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

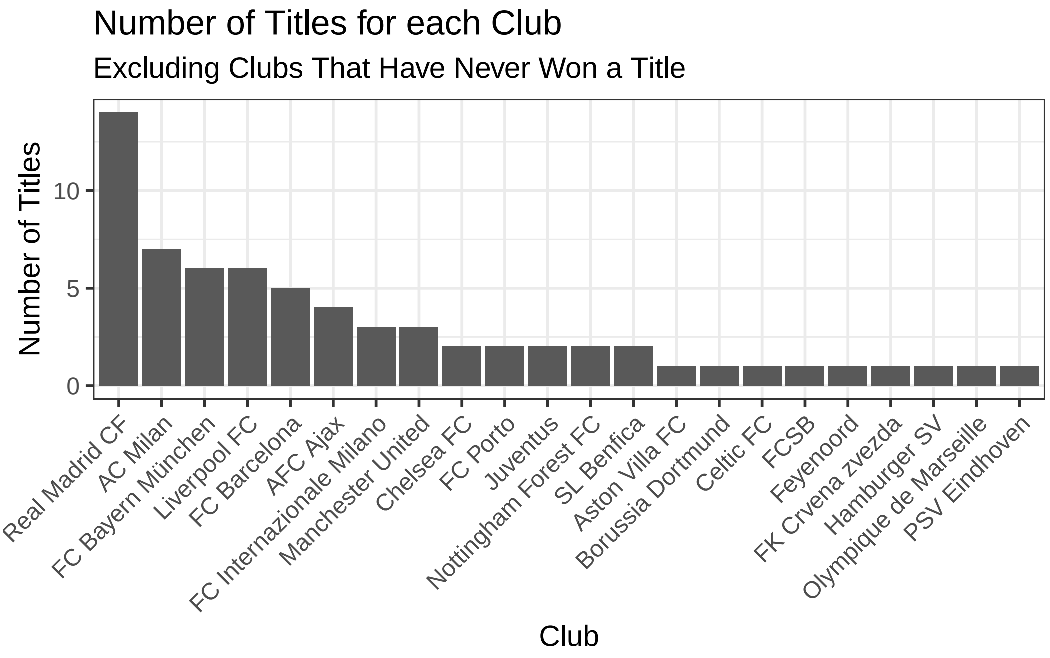
Data Cleaning

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

soccer = soccer %>%
  mutate(winpercentage = 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

