621 HW1

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1. Data Exploration

The moneyball training data set contains 2276 rows and 17 columns, including variables such as TARGET_WINS, TEAM_BATTING, TEAN_BASERUN, etc. The variables are thought to have a positive or negative effect on the number of games the baseball team won during the season. Running a summary() function on the data set, we are able to get the mean, median, first and third quartile and the minimum and maximum values for each variable. We included a correlation plot and pairs plot to visualize the relationship among the variables. Histograms were created for each type of hits to observe the normality of the variables. We explored the structure of the variables for both the training and evaluation data sets and finally observed how TARGET_WINS are affected by other factors. Interestingly, the number of wins seems positively correlated with all hits by batters except triples by batters, which the correlation plot shows as slightly negatively correlated. One potential explanation may be that getting triples, while good, is actually always worse than getting homeruns, so having a large number of triples may actually mean the team is just barely falling short. Nothing from the correlation plot can be used to conclude this, but it is something that can be investigated further in the future. Also surprising is that stolen bases barely has any positive correlation with wins, but that may just be due to the rarity of the event (stolen bases). TEAM_PITCHING_H, TEAM_PITCHING_BB, and TEAM_PITCHING_HR surprisingly shows a positive correlation with team wins, but maybe this alludes to having good batters and getting runs being more important to winning than stopping the opponent from getting runs. Similarly, TEAM_PITCHING_SO and TEAM_PITCHING_DP are events of denying the opponent runs, but they show a negative correlation with number of wins and may also point to getting runs for your team as the key to winning.

2. Data Preparation

We addressed issues with imperfect data before building models or performing statistical analysis. We observed that several variables have high numbers of NA or missing values. TEAM_BATTING_HBP has the highest number of missing cases i.e., 2085 (~ 90%). Based on the variable definitions given in the assignment, it seemed reasonable that NA values meant that there were no occurrences of that event. So we chose to create additional columns flagging whether the original variable was NA or not (1 if NA, 0 if not NA), and then filled NAs with 0.

3. Build Models

First we built a model using the backward elimination process. In this process, we rejected predictors with p-value greater than 0.05 and stopped after all remaining model predictors had p-values of less than 0.05. For our second model we decided to use stepwise selection. Stepwise selection uses an automated process of building a model by adding or removing predictors repeatedly based on an improvement of a criterion (Akaike information criterion in our case). We noticed one of the variables, TEAM_PITCHING_SO, had a p-value greater than 0.05 in the second model so we decided to build a third model using stepwise regression with the TEAM_PITCHING_SO predictor removed. The third model's R squared dropped slightly, so we decided to stick with our second model.

4. Select Models

Out of the three models we created, the second model with stepwise selection was the best of the three. The Adjusted R squared is 0.4098 which translates to approximately 41% of variation in Target Wins can be explained by our model. The F statistic tells us if there is a relationship between the dependent and independent variables we are testing. Generally, a large F indicates a stronger relationship and we have 113.9. The normal quantile quantile plot for residuals displays an approximately straight line so the residuals are approximately normally distributed. However, there is slight deviation at the extreme values, meaning our model does have a bit of trouble predicting a very high or low number of wins accurately. The MSE is 743.6606. Using this model we were able to make predictions for the test dataset. Finally, we made a histogram of wins from the training and evaluation set to see if the prediction distribution looked fairly similar to the training distribution, which it does.

Appendix

```r
# load required packages
library(ggplot2)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##     filter, lag

## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```r
#library(tidyr)
library(corrplot)
```

```
## corrplot 0.84 loaded
```

```r
library(MASS)
```

```
##
## Attaching package: 'MASS'

## The following object is masked from 'package:dplyr':
##
##     select
```

```r
library(caret)
```

```
## Loading required package: lattice
```

```
library(RCurl)
```

```
## Loading required package: bitops
```

```
# Loading the data
git_dir <- 'https://raw.github.com/odonnell31/data621-HW1/master/data'
train_df = read.csv(paste(git_dir, "/moneyball-training-data.csv", sep=""))
test_df = read.csv(paste(git_dir, "/moneyball-evaluation-data.csv", sep = ""))
```

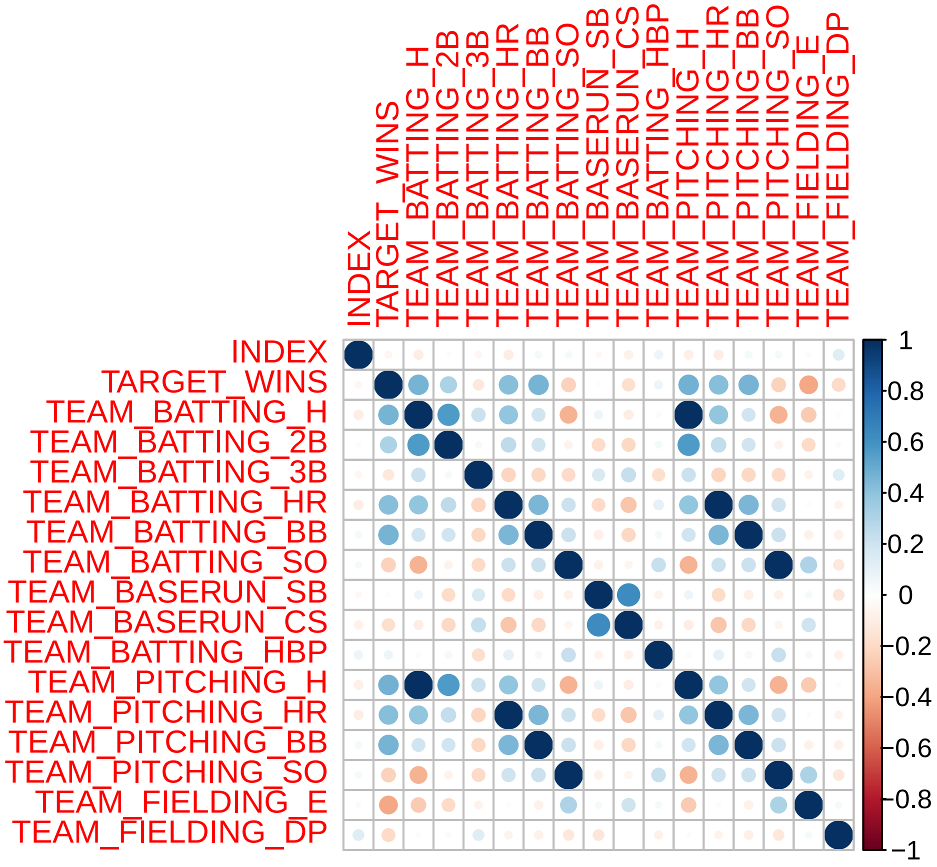
1. Data Exploration

See a summary of each column in the train_dfing set

```
# view a summary of all columns
summary(train_df)
```

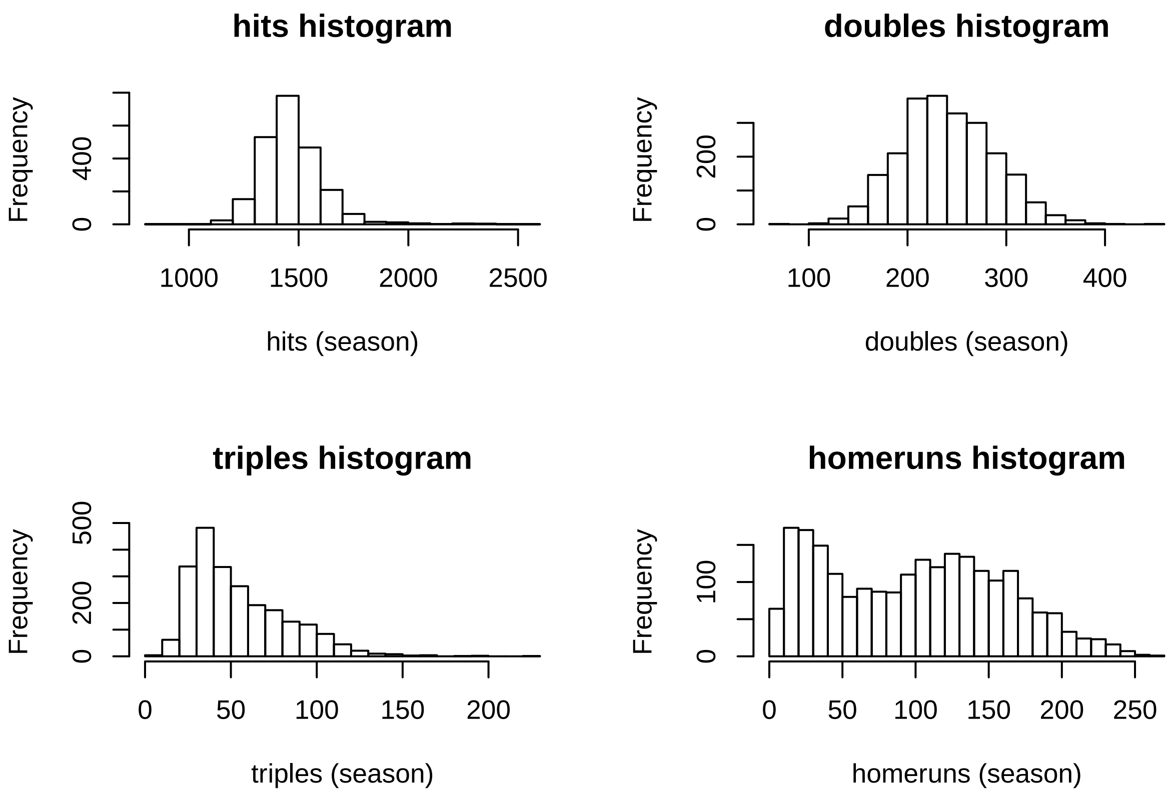
```
##      INDEX         TARGET_WINS     TEAM_BATTING_H TEAM_BATTING_2B
##  Min.   :   1.0   Min.   :  0.00   Min.   : 891   Min.   : 69.0  
##  1st Qu.: 630.8   1st Qu.: 71.00   1st Qu.:1383   1st Qu.:208.0  
##  Median :1270.5   Median : 82.00   Median :1454   Median :238.0  
##  Mean   :1268.5   Mean   : 80.79   Mean   :1469   Mean   :241.2  
##  3rd Qu.:1915.5   3rd Qu.: 92.00   3rd Qu.:1537   3rd Qu.:273.0  
##  Max.   :2535.0   Max.   :146.00   Max.   :2554   Max.   :458.0  
##                                                                  
##  TEAM_BATTING_3B  TEAM_BATTING_HR  TEAM_BATTING_BB TEAM_BATTING_SO
##  Min.   :  0.00   Min.   :  0.00   Min.   :  0.0   Min.   :   0.0  
##  1st Qu.: 34.00   1st Qu.: 42.00   1st Qu.:451.0   1st Qu.: 548.0  
##  Median : 47.00   Median :102.00   Median :512.0   Median : 750.0  
##  Mean   : 55.25   Mean   : 99.61   Mean   :501.6   Mean   : 735.6  
##  3rd Qu.: 72.00   3rd Qu.:147.00   3rd Qu.:580.0   3rd Qu.: 930.0  
##  Max.   :223.00   Max.   :264.00   Max.   :878.0   Max.   :1399.0  
##                                                    NA's   :102     
##  TEAM_BASERUN_SB TEAM_BASERUN_CS TEAM_BATTING_HBP TEAM_PITCHING_H
##  Min.   :  0.0   Min.   :  0.0   Min.   :29.00    Min.   : 1137  
##  1st Qu.: 66.0   1st Qu.: 38.0   1st Qu.:50.50    1st Qu.: 1419  
##  Median :101.0   Median : 49.0   Median :58.00    Median : 1518  
##  Mean   :124.8   Mean   : 52.8   Mean   :59.36    Mean   : 1779  
##  3rd Qu.:156.0   3rd Qu.: 62.0   3rd Qu.:67.00    3rd Qu.: 1682  
##  Max.   :697.0   Max.   :201.0   Max.   :95.00    Max.   :30132  
##  NA's   :131     NA's   :772     NA's   :2085                    
##  TEAM_PITCHING_HR TEAM_PITCHING_BB TEAM_PITCHING_SO  TEAM_FIELDING_E 
##  Min.   :  0.0    Min.   :   0.0   Min.   :    0.0   Min.   :  65.0  
##  1st Qu.: 50.0    1st Qu.: 476.0   1st Qu.:  615.0   1st Qu.: 127.0  
##  Median :107.0    Median : 536.5   Median :  813.5   Median : 159.0  
##  Mean   :105.7    Mean   : 553.0   Mean   :  817.7   Mean   : 246.5  
##  3rd Qu.:150.0    3rd Qu.: 611.0   3rd Qu.:  968.0   3rd Qu.: 249.2  
##  Max.   :343.0    Max.   :3645.0   Max.   :19278.0   Max.   :1898.0  
##                                    NA's   :102                       
##  TEAM_FIELDING_DP
##  Min.   : 52.0   
##   1st Qu.:131.0  
##   Median :149.0  
##   Mean   :146.4  
##   3rd Qu.:164.0  
##   Max.   :228.0  
##   NA's   :286
```

```
# Correlations
cor_train = cor(train_df,  use = "na.or.complete")
corrplot(cor_train)
```



