ASTERISK OR EXCLAMATION POINT?:

Power Hitting in Major League Baseball from 1950 Through the “Steroid Era”

by

Gary Evans
Stat 201B
Winter, 2010

Introduction: After a player's strike in 1994 which resulted in the first-ever cancellation of a World Series, the image and popularity of Major League Baseball (MLB) was severely damaged. Beginning in 1996 (some believe not coincidentally), run-scoring and home run hitting began to show marked increases over historical norms. Older players began to have rejuvenated statistical production, both hitters and pitchers. Eventually, 2 players (former MVP's Ken Caminitti and Jose Canseco) disclosed that they and perhaps two-thirds of all major leaguers were using steroids and human growth hormones. Over time, a few players tested positive for steroid use and a few more admitted using, either wittingly or unwittingly. In 2006-07, MLB conducted an internal investigation of the situation which resulted in the issuance of the Mitchell Report in December, 2007. This report, while acknowledging the illegal drug usage, suggests that far fewer than two-thirds of players used and, of those who did, many used only sporadically to recover from injuries. This period, from 1996 to 2007, has come to be known as the "Steroid Era" in MLB. Even as recently as last year, players are still testing positive for steroids or other illicit performance enhancing substances.

Well-known, and receiving by far the most publicity, are the exploits of a few players who shattered decades-old home run records or who far surpassed their prior performance. For example, in 1996, Brady Anderson hit 50 home runs, long considered a benchmark number. He had only 73 in the 10 prior years, never hit more than 21 before 1996 and had only 16 in 1995. In the 46 seasons from 1950 through 1995, the 50 home run mark had been reached only 8 times (by 6 players). In 1998, Mark McGwire hit 70 home runs and Sammy Sosa hit 66. Only 2 players had ever hit 60 in the previous 78 years of the modern game (Babe Ruth with 60 in 1927 and Roger Maris with 61 in 1961). Sosa hit over 60 twice more during the era. In 2001, Barry Bonds hit 73 home runs. All of these players have either admitted or been implicated in steroid usage.

This paper seeks to get a sense of how wide-spread the drug usage problem may have been. We do this by focusing on a broader measure of power hitting, total bases, as our response variable and predictor variables chosen to address some standard arguments that the increased power hitting was not historically anomalous. To effectively measure the historical trends, such as they are, we examine data from 1950 to 2009. (We omit the years 1981 and 1994 since these seasons were greatly shortened by player strikes.) During this time, the following factors determined our predictors. The number of MLB teams went from 16 to 30 and the season was increased from 154 to 162 games. In 1973, the American League instituted the designated hitter (pitchers no longer hit), which is believed to have at least marginally increased offensive production. The setting of the pitcher's mound had to be considered. It was 15 inches high from 1950-1964. Then a loophole in the rule was believed to have been found and some mounds were raised (perhaps as much as 5 inches). This led to the famously pitcher-dominated seasons of 1967 & 1968. From 1969 on, by rule the mound is to be ten inches high. The steroid era years are coded as 1. Finally, to account for the arguments that the dilution of pitching talent (by having too many teams) and/or hitters focusing on home runs more and batting average less account for the power surge, strikeouts per game is considered. Using total bases as response should help to address this latter issue as well. The raw data is shown in Figure A of the Appendix.

Results: The simplest look at the data (Figure B) shows a large jump in the number of 300 TB hitters from 1996 on. There were 28 teams in '96 and '97, then 30 from '98 on, so such a large jump is hard to account for simply by increased numbers of players, particularly when, as can be easily gleaned from Figures A & C, this increase did not seem to increase the 300 TB club much during the expansion from 16 to 28 teams. Something more appears to be involved.

We start with OLS regression on all variables. Figure 1 gives the regression summary. The steroid era is a highly significant factor; # of teams is far less so, even though it (and therefore the # of players) nearly doubled over the time period under study. Games and DH having negative coefficients are surprising and we suspect some hidden variable(s) or correlation is responsible. The R-squared of .7778 indicates a fairly good fit, though the residual standard error is a bit higher than we would like.

Our residuals plots (Figure 2) show some heteroskedasticity, with higher fitted-value residuals appearing to have slightly higher variance. Normality of the residuals, however, appears to be a sound model assumption, with only some slight deviation apparent. In Figure 3, the Variance and Shapiro tests confirm these observations. Figure 4, the influence and outlier plots, show observations 12, 57, and 58 as influential, but studentizing the residuals show none of these to be significant outliers. (We will see at least one of these 3 points, along with point 19, or some combination of the 4, as influential points in all models considered, but, using the jack-knife test, they do not test as significant outliers in any of the models.)

To cull out insignificant predictors and in the hope of lessening the effect of hidden variables, we try OLS with AIC variable selection. Figure 5 shows the regression summary. DH and Mound are selected out. The Teams coefficient is cut in half, though its significance level is increased. Games remains negative and Roids highly significant. Now Ks/Game is significant and slightly higher, something of a surprise. R-squared and residual std. error are little changed and adjusted R-squared is positive. From Figure 6 (residual plots) and variance and Shapiro tests (output omitted), we reach the same conclusions as above regarding our residuals except that we now have some short-tail deviation from normal (which is still not problematic). The same for Figure 7 and our "unusual points" analysis. Overall, this model is superior, but not optimum; some of our concerns remain.

Because of the heteroskedasticity of the residuals and the nature of our data, a square root transformation of the response seemed called for. Figure 8 gives the regression summary. The relationships between our predictor coefficients seem little changed (though Ks/Game jumps somewhat in significance). The heteroskedasticity may have been over-cured (though the variance F-test suggests this graphic observation is probably not significant) and normality is still not a concern. The variance curing, however, came at a considerable loss of R-squared and adjusted R-squared so, overall, we are not satisified with this model.