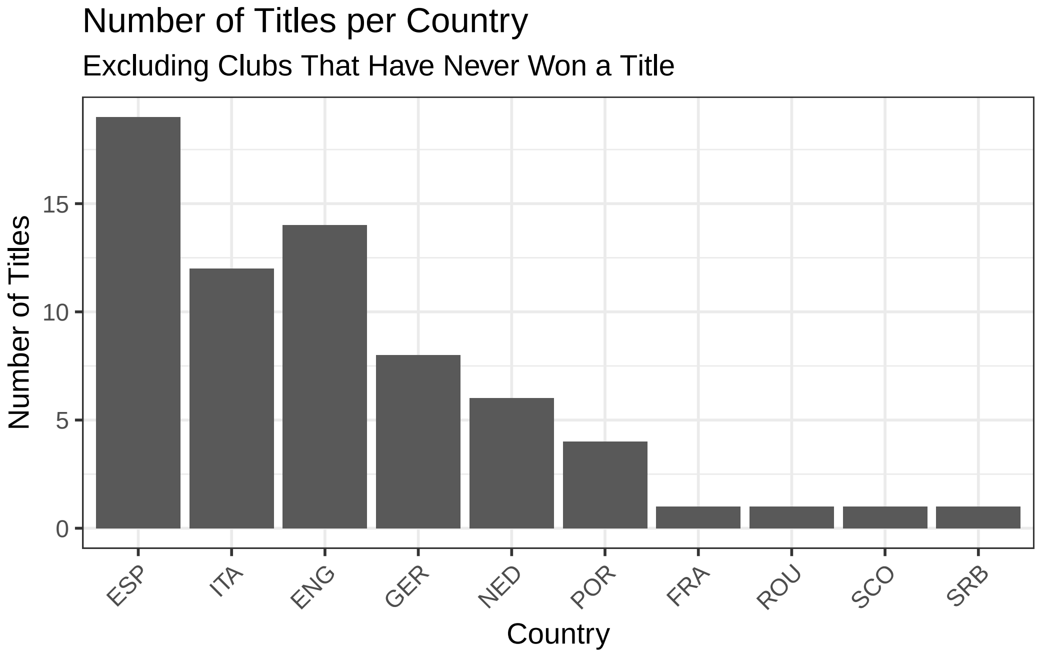
Plot 1:

```
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:

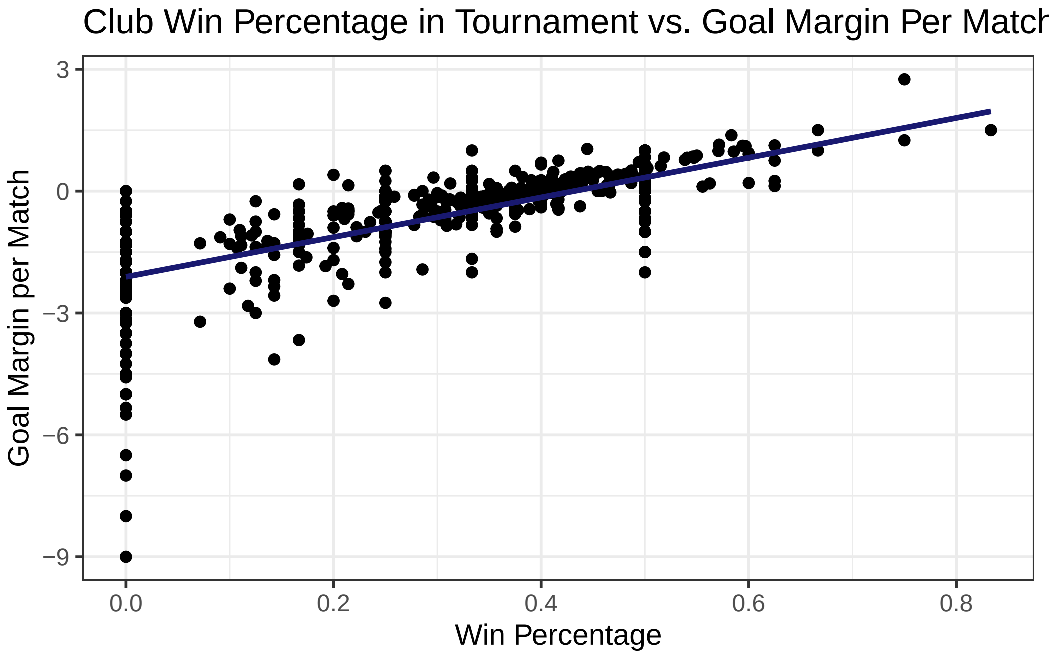
```
soccer %>%
  filter(Titles > 0) %>%
  ggplot(aes(x = reorder(Country, (-Titles)), y = Titles)) +
  geom_bar(stat = 'identity') +
  labs(x = 'Country', y = 'Number of Titles', title = 'Number of Titles per Country',
       subtitle = 'Excluding Clubs That Have Never Won a Title') +
  theme_bw() +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



Plot 3:

```
ggplot(data = soccer, aes(x = winpercentage, 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'
```



Club Win Percentage in Tournament vs. Goal Margin Per Match

Methods

we can only do linear or linear mixed effects…expand later

Variable Selection - LASSO

```
y = soccer$pointspermatch
x = model.matrix(pointspermatch ~ winpercentage + 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)          .
winpercentage        1.37038572
goalspermatch        .
goalsagainstpermatch .
goalmarginpermatch   0.09659559
topfiveleaguetop five 0.01905888
```

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

Variable Selection - Stepwise Selection

```
m_none = lm(pointspermatch ~ 1, data = soccer)
m_all = lm(pointspermatch ~ winpercentage + 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
+ winpercentage         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 ~ winpercentage

                       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 ~ winpercentage + 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 ~ winpercentage + 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 ~ winpercentage + goalmarginpermatch + 
    topfiveleague, data = soccer)

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

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

Backward Selection

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

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


Step:  AIC=-2113.69
pointspermatch ~ winpercentage + 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
- winpercentage         1   14.4821 24.1221 -1629.6



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

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