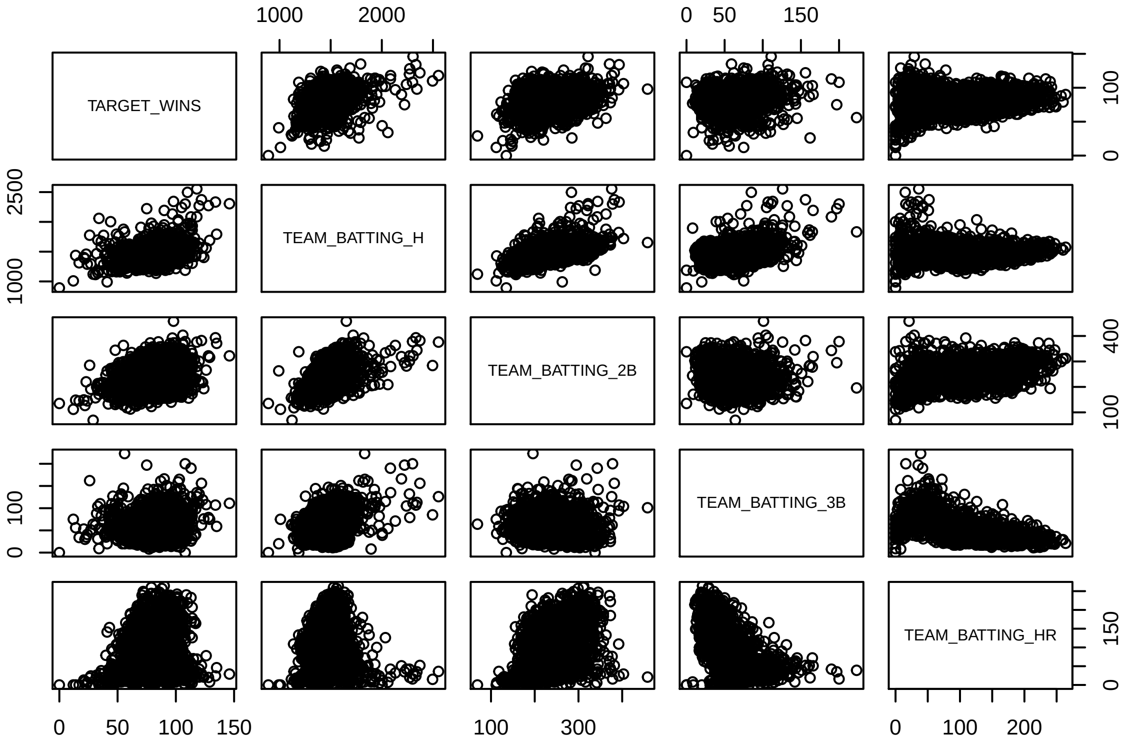
For types of hits, see a histogram of each

```
par(mfrow=c(2,2))
hist(train_df$TEAM_BATTING_H,
     main = "hits histogram", xlab = "hits (season)",
     breaks = 20)
hist(train_df$TEAM_BATTING_2B,
     main = "doubles histogram", xlab = "doubles (season)",
     breaks = 20)
hist(train_df$TEAM_BATTING_3B,
     main = "triples histogram", xlab = "triples (season)",
     breaks = 20)
hist(train_df$TEAM_BATTING_HR,
     main = "homeruns histogram", xlab = "homeruns (season)",
     breaks = 20)
```



```
par(mfrow=c(1,1))
```

```
pairs(~ TARGET_WINS + TEAM_BATTING_H + TEAM_BATTING_2B
      + TEAM_BATTING_3B + TEAM_BATTING_HR, data = train_df)
```



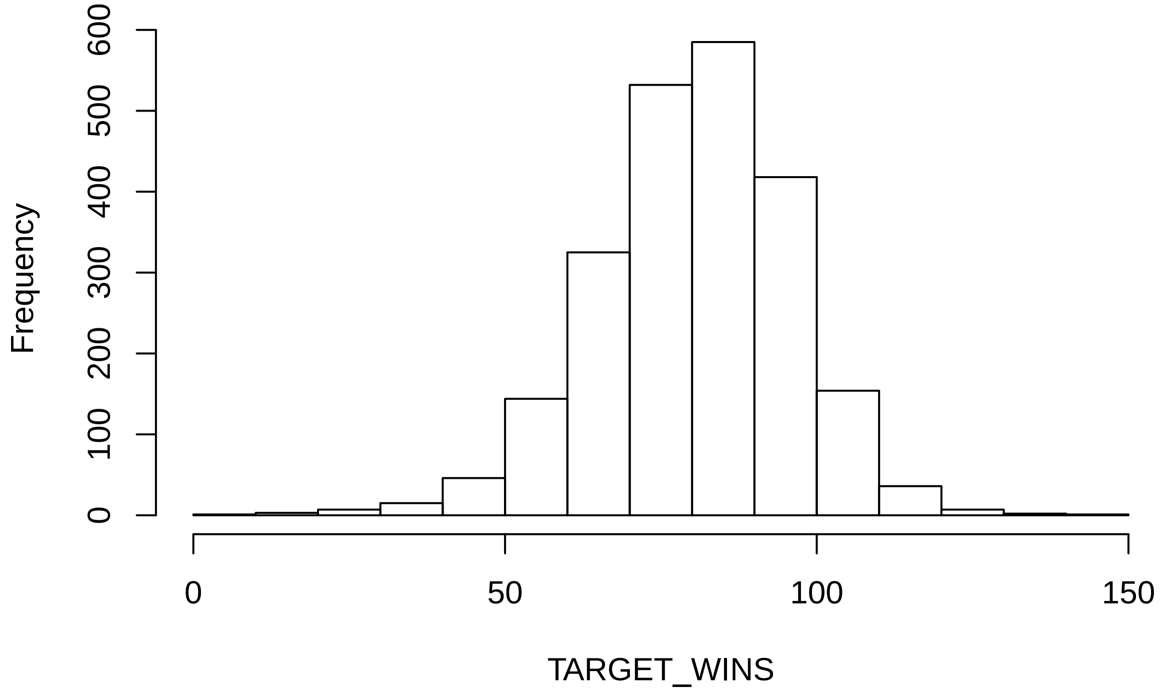
```
# look at the structure of the variables
str(train_df)
```

```
## 'data.frame':    2276 obs. of  17 variables:
##  $ INDEX           : int  1 2 3 4 5 6 7 8 11 12 ...
##  $ TARGET_WINS     : int  39 70 86 70 82 75 80 85 86 76 ...
##  $ TEAM_BATTING_H  : int  1445 1339 1377 1387 1297 1279 1244 1273 1391 1271 ...
##  $ TEAM_BATTING_2B : int  194 219 232 209 186 200 179 171 197 213 ...
##  $ TEAM_BATTING_3B : int  39 22 35 38 27 36 54 37 40 18 ...
##  $ TEAM_BATTING_HR : int  13 190 137 96 102 92 122 115 114 96 ...
##  $ TEAM_BATTING_BB : int  143 685 602 451 472 443 525 456 447 441 ...
##  $ TEAM_BATTING_SO : int  842 1075 917 922 920 973 1062 1027 922 827 ...
##  $ TEAM_BASERUN_SB : int  NA 37 46 43 49 107 80 40 69 72 ...
##  $ TEAM_BASERUN_CS : int  NA 28 27 30 39 59 54 36 27 34 ...
##  $ TEAM_BATTING_HBP: int  NA NA NA NA NA NA NA NA NA NA ...
##  $ TEAM_PITCHING_H : int  9364 1347 1377 1396 1297 1279 1244 1281 1391 1271 ...
##  $ TEAM_PITCHING_HR: int  84 191 137 97 102 92 122 116 114 96 ...
##  $ TEAM_PITCHING_BB: int  927 689 602 454 472 443 525 459 447 441 ...
##  $ TEAM_PITCHING_SO: int  5456 1082 917 928 920 973 1062 1033 922 827 ...
##  $ TEAM_FIELDING_E : int  1011 193 175 164 138 123 136 112 127 131 ...
##  $ TEAM_FIELDING_DP: int  NA 155 153 156 168 149 186 136 169 159 ...
```

```
str(eval)
```

```
## function (expr, envir = parent.frame(), enclos = if (is.list(envir) ||
##     is.pairlist(envir)) parent.frame() else baseenv())
```

```
# lets observe how targets_win are effected by other factors
hist(train_df$TARGET_WINS,xlab="TARGET_WINS",main="")
```

