginpermatch + topfiveleague

                      Df Sum of Sq     RSS     AIC
<none>                              9.6402 -2115.7
- topfiveleague        1    0.0445  9.6847 -2115.2
+ goalspermatch        1    0.0002  9.6400 -2113.7
+ goalsagainstpermatch 1    0.0002  9.6400 -2113.7
- goalmarginpermatch   1    4.3594 13.9996 -1919.9
- winspermatch         1   18.4525 28.0927 -1550.8


Call:
lm(formula = pointspermatch ~ winspermatch + goalmarginpermatch +
    topfiveleague, data = soccer)

Coefficients:
          (Intercept)           winspermatch     goalmarginpermatch
              0.43402                1.37907                0.09770
topfiveleaguetop five
              0.02556
```

```
bestboth = lm(pointspermatch ~ winspermatch + goalmarginpermatch + topfiveleague, data = s
```

Variable Selection - Mallo's CP

```
soccer_allsub = regsubsets(pointspermatch ~ winspermatch + goalspermatch +
                           goalsagainstpermatch + goalmarginpermatch + topfiveleague,
                           data = soccer,
                           nbest = 1, nvmax = 5)
```

```
Warning in leaps.setup(x, y, wt = wt, nbest = nbest, nvmax = nvmax, force.in =
force.in, : 1 linear dependencies found
```

```
Reordering variables and trying again:
```

```
soccer_allsub
```

```
Subset selection object
Call: regsubsets.formula(pointspermatch ~ winspermatch + goalspermatch +
    goalsagainstpermatch + goalmarginpermatch + topfiveleague,
    data = soccer, nbest = 1, nvmax = 5)
5 Variables  (and intercept)
                      Forced in Forced out
winspermatch              FALSE      FALSE
goalspermatch             FALSE      FALSE
goalsagainstpermatch      FALSE      FALSE
topfiveleaguetop five     FALSE      FALSE
goalmarginpermatch        FALSE      FALSE
1 subsets of each size up to 4
Selection Algorithm: exhaustive
```

```
summary(soccer_allsub)$rsq
```

```
[1] 0.8287614 0.8839632 0.8844959 0.8844979
```

```
summary(soccer_allsub)$which
```

```
  (Intercept) winspermatch goalspermatch goalsagainstpermatch
1        TRUE         TRUE         FALSE                FALSE
2        TRUE         TRUE         FALSE                FALSE
3        TRUE         TRUE         FALSE                FALSE
4        TRUE         TRUE          TRUE                 TRUE
  goalmarginpermatch topfiveleaguetop five
1              FALSE                 FALSE
2               TRUE                 FALSE
3               TRUE                  TRUE
4              FALSE                  TRUE
```

```
bestallsubset = lm(pointspermatch ~ winspermatch, data = soccer)
```

Comparing RMSE after variable selection

RMSE All Subset: 0.1642128

RMSE Best Backward: 0.1348656 - LOWEST

RMSE Best Both, Forward, Lasso: 0.1348667

(they had the same predictors in it)

CONCLUSION:

- best backward has lowest rmse so better
- predictors: wins per match, top five league, goals per match, goals against per match

```
rmse(bestallsubset)
```

```
[1] 0.1642128
```

```
rmse(bestbackward)
```

```
[1] 0.1348656
```

```
rmse(bestboth)
```

```
[1] 0.1348667
```

```
rmse(bestforward)
```

```
[1] 0.1348667
```

```
rmse(bestlasso)
```

```
[1] 0.1348667
```

##possibly delete – Comparing Models: RMSE

RMSE Model 1: 0.1348656 RMSE Model 2: 0.1348656 RMSE Model 3: 0.1348667 RMSE Model 4: 0.1349185

```
rmse(model1)
```

```
[1] 0.1348656
```

```r
rmse(model2)
```

```
[1] 0.1348656
```

```r
rmse(model3)
```

```
[1] 0.1348667
```

```r
rmse(model4)
```

```
[1] 0.1349185
```

Results

Conclusion