```
bestbackward = lm(pointspermatch ~ winpercentage + 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
+ winpercentage         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 ~ winpercentage

                       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
- winpercentage         1    69.170 83.462  -977.7

Step:  AIC=-2115.24
pointspermatch ~ winpercentage + 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
- winpercentage         1   18.9058 28.5905 -1543.5

Step:  AIC=-2115.68
pointspermatch ~ winpercentage + 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
- winpercentage         1   18.4525 28.0927 -1550.8


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

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

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

Variable Selection - All Subset

```
soccer_allsub = regsubsets(pointspermatch ~ winpercentage + 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 ~ winpercentage + goalspermatch +
    goalsagainstpermatch + goalmarginpermatch + topfiveleague,
    data = soccer, nbest = 1, nvmax = 5)
5 Variables  (and intercept)
                      Forced in Forced out
winpercentage             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) winpercentage 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 ~ winpercentage, 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
```

Checking Assumptions

Model 1: Linear Regression

Outcome:

- points per match

Predictors:

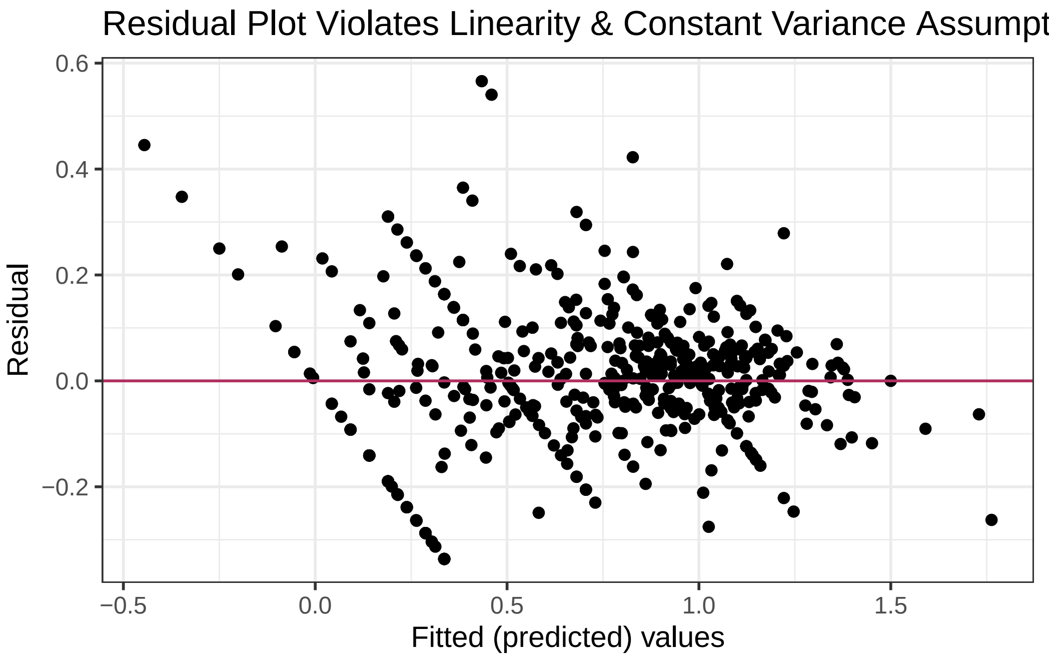
- win percentage
- goal margin per match
- top five league

```
linear = lm(pointspermatch ~ winpercentage + goalmarginpermatch + topfiveleague,
            data = soccer)
summary(linear)
```