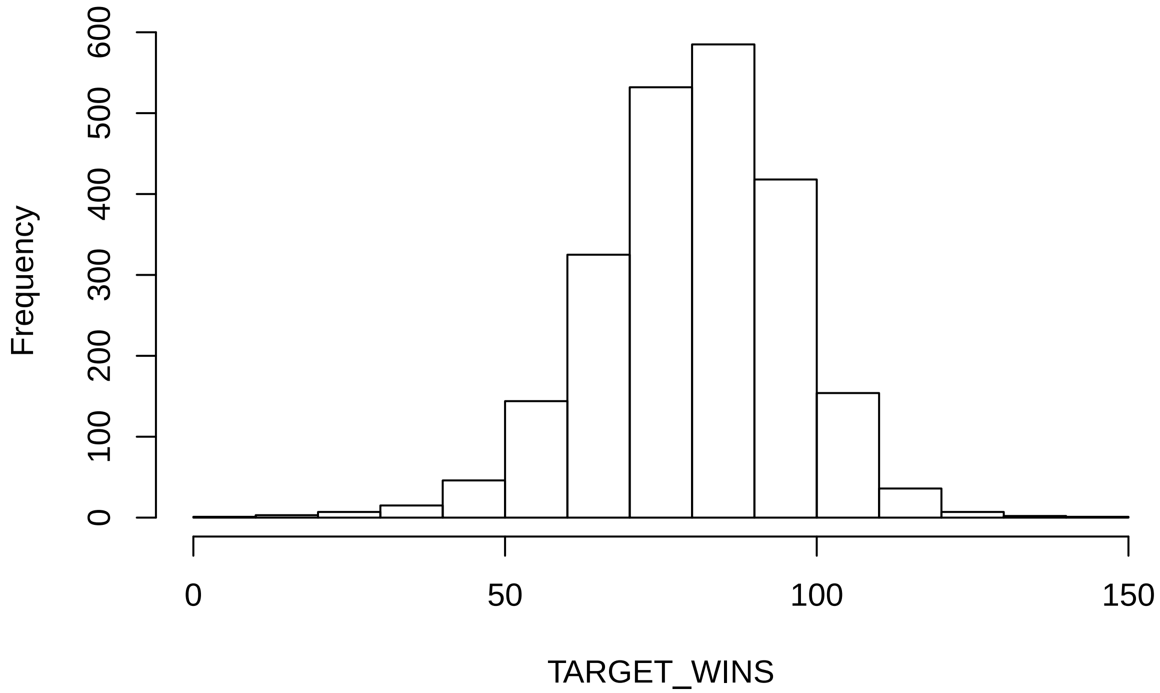


```
# we have no TARGET_WINS from eval
# hist(eval$TARGET_WINS,xlab="TARGET_WINS",main="")
```

2. Data Preparation

1. We are told everything is standardized to match a 162 game season, so it is my preference to make TARGET_WINS a decimal of 162

```
train_target_wins = train_df$TARGET_WINS
#train_df$TARGET_WINS = train_df$TARGET_WINS/162.
# TARGET_WINS now a decimal of games won in 162 game season
hist(train_df$TARGET_WINS,xlab="TARGET_WINS",main="")
```



```r
str(train_df)
```

```
## 'data.frame':    2276 obs. of  17 variables:
##  $ INDEX           : int  1 2 3 4 5 6 7 8 11 12 ...
##  $ TARGET_WINS     : int  39 70 86 70 82 75 80 85 86 76 ...
##  $ TEAM_BATTING_H  : int  1445 1339 1377 1387 1297 1279 1244 1273 1391 1271 ...
##  $ TEAM_BATTING_2B : int  194 219 232 209 186 200 179 171 197 213 ...
##  $ TEAM_BATTING_3B : int  39 22 35 38 27 36 54 37 40 18 ...
##  $ TEAM_BATTING_HR : int  13 190 137 96 102 92 122 115 114 96 ...
##  $ TEAM_BATTING_BB : int  143 685 602 451 472 443 525 456 447 441 ...
##  $ TEAM_BATTING_SO : int  842 1075 917 922 920 973 1062 1027 922 827 ...
##  $ TEAM_BASERUN_SB : int  NA 37 46 43 49 107 80 40 69 72 ...
##  $ TEAM_BASERUN_CS : int  NA 28 27 30 39 59 54 36 27 34 ...
##  $ TEAM_BATTING_HBP: int  NA NA NA NA NA NA NA NA NA NA ...
##  $ TEAM_PITCHING_H : int  9364 1347 1377 1396 1297 1279 1244 1281 1391 1271 ...
##  $ TEAM_PITCHING_HR: int  84 191 137 97 102 92 122 116 114 96 ...
##  $ TEAM_PITCHING_BB: int  927 689 602 454 472 443 525 459 447 441 ...
##  $ TEAM_PITCHING_SO: int  5456 1082 917 928 920 973 1062 1033 922 827 ...
##  $ TEAM_FIELDING_E : int  1011 193 175 164 138 123 136 112 127 131 ...
##  $ TEAM_FIELDING_DP: int  NA 155 153 156 168 149 186 136 169 159 ...
```

2. Assuming that everything that is NA can be filled by 0 based on the description of variables, create columns flagging if original values were NA (e.g. create TEAM_BATTING_HBP_NA column and value is 1 if TEAM_BATTING_HBP is NA and 0 otherwise meaning it wasn't NA and had a value. Do this for all columns)

```
#
has_NA = names(which(sapply(train_df, anyNA)))
for (col in has_NA)
{
   new_col = (paste(col,"_NA", sep=""))
   train_df[,new_col] = as.numeric(is.na(train_df[,col]))
   test_df[,new_col] = as.numeric(is.na(test_df[,col]))
}
train_df[is.na(train_df)] = 0
test_df[is.na(test_df)] = 0
```

3. Build Models

```
# set seed for reproducibility
n_records = nrow(train_df)
set.seed(1)
```

Model 1 - Backward Elimination Process

We will be rejecting predictors with p-value greater than 0.05 with the backward elimination process. We will stop after all the predictors are less than 0.05

```
model <- lm(TARGET_WINS ~ TEAM_BATTING_H + TEAM_BATTING_2B + TEAM_BATTING_3B + TEAM_BATTING_HR + TEAM_BA
summary(train_df)
```

```
##      INDEX         TARGET_WINS     TEAM_BATTING_H TEAM_BATTING_2B
##  Min.   :   1.0   Min.   :  0.00   Min.   : 891   Min.   : 69.0  
##  1st Qu.: 630.8   1st Qu.: 71.00   1st Qu.:1383   1st Qu.:208.0  
##  Median :1270.5   Median : 82.00   Median :1454   Median :238.0  
##  Mean   :1268.5   Mean   : 80.79   Mean   :1469   Mean   :241.2  
##  3rd Qu.:1915.5   3rd Qu.: 92.00   3rd Qu.:1537   3rd Qu.:273.0  
##  Max.   :2535.0   Max.   :146.00   Max.   :2554   Max.   :458.0  
##  TEAM_BATTING_3B  TEAM_BATTING_HR  TEAM_BATTING_BB TEAM_BATTING_SO
##  Min.   :  0.00   Min.   :  0.00   Min.   :  0.0   Min.   :   0.0  
##  1st Qu.: 34.00   1st Qu.: 42.00   1st Qu.:451.0   1st Qu.: 524.0  
##  Median : 47.00   Median :102.00   Median :512.0   Median : 728.0  
##  Mean   : 55.25   Mean   : 99.61   Mean   :501.6   Mean   : 702.6  
##  3rd Qu.: 72.00   3rd Qu.:147.00   3rd Qu.:580.0   3rd Qu.: 925.0  
##  Max.   :223.00   Max.   :264.00   Max.   :878.0   Max.   :1399.0  
##  TEAM_BASERUN_SB TEAM_BASERUN_CS  TEAM_BATTING_HBP TEAM_PITCHING_H
##  Min.   :  0.0   Min.   :  0.00   Min.   : 0.000   Min.   : 1137  
##  1st Qu.: 60.0   1st Qu.:  0.00   1st Qu.: 0.000   1st Qu.: 1419  
##  Median : 97.0   Median : 38.00   Median : 0.000   Median : 1518  
##  Mean   :117.6   Mean   : 34.89   Mean   : 4.981   Mean   : 1779  
##  3rd Qu.:151.0   3rd Qu.: 54.25   3rd Qu.: 0.000   3rd Qu.: 1682  
##  Max.   :697.0   Max.   :201.00   Max.   :95.000   Max.   :30132  
##  TEAM_PITCHING_HR TEAM_PITCHING_BB TEAM_PITCHING_SO  TEAM_FIELDING_E
##  Min.   :  0.0    Min.   :   0.0   Min.   :    0.0   Min.   :  65.0  
##  1st Qu.: 50.0    1st Qu.: 476.0   1st Qu.:  587.8   1st Qu.: 127.0  
##  Median :107.0    Median : 536.5   Median :  797.0   Median : 159.0  
##  Mean   :105.7    Mean   : 553.0   Mean   :  781.1   Mean   : 246.5  
##  3rd Qu.:150.0    3rd Qu.: 611.0   3rd Qu.:  957.0   3rd Qu.: 249.2  
##  Max.   :343.0    Max.   :3645.0   Max.   :19278.0   Max.   :1898.0  
##  TEAM_FIELDING_DP TEAM_BATTING_SO_NA TEAM_BASERUN_SB_NA TEAM_BASERUN_CS_NA
##  Min.   :  0.0    Min.   :0.00000    Min.   :0.00000    Min.   :0.0000    
##  1st Qu.:118.0    1st Qu.:0.00000    1st Qu.:0.00000    1st Qu.:0.0000    
##  Median :145.0    Median :0.00000    Median :0.00000    Median :0.0000    
##  Mean   :128.0    Mean   :0.04482    Mean   :0.05756    Mean   :0.3392    
##  3rd Qu.:161.2    3rd Qu.:0.00000    3rd Qu.:0.00000    3rd Qu.:1.0000    
##  Max.   :228.0    Max.   :1.00000    Max.   :1.00000    Max.   :1.0000    
##  TEAM_BATTING_HBP_NA TEAM_PITCHING_SO_NA TEAM_FIELDING_DP_NA
##  Min.   :0.0000      Min.   :0.00000     Min.   :0.0000     
##  1st Qu.:1.0000      1st Qu.:0.00000     1st Qu.:0.0000     
##  Median :1.0000      Median :0.00000     Median :0.0000     
##  Mean   :0.9161      Mean   :0.04482     Mean   :0.1257     
##  3rd Qu.:1.0000      3rd Qu.:0.00000     3rd Qu.:0.0000     
##  Max.   :1.0000      Max.   :1.00000     Max.   :1.0000     
```