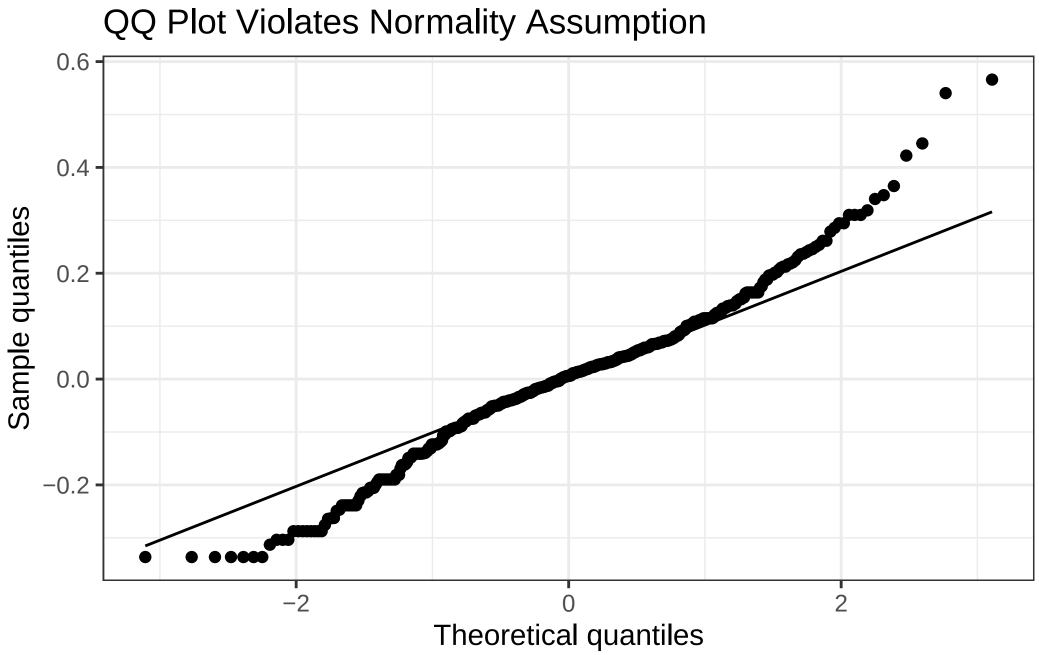
```

Call:
lm(formula = pointspermatch ~ winpercentage + 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 ***
winpercentage         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
```

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

```r
linearaug = augment(linear)

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



Model 2: Linear Mixed Effects Model

Outcome:

- points per match

Predictors:

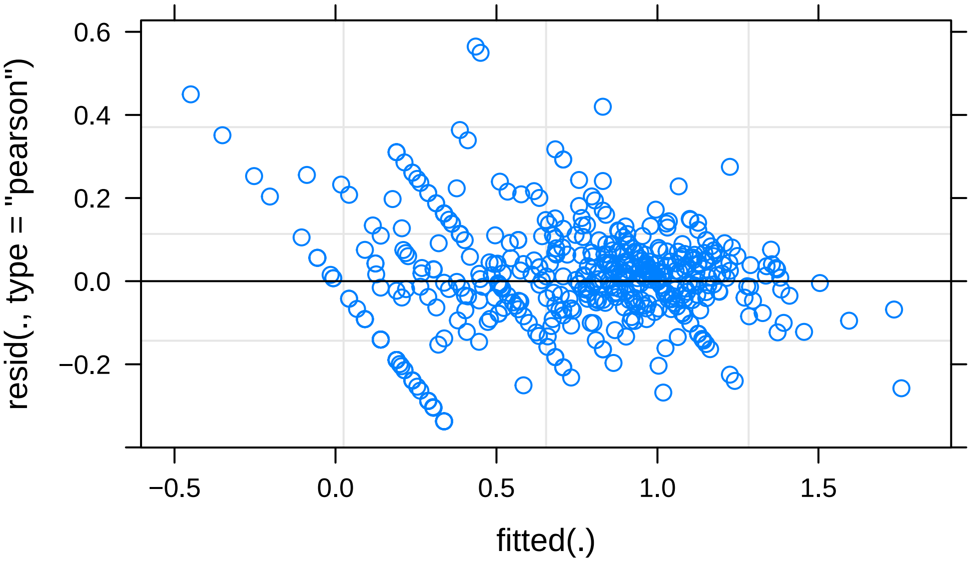
- win percentage
- goal margin per match
- random intercept for top five league