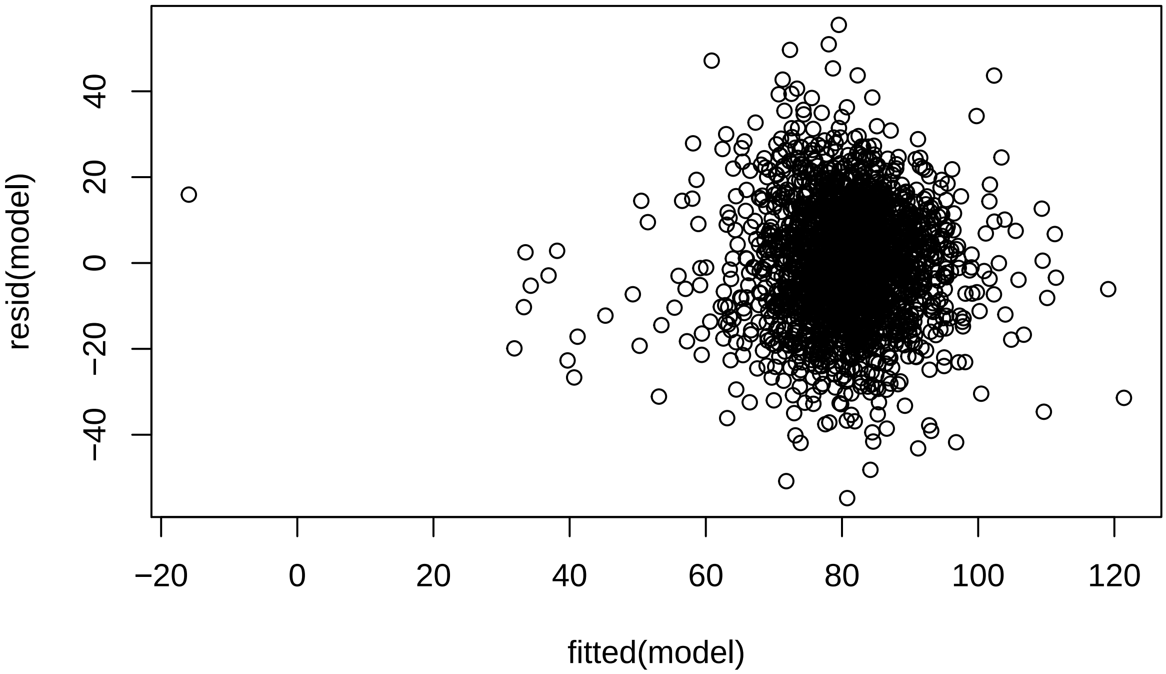
```r
model <- update(model, .~. - TEAM_BATTING_BB, data=train_df)
summary(model)
```

```
## 
## Call:
## lm(formula = TARGET_WINS ~ TEAM_BATTING_H + TEAM_BATTING_2B + 
##     TEAM_BATTING_3B + TEAM_BATTING_HR + TEAM_PITCHING_H + TEAM_PITCHING_HR + 
##     TEAM_PITCHING_BB + TEAM_FIELDING_E, data = train_df)
## 
## Residuals:
##     Min      1Q  Median      3Q     Max 
## -54.273  -8.832   0.127   8.886  55.587 
## 
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)    
## (Intercept)       6.526453   3.423988   1.906   0.0568 .  
## TEAM_BATTING_H    0.048766   0.003208  15.200  < 2e-16 ***
## TEAM_BATTING_2B  -0.026072   0.009050  -2.881   0.0040 ** 
## TEAM_BATTING_3B   0.102196   0.016708   6.116 1.12e-09 ***
## TEAM_BATTING_HR   0.054383   0.024691   2.203   0.0277 *  
## TEAM_PITCHING_H  -0.001282   0.000327  -3.922 9.05e-05 ***
## TEAM_PITCHING_HR -0.016991   0.022575  -0.753   0.4517    
## TEAM_PITCHING_BB  0.010755   0.002036   5.283 1.40e-07 ***
## TEAM_FIELDING_E  -0.016351   0.002287  -7.149 1.18e-12 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
## 
## Residual standard error: 13.48 on 2267 degrees of freedom
## Multiple R-squared:  0.2702, Adjusted R-squared:  0.2677 
## F-statistic: 104.9 on 8 and 2267 DF,  p-value: < 2.2e-16
```

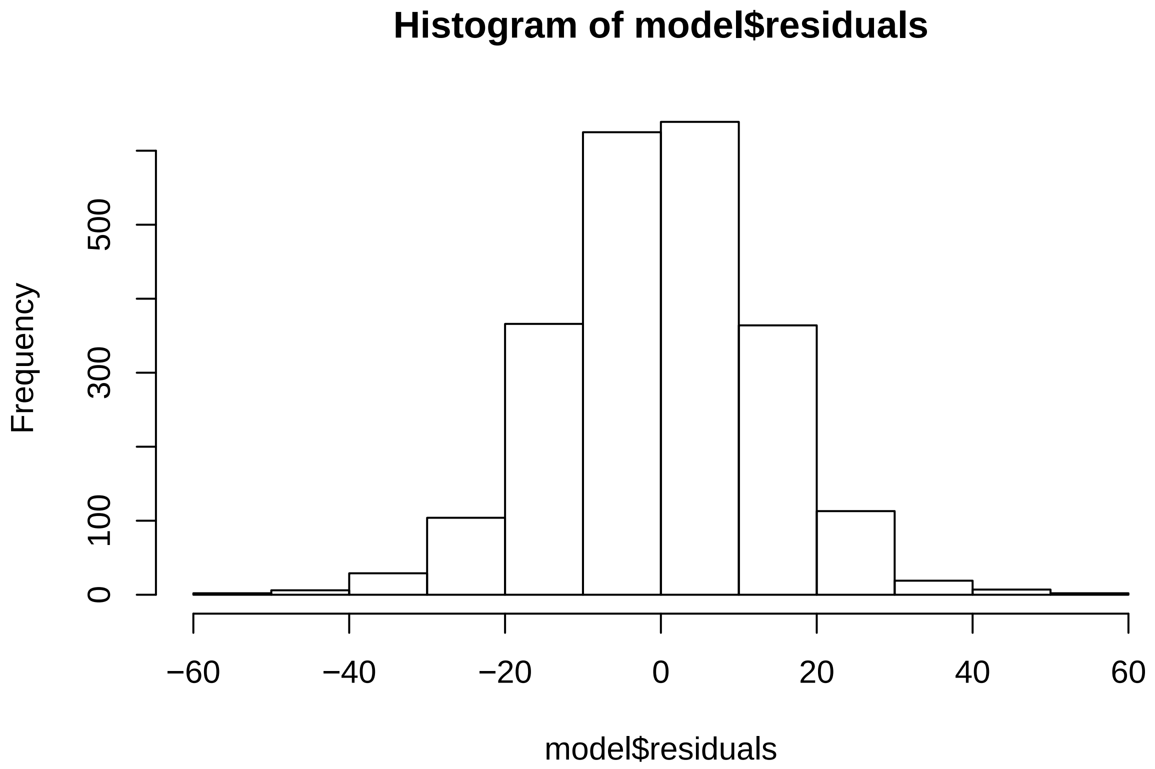
```r
model <- update(model, .~. - TEAM_PITCHING_HR, data=train_df)
summary(model)
```

```
##
## Call:
## lm(formula = TARGET_WINS ~ TEAM_BATTING_H + TEAM_BATTING_2B +
##     TEAM_BATTING_3B + TEAM_BATTING_HR + TEAM_PITCHING_H + TEAM_PITCHING_BB +
##     TEAM_FIELDING_E, data = train_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -54.763  -8.861   0.095   8.860  55.469
##
## Coefficients:
##                   Estimate Std. Error t value Pr(>|t|)
## (Intercept)       7.2713462  3.2775220   2.219  0.02662 *
## TEAM_BATTING_H    0.0484775  0.0031849  15.221  < 2e-16 ***
## TEAM_BATTING_2B  -0.0258127  0.0090430  -2.854  0.00435 **
## TEAM_BATTING_3B   0.1010776  0.0166406   6.074 1.46e-09 ***
## TEAM_BATTING_HR   0.0366916  0.0075591   4.854 1.29e-06 ***
## TEAM_PITCHING_H  -0.0013088  0.0003251  -4.026 5.87e-05 ***
## TEAM_PITCHING_BB  0.0103207  0.0019522   5.287 1.36e-07 ***
## TEAM_FIELDING_E  -0.0166263  0.0022577  -7.364 2.48e-13 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 13.48 on 2268 degrees of freedom
## Multiple R-squared:   0.27,  Adjusted R-squared:  0.2678
## F-statistic: 119.9 on 7 and 2268 DF,  p-value: < 2.2e-16
```

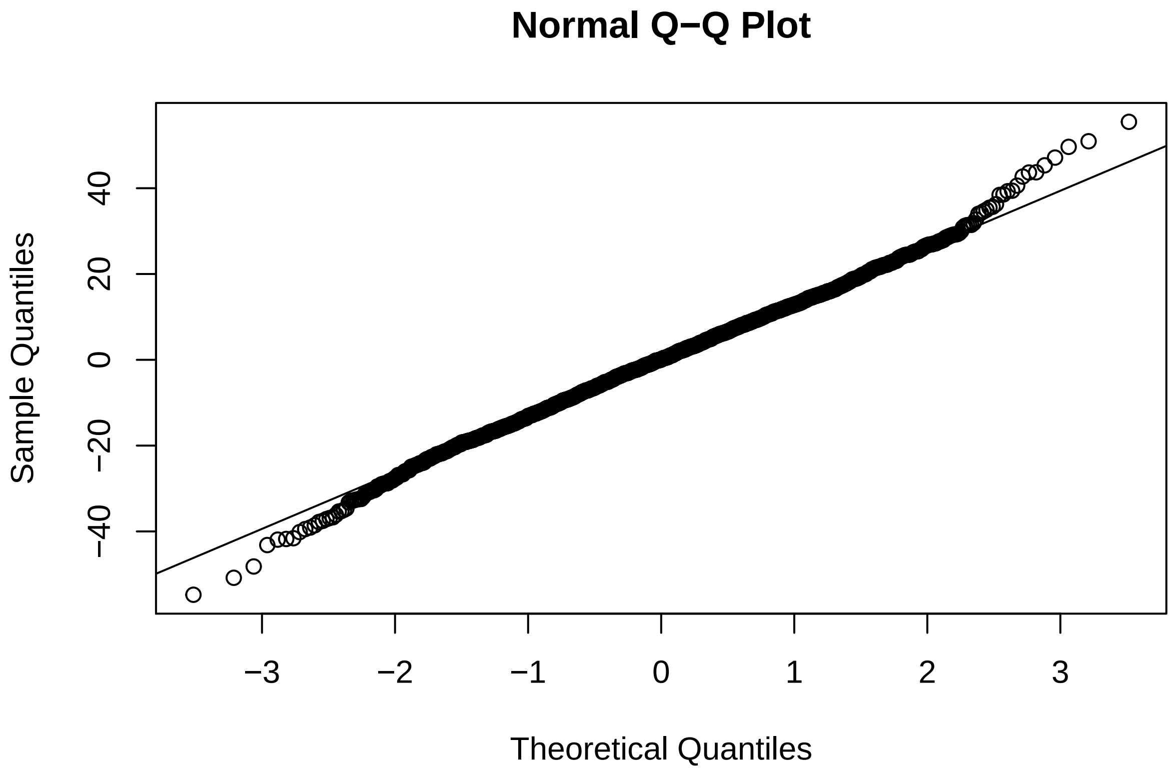
```
plot(fitted(model), resid(model))
```



```
hist(model$residuals)
```



```
qqnorm(resid(model))
qqline(resid(model))
```



```
#predict the model on the eval
colnames(test_df)
```

```
##  [1] "INDEX"               "TEAM_BATTING_H"      "TEAM_BATTING_2B"
##  [4] "TEAM_BATTING_3B"     "TEAM_BATTING_HR"     "TEAM_BATTING_BB"
##  [7] "TEAM_BATTING_SO"     "TEAM_BASERUN_SB"     "TEAM_BASERUN_CS"
## [10] "TEAM_BATTING_HBP"    "TEAM_PITCHING_H"     "TEAM_PITCHING_HR"
## [13] "TEAM_PITCHING_BB"    "TEAM_PITCHING_SO"    "TEAM_FIELDING_E"
## [16] "TEAM_FIELDING_DP"    "TEAM_BATTING_SO_NA"  "TEAM_BASERUN_SB_NA"
## [19] "TEAM_BASERUN_CS_NA"  "TEAM_BATTING_HBP_NA" "TEAM_PITCHING_SO_NA"
## [22] "TEAM_FIELDING_DP_NA"
```

```
#remove the predictors that have negative effect to the target wins

new_eval_model = subset(test_df, select=c(TEAM_BATTING_H, TEAM_BATTING_2B, TEAM_BATTING_3B, TEAM_BATTIN
# Turn the NA values in 0
new_eval_model[is.na(new_eval_model)] = 0

# prediction model
prediction_model <- predict(model, newdata=new_eval_model)
prediction_model
```

```
##        1        2        3        4        5        6        7
## 68.57679 70.20767 77.35107 83.60728 66.44188 67.44392 74.01699
##        8        9       10       11       12       13       14
##  72.52290  72.07908  75.86204  76.14127  85.66302  84.25863  82.11244
##        15        16        17        18        19        20        21
##  79.28366  80.65313  72.72498  80.73209  68.24429  93.15727  84.03790
##        22        23        24        25        26        27        28
##  86.72537  83.94422  76.45507  82.33443  84.46690  53.99437  77.34772
##        29        30        31        32        33        34        35
##  83.55037  76.54752  89.64897  87.49762  86.39979  88.63464  83.07959
##        36        37        38        39        40        41        42
##  82.97654  76.59917  90.98962  88.25264  89.93392  81.06430  86.65244
##        43        44        45        46        47        48        49
##  32.00565  93.94542  84.49850  91.12091  95.25990  72.55215  70.71842
##        50        51        52        53        54        55        56
##  77.42567  80.56279  86.18097  79.54452  75.66770  76.77920  78.91475
##        57        58        59        60        61        62        63
##  87.00232  70.24445  62.43238  76.94456  85.57690  82.32992  84.10415
##        64        65        66        67        68        69        70
##  84.08464  81.72510  88.61128  77.01994  84.45808  75.03575  84.58887
##        71        72        73        74        75        76        77
##  93.11545  78.11656  83.60987  87.48446  83.25982  87.59647  81.10361
##        78        79        80        81        82        83        84
##  79.45530  69.17038  75.34361  86.58620  91.02278  98.65784  83.24041
##        85        86        87        88        89        90        91
##  86.29588  81.38914  77.81345  83.29427  82.14307  85.78844  77.31626
##        92        93        94        95        96        97        98
##  90.17090  74.92238  80.27929  76.63840  76.41073  83.76351 101.49146
##        99       100       101       102       103       104       105
##  90.66066  91.80633  85.67709  75.74458  85.85636  82.51112  80.28514
##       106       107       108       109       110       111       112
##  75.74648  59.21657  80.05705  83.36447  63.89810  81.69559  80.89442
##       113       114       115       116       117       118       119
##  90.51339  88.42404  82.00004  79.88766  89.12636  79.28716  78.32773
##       120       121       122       123       124       125       126
##  70.56117  88.18073  64.83877  68.79647  62.89740  70.53486  89.14903
##       127       128       129       130       131       132       133
##  93.52098  77.13546  89.76420  96.00349  87.87496  79.55286  74.18762
##       134       135       136       137       138       139       140
##  83.65916  84.63120  67.92567  76.76088  79.31622  80.25903  79.00221
##       141       142       143       144       145       146       147
##  65.97271  70.88566  93.96534  80.09868  75.63502  76.66057  79.09194
##       148       149       150       151       152       153       154
##  81.58381  85.45157  81.03183  83.18578  79.69117  32.00533  74.74922
##       155       156       157       158       159       160       161
##  76.72696  73.53798  83.62346  70.38656  90.86799  71.82949 103.86302
##       162       163       164       165       166       167       168
## 102.94796  91.40787 103.43996  96.25437  92.15061  87.44536  83.28689
##       169       170       171       172       173       174       175
##  73.88550  80.44850  87.53529  83.90489  81.81791  91.73197  83.62750
##       176       177       178       179       180       181       182
##  78.62979  78.72177  78.62720  77.61974  80.23747  75.75891  82.42463
##       183       184       185       186       187       188       189
##  82.50687  83.40560  93.86719  84.08224  84.88270  59.90440  62.71131
##       190       191       192       193       194       195       196
## 106.61875  70.30532  79.80179  77.50981  80.91032  82.33698  71.26555
##       197       198       199       200       201       202       203
##  77.85090  81.87750  80.77272  86.39044  80.67028  82.42010  76.24716
##       204       205       206       207       208       209       210
##  85.64095  77.63218  78.86158  80.18659  76.75479  78.45877  74.04968
##       211       212       213       214       215       216       217
## 102.73424  94.95937  83.50166  71.04174  76.47425  88.75922  87.14607
##       218       219       220       221       222       223       224
##  86.32952  77.07959  76.85061  79.78128  75.26852  82.97115  79.90219
##       225       226       227       228       229       230       231
##  88.18673  76.73958  79.38705  80.08819  80.21071  76.68290  71.78995
##       232       233       234       235       236       237       238
##  94.28243  83.96099  86.59268  79.03424  74.35427  81.44309  78.25418
##       239       240       241       242       243       244       245
##  92.42152  75.30730  90.78059  88.86296  85.17144  83.49939  63.68535
##       246       247       248       249       250       251       252
##  86.98493  79.74425  82.77956  76.14821  84.12894  82.43395  59.19506
##       253       254       255       256       257       258       259
##  90.43189  46.23627  70.80823  77.18288  75.82183  77.87520  77.54615
```

Model 2 - Stepwise Regression

```
# Try stepwise regression as mentioned in http://www.sthda.com/english/articles/37-model-selection-esse
full_model = lm(TARGET_WINS ~ ., data=train_df)
step.model <- stepAIC(full_model, direction = "both",
                      trace = FALSE)
summary(step.model)
```

```
##
## Call:
## lm(formula = TARGET_WINS ~ TEAM_BATTING_H + TEAM_BATTING_2B +
##     TEAM_BATTING_3B + TEAM_BATTING_HR + TEAM_BATTING_BB + TEAM_BATTING_SO +
##     TEAM_BASERUN_SB + TEAM_PITCHING_H + TEAM_PITCHING_SO + TEAM_FIELDING_E +
##     TEAM_FIELDING_DP + TEAM_BASERUN_SB_NA + TEAM_BATTING_HBP_NA +
##     TEAM_FIELDING_DP_NA, data = train_df)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -63.693  -8.067   0.330   7.875  49.924
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          1.820e+01  4.192e+00   4.340 1.49e-05 ***
## TEAM_BATTING_H       4.682e-02  3.212e-03  14.578  < 2e-16 ***
## TEAM_BATTING_2B     -2.757e-02  8.973e-03  -3.073 0.002147 **
## TEAM_BATTING_3B      5.424e-02  1.547e-02   3.507 0.000461 ***
## TEAM_BATTING_HR      7.549e-02  8.642e-03   8.736  < 2e-16 ***
## TEAM_BATTING_BB      2.398e-02  3.239e-03   7.404 1.86e-13 ***
## TEAM_BATTING_SO     -1.025e-02  1.776e-03  -5.771 8.97e-09 ***
## TEAM_BASERUN_SB      5.014e-02  4.457e-03  11.249  < 2e-16 ***
## TEAM_PITCHING_H      1.980e-03  3.339e-04   5.930 3.49e-09 ***
## TEAM_PITCHING_SO    -1.096e-03  6.613e-04  -1.657 0.097666 .
## TEAM_FIELDING_E     -5.685e-02  3.370e-03 -16.873  < 2e-16 ***
## TEAM_FIELDING_DP    -1.045e-01  1.309e-02  -7.985 2.21e-15 ***
## TEAM_BASERUN_SB_NA   3.969e+01  2.048e+00  19.385  < 2e-16 ***
## TEAM_BATTING_HBP_NA  3.277e+00  1.071e+00   3.059 0.002244 **
## TEAM_FIELDING_DP_NA -1.073e+01  1.948e+00  -5.507 4.07e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.1 on 2261 degrees of freedom
## Multiple R-squared:  0.4135, Adjusted R-squared:  0.4098
## F-statistic: 113.9 on 14 and 2261 DF,  p-value: < 2.2e-16
```

```
# Train model
train_control = trainControl(method = "cv", number = 10)
step_model = train(TARGET_WINS ~ ., data=train_df,
                   method = "lmStepAIC",
                   trControl = train_control,
                   trace=FALSE)
# Model accuracy
step_model$results
```

```
##   parameter     RMSE  Rsquared      MAE    RMSESD RsquaredSD     MAESD
## 1      none 12.31609 0.3899591 9.658693 0.4442817 0.05989111 0.2888267
```