```
linearmixed = lmer(pointspermatch ~ 1 + winpercentage + goalmarginpermatch +
              (1|topfiveleague), data = soccer)
summary(linearmixed)
```

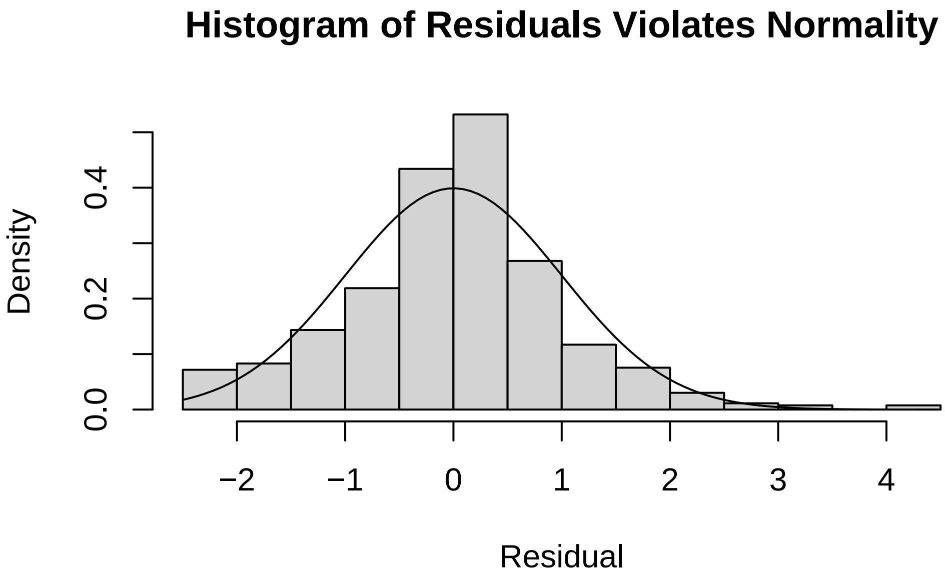
```
Linear mixed model fit by REML ['lmerMod']
Formula: pointspermatch ~ 1 + winpercentage + goalmarginpermatch + (1 |
    topfiveleague)
   Data: soccer

REML criterion at convergence: -595.8
```

```
Scaled residuals:
    Min      1Q  Median      3Q     Max
-2.4907 -0.5174  0.0556  0.5114  4.1696

Random effects:
 Groups        Name        Variance  Std.Dev.
 topfiveleague (Intercept) 0.0001921 0.01386
 Residual                  0.0183274 0.13538
Number of obs: 530, groups:  topfiveleague, 2

Fixed effects:
                   Estimate Std. Error t value
(Intercept)        0.443040   0.019785   22.39
winpercentage      1.382252   0.043345   31.89
goalmarginpermatch 0.098334   0.006304   15.60

Correlation of Fixed Effects:
            (Intr) wnprcn
winpercentg -0.780
glmrgnprmtc  0.636 -0.690
```

```
plot(linearmixed)
```



```
hist((resid(linearmixed) - mean(resid(linearmixed))) / sd(resid(linearmixed)), xlab = "Res
```



Assumptions are worse for mixed effects…moving forward with linear regression

Results

FINAL MODEL:

$$y_{ij} = (\gamma_{00} + \mu_{0j}) + \gamma_1 WinPercentage_{ij} + \gamma_2 TopFiveLeague_{ij} + \gamma_3 GoalsPerMatch_{ij} + \gamma_4 GoalsAgainstperMatch_{ij} + \epsilon_{ij}$$

where

y_{ij} = points per match

γ_1: wins percentage

γ_2: top five league, 1 = top five

γ_3: goals per match

γ_4: goals against per match

```
finalmodel = lmer(pointspermatch ~ 1 + winpercentage + goalspermatch + goalsagainstpermatc
                 (1|topfiveleague), data = soccer)
summary(finalmodel)
```

```
Linear mixed model fit by REML ['lmerMod']
Formula:
pointspermatch ~ 1 + winpercentage + goalspermatch + 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
winpercentage         1.383025   0.049148  28.140
goalspermatch         0.097878   0.014635   6.688
goalsagainstpermatch -0.098400   0.006629 -14.843

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

Conclusion