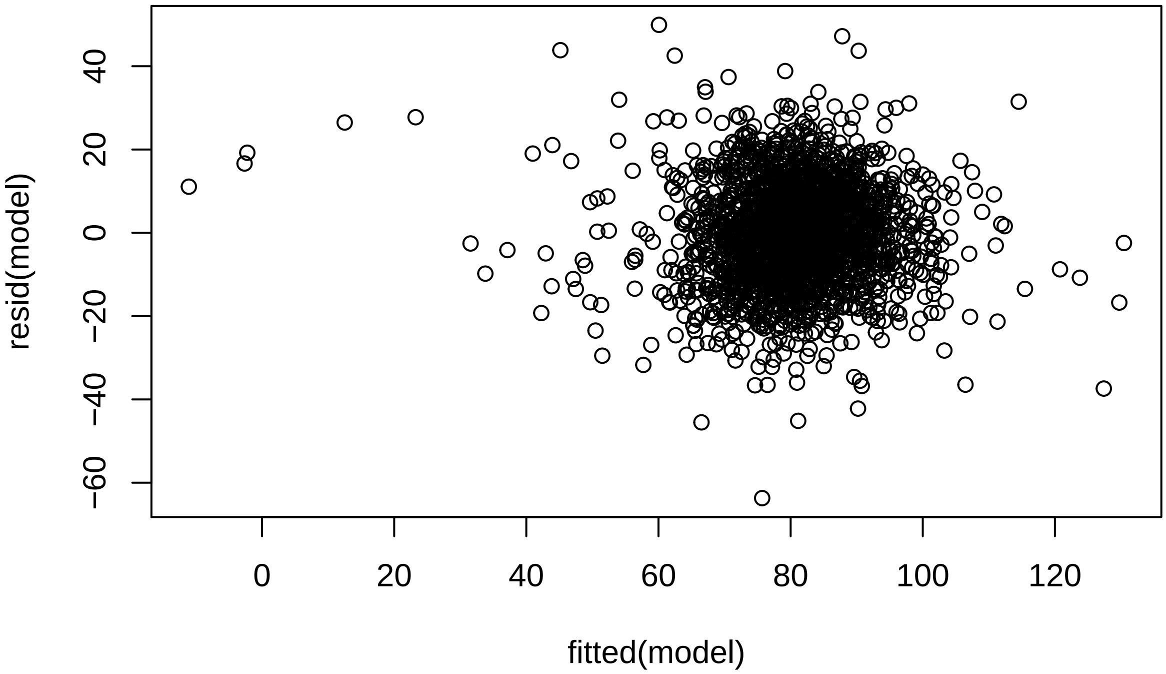
```
# Final model coefficients
step_model$finalModel
```

```
##
## Call:
## lm(formula = .outcome ~ TEAM_BATTING_H + TEAM_BATTING_2B + TEAM_BATTING_3B +
##     TEAM_BATTING_HR + TEAM_BATTING_BB + TEAM_BATTING_SO + TEAM_BASERUN_SB +
##     TEAM_PITCHING_H + TEAM_PITCHING_SO + TEAM_FIELDING_E + TEAM_FIELDING_DP +
##     TEAM_BASERUN_SB_NA + TEAM_BATTING_HBP_NA + TEAM_FIELDING_DP_NA,
##     data = dat)
##
## Coefficients:
##         (Intercept)       TEAM_BATTING_H      TEAM_BATTING_2B
##           18.196340             0.046820            -0.027572
##     TEAM_BATTING_3B      TEAM_BATTING_HR      TEAM_BATTING_BB
##            0.054244             0.075494             0.023983
##     TEAM_BATTING_SO      TEAM_BASERUN_SB      TEAM_PITCHING_H
##           -0.010247             0.050139             0.001980
##    TEAM_PITCHING_SO      TEAM_FIELDING_E     TEAM_FIELDING_DP
##           -0.001096            -0.056855            -0.104532
##  TEAM_BASERUN_SB_NA  TEAM_BATTING_HBP_NA  TEAM_FIELDING_DP_NA
##           39.693780             3.277467           -10.727882
```

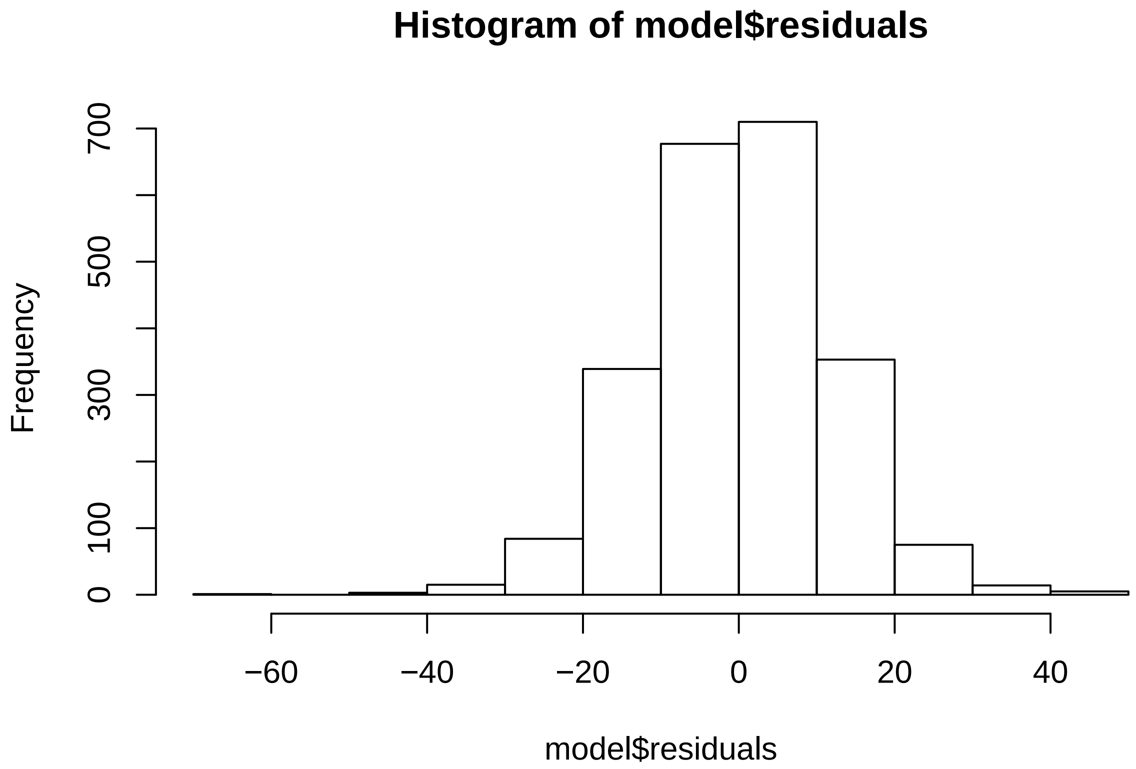
```
# Summary of model
summary(step_model$finalModel)
```

```
##
## Call:
## lm(formula = .outcome ~ TEAM_BATTING_H + TEAM_BATTING_2B + TEAM_BATTING_3B +
##     TEAM_BATTING_HR + TEAM_BATTING_BB + TEAM_BATTING_SO + TEAM_BASERUN_SB +
##     TEAM_PITCHING_H + TEAM_PITCHING_SO + TEAM_FIELDING_E + TEAM_FIELDING_DP +
##     TEAM_BASERUN_SB_NA + TEAM_BATTING_HBP_NA + TEAM_FIELDING_DP_NA,
##     data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -63.693  -8.067   0.330   7.875  49.924
##
## Coefficients:
##                       Estimate Std. Error t value Pr(>|t|)
## (Intercept)          1.820e+01  4.192e+00   4.340 1.49e-05 ***
## TEAM_BATTING_H       4.682e-02  3.212e-03  14.578  < 2e-16 ***
## TEAM_BATTING_2B     -2.757e-02  8.973e-03  -3.073 0.002147 **
## TEAM_BATTING_3B      5.424e-02  1.547e-02   3.507 0.000461 ***
## TEAM_BATTING_HR      7.549e-02  8.642e-03   8.736  < 2e-16 ***
## TEAM_BATTING_BB      2.398e-02  3.239e-03   7.404 1.86e-13 ***
## TEAM_BATTING_SO     -1.025e-02  1.776e-03  -5.771 8.97e-09 ***
## TEAM_BASERUN_SB      5.014e-02  4.457e-03  11.249  < 2e-16 ***
## TEAM_PITCHING_H      1.980e-03  3.339e-04   5.930 3.49e-09 ***
## TEAM_PITCHING_SO    -1.096e-03  6.613e-04  -1.657 0.097666 .
## TEAM_FIELDING_E     -5.685e-02  3.370e-03 -16.873  < 2e-16 ***
## TEAM_FIELDING_DP    -1.045e-01  1.309e-02  -7.985 2.21e-15 ***
## TEAM_BASERUN_SB_NA   3.969e+01  2.048e+00  19.385  < 2e-16 ***
## TEAM_BATTING_HBP_NA  3.277e+00  1.071e+00   3.059 0.002244 **
## TEAM_FIELDING_DP_NA -1.073e+01  1.948e+00  -5.507 4.07e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.1 on 2261 degrees of freedom
## Multiple R-squared:  0.4135, Adjusted R-squared:  0.4098
## F-statistic: 113.9 on 14 and 2261 DF,  p-value: < 2.2e-16
```

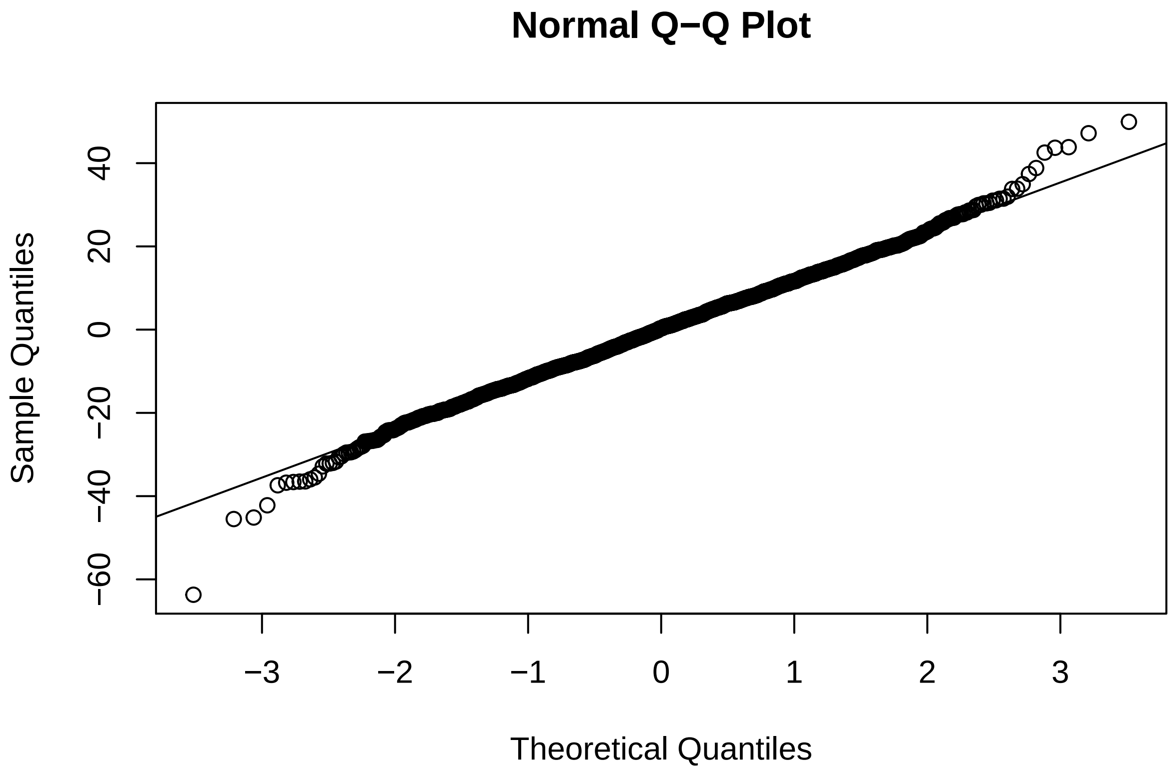
```r
model = step_model$finalModel
plot(fitted(model), resid(model))
```



```r
hist(model$residuals)
```



```
qqnorm(resid(model))
qqline(resid(model))
```



```
# Check MSE
mean(summary(model$residuals^2))
```

```
## [1] 743.6606
```

```
# 743.6606
```

Model 3 - Try removing TEAM_PITCHING_SO

```
# Train model without TEAM_PITCHING_SO since it has a relatively high p-value
train_control = trainControl(method = "cv", number = 10)
no_TPS = subset(train_df, select=-c(TEAM_PITCHING_SO))
step_model_noTPS = train(TARGET_WINS ~ ., data=no_TPS,
                   method = "lmStepAIC",
                   trControl = train_control,
                   trace=FALSE)
# Model accuracy
step_model_noTPS$results
```

```
##   parameter     RMSE  Rsquared      MAE    RMSESD RsquaredSD     MAESD
## 1      none 12.26453 0.3954876 9.666676 0.7529562 0.07765096 0.5805426
```

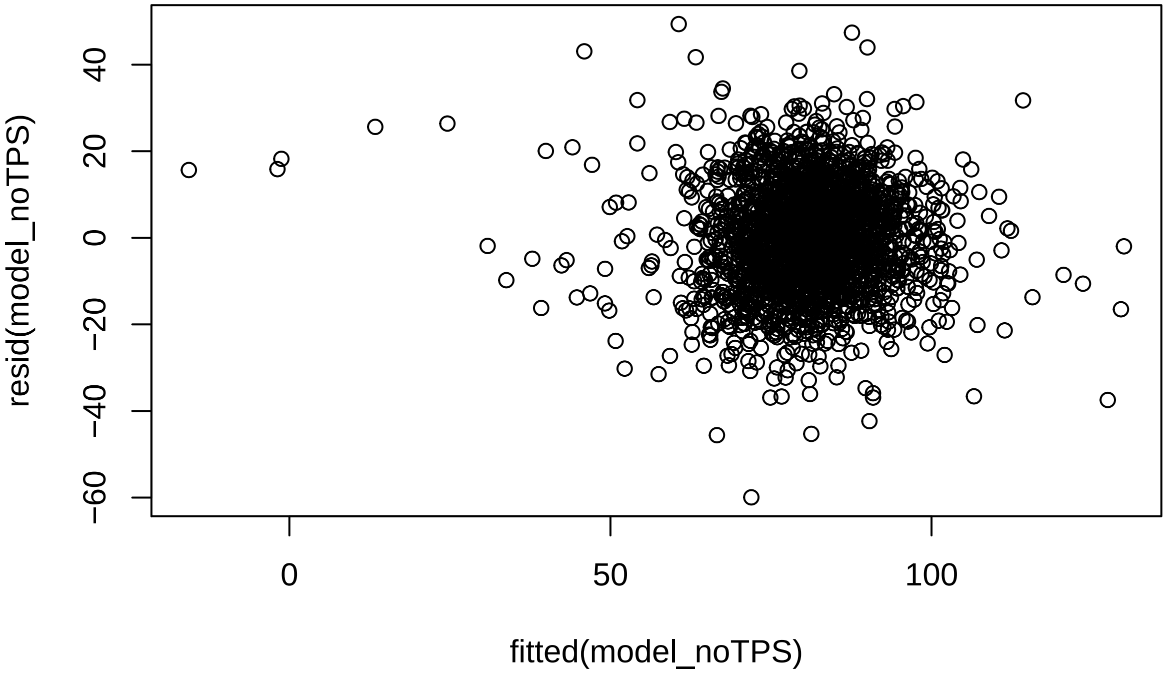
```r
# Final model coefficients
step_model_noTPS$finalModel
```

```
##
## Call:
## lm(formula = .outcome ~ TEAM_BATTING_H + TEAM_BATTING_2B + TEAM_BATTING_3B +
##     TEAM_BATTING_HR + TEAM_BATTING_BB + TEAM_BATTING_SO + TEAM_BASERUN_SB +
##     TEAM_PITCHING_H + TEAM_FIELDING_E + TEAM_FIELDING_DP + TEAM_BASERUN_SB_NA +
##     TEAM_BATTING_HBP_NA + TEAM_FIELDING_DP_NA, data = dat)
##
## Coefficients:
##         (Intercept)       TEAM_BATTING_H      TEAM_BATTING_2B
##           17.475160             0.047857            -0.029176
##     TEAM_BATTING_3B      TEAM_BATTING_HR      TEAM_BATTING_BB
##            0.053032             0.076969             0.023764
##     TEAM_BATTING_SO      TEAM_BASERUN_SB      TEAM_PITCHING_H
##           -0.011516             0.049503             0.001683
##     TEAM_FIELDING_E     TEAM_FIELDING_DP   TEAM_BASERUN_SB_NA
##           -0.055278            -0.104090            38.683727
## TEAM_BATTING_HBP_NA  TEAM_FIELDING_DP_NA
##            3.170394           -11.012818
```

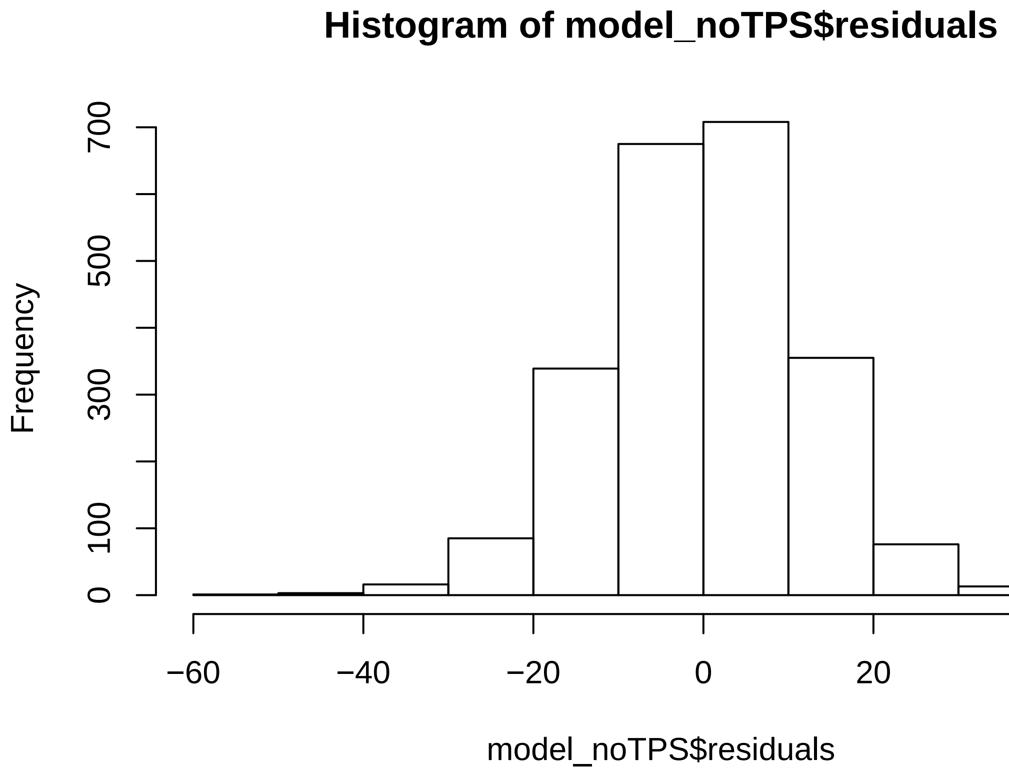
```r
# Summary of model
summary(step_model_noTPS$finalModel)
```

```
##
## Call:
## lm(formula = .outcome ~ TEAM_BATTING_H + TEAM_BATTING_2B + TEAM_BATTING_3B +
##     TEAM_BATTING_HR + TEAM_BATTING_BB + TEAM_BATTING_SO + TEAM_BASERUN_SB +
##     TEAM_PITCHING_H + TEAM_FIELDING_E + TEAM_FIELDING_DP + TEAM_BASERUN_SB_NA +
##     TEAM_BATTING_HBP_NA + TEAM_FIELDING_DP_NA, data = dat)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -59.938  -8.049   0.369   7.904  49.371
##
## Coefficients:
##                      Estimate Std. Error t value Pr(>|t|)
## (Intercept)          1.748e+01  4.171e+00   4.189 2.91e-05 ***
## TEAM_BATTING_H       4.786e-02  3.151e-03  15.187  < 2e-16 ***
## TEAM_BATTING_2B     -2.918e-02  8.924e-03  -3.269 0.001094 **
## TEAM_BATTING_3B      5.303e-02  1.545e-02   3.432 0.000611 ***
## TEAM_BATTING_HR      7.697e-02  8.599e-03   8.951  < 2e-16 ***
## TEAM_BATTING_BB      2.376e-02  3.238e-03   7.339 2.98e-13 ***
## TEAM_BATTING_SO     -1.152e-02  1.603e-03  -7.185 9.12e-13 ***
## TEAM_BASERUN_SB      4.950e-02  4.442e-03  11.144  < 2e-16 ***
## TEAM_PITCHING_H      1.683e-03  2.817e-04   5.974 2.68e-09 ***
## TEAM_FIELDING_E     -5.528e-02  3.234e-03 -17.095  < 2e-16 ***
## TEAM_FIELDING_DP    -1.041e-01  1.309e-02  -7.950 2.92e-15 ***
## TEAM_BASERUN_SB_NA   3.868e+01  1.956e+00  19.782  < 2e-16 ***
## TEAM_BATTING_HBP_NA  3.170e+00  1.070e+00   2.964 0.003072 **
## TEAM_FIELDING_DP_NA -1.101e+01  1.941e+00  -5.673 1.58e-08 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 12.11 on 2262 degrees of freedom
## Multiple R-squared:  0.4128, Adjusted R-squared:  0.4094
## F-statistic: 122.3 on 13 and 2262 DF,  p-value: < 2.2e-16
```

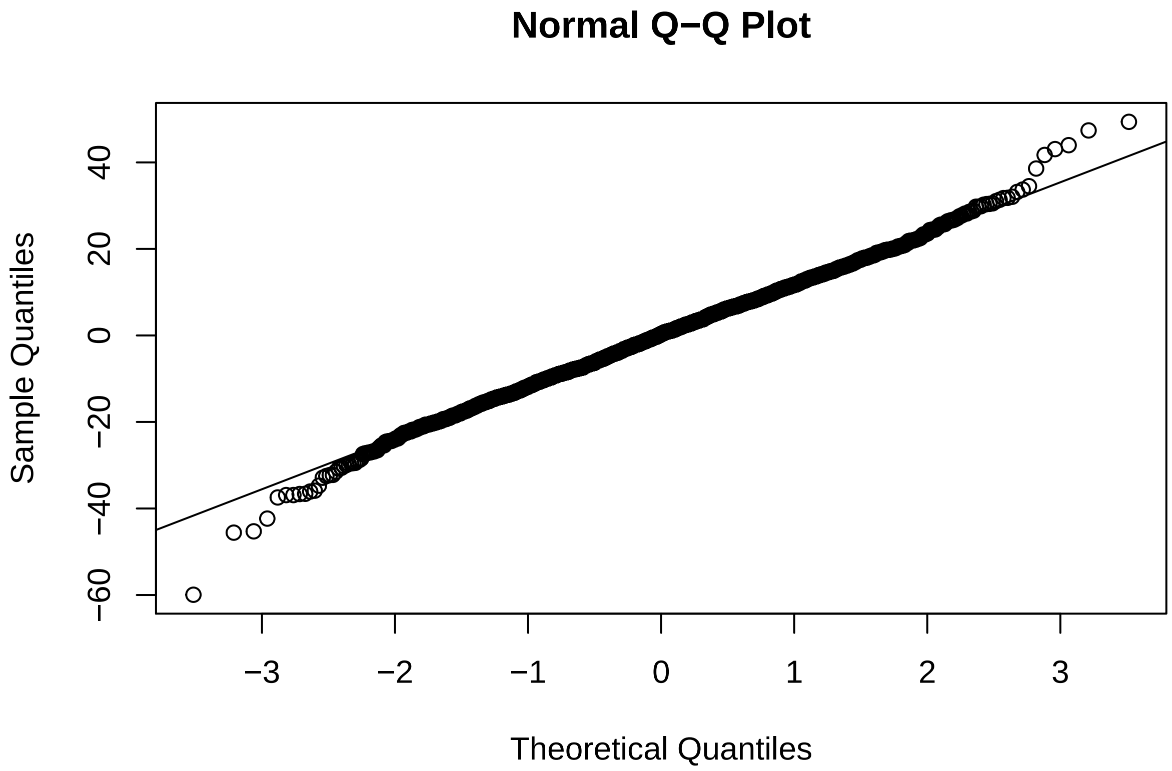
```
model_noTPS = step_model_noTPS$finalModel
plot(fitted(model_noTPS), resid(model_noTPS))
```



```
hist(model_noTPS$residuals)
```



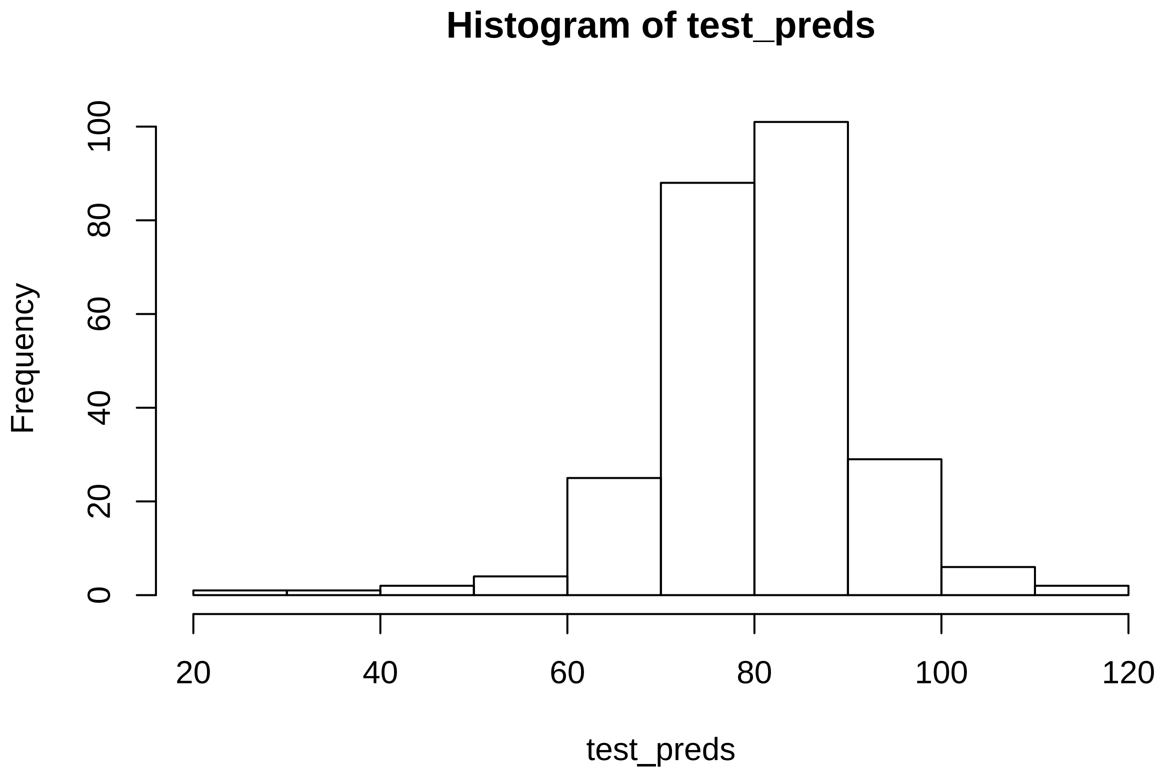
```r
qqnorm(resid(model_noTPS))
qqline(resid(model_noTPS))
```



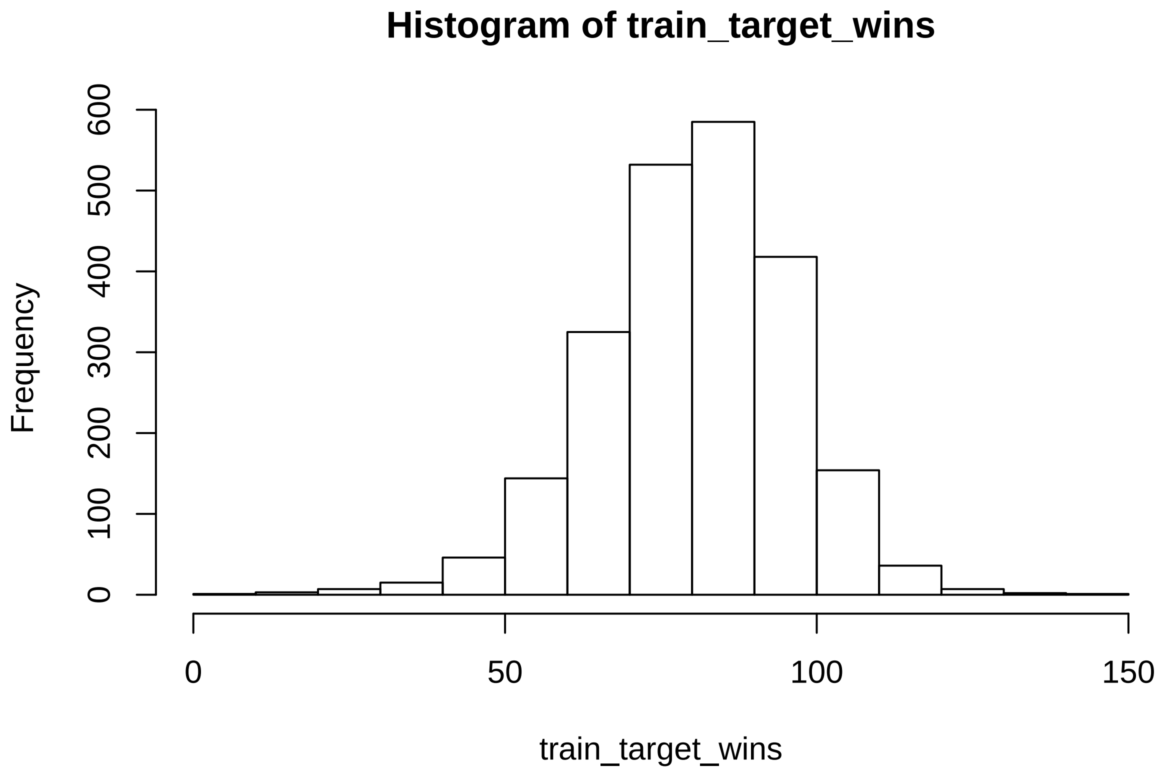
Predictions on Evaluation Set

```
# convert decimals of wins back to number of wins, rounded
test_preds = round(predict(model, newdata=test_df)) #*162
test_df$PRED_TARGET_WINS = test_preds
# write out evaluation data with predictions
write.csv(test_df, 'data/eval_with_preds.csv')

# visually inspect the distribution of predictions for test and wins from the training set
hist(test_preds)
```



```
hist(train_target_wins)
```


Histogram of train_target_wins
Frequency
0
100
200
300
400
500
600
0
50
100
150
train_target_wins