Finally, we consider correlation and colinearity issues. Figure 10 shows Teams and Games to have the highest correlation and to have the highest VIF's (though these latter figures appear to be at acceptable levels). Only one of the condition numbers is > 30. This and the negative Games coefficients seems to call for a selection between these 2 variables. Common sense and our knowledge of the game suggest that we include the Teams variable in our final OLS model. This model restores our R-squared's to more satisfactory levels. Also, heteroskedasticity appears in Figure 12 to be slightly reduced. (The lower bound of the variance F-test confidence interval moving from 1.15 to 1.07.) We are willing to accept this slight breach of our assumptions regarding residuals.

With regard to model structure, the partial residual plots of the final model are shown in Figure 13. Using Roids and Ks/Game as linear predictors seems justifiable, but Teams as a linear predictor may be problematic. Our kernel regression analysis discusses this in a bit more detail.

Next, we turn to Poisson regression. Figure 14 shows the full model Poisson regression summary with graphics. Roids, again, is highly significant, as is Ks/Game. DH and Mound are not. Games is, again, negative, though significant at 10%. Teams, again is a bit of a puzzling predictor. The residual deviance of 96.533 on 51 degrees of freedom shows a not particularly good-fitting model if the Poisson is correct, though the null model is clearly rejected by the chi-squared test. The proportion of deviance explained by the model is .727 (1 -(96.533/353.528)), about the same as our OLS models. The half normal plot of residuals raises no concern about outliers and the variance plot shows what appears to be acceptable dispersion (with a dispersion parameter of 1.845). The Pearson's plots (Figure 15) also do not seem to suggest any problems.

The Poisson model bearing such similarities to the OLS, a similar approach was taken to trying to analyze and improve it. The result is shown in Figure 16, the Poisson with the AIC selected variables. Teams, with a lower coefficient, is significant nearly at the 5% level; Games, with a similar coefficient, nearly at 10%. Roids and Ks/Game, with slightly higher coefficients, are still highly significant. The proportion of explained deviance is .725 (nearly identical) and (see Figure 17) there are no concerns about outliers, residuals, or dispersion (dispersion parameter = 1.784). Since it has fewer predictors and, as we will see, predicts with less standard error, we adopt the Poisson with AIC predictors as our Poisson model.

Next, we look at our elective test. Given the heteroskedasticity of our OLS residuals and the effectiveness of the square root transformation in dealing with this, we chose to do least absolute deviation (LAD) regression. Figure 18 gives regression summaries for 3 LAD models. The results are perhaps our most interesting. Roids is a significant predictor in all 3 models, but its coefficient changes strikingly as other predictors are removed. Teams, again, stands out as warranting examination. In the full model, its coefficient is fairly high and 0 is not within its confidence interval indicating that Teams is a significant variable. However, its coefficient drops to near zero and to insignificance as variables are removed. Ks/Game, significant in our other models, is insignificant (judging by confidence intervals), except in the final model and has large changes in its coefficient from model to model.

We notice that the coefficients in the final LAD model are similar to those in our final OLS model (with the Teams coefficients slightly lower here, Ks/Game slightly higher). Our residual plots (Figure 19), show only non-concerning short tail deviation from normal and lessened concerns about heteroskedasticity. Given what we have learned from our earlier examinations of this data, this is the LAD model we are adopting.

Last, we turn our attention to kernel regression. Following the procedure outlined in class, we performed one-at-a-time kernel regression on our AIC selected variables. The results are shown in the plots of FIgure 20. The categorical variables are modeled linearly, but, of interest, Teams and Ks/Game, particularly Teams, show some striking non-linearity. Certainly, the number of 300 TB hitters did not increase even close to proportionately as the number of teams went from 16 to 26. Then, the increase from 26 to 30 teams corresponded with a large increase in the number of 300 TB hitters, suggesting some other factor at play. It seems logical, also, that this non-linearity in the Teams predictor may account for some of the counter-intuitive behavior in this variable that was notice during our analysis. Regarding Ks/Game, it seems that the last data point (for 2009, a post-steroid-era year), where Ks/Game reached a high of 14, but there were only 20 300 TB hitters, may have been highly influential in the kernel regression. It looks as if removal of that point may lead to a slightly upward sloping, jaggedly-linear relationship. Figure 21, the residual histograms, give no concern regarding outliers and show a well-fitting model.

Conclusion: As noted above, overall, all of the models considered were reasonably well-behaved. Model assumptions were met within workable limits and model structures were sound. No outlier points were encountered in any model even though the steroid era numbers were, in some cases, astonishingly higher than in other seasons. Also, our final model selections seem to be justified. In all cases, they give reasonable predictions with lower standard of errors than the corresponding full models. For example, assuming the number of teams remains at 30 and Ks/Game reverts to its sample mean of 11.202, our final OLS model predicts 11.148 players would reach 300 TB in a non-steroid year with a standard error of 2.883. Our final Poisson model gives an expected value of 11.858 with a standard error of 1.113. These values would be in line with a return to the overall trend line seen in Figure B which I commented on in my oral presentation. Further, the final Poisson gives the probability that the number will be within the final OLS 95% confidence interval as .689. Similar stability of results is found for steroid era predictions.

Interestingly, the final LAD model gives a lower prediction (10.335) for a non-steroid season than all other models and a lower prediction (25.835) for a steroid season than all other OLS models. For this and other reasons, this regression method seems to me to be, from a statistics point of view, the most interesting to study. The fairly dramatic changes from full model to final model in the Teams and Ks/Game coefficients, and their accompanying changes in significance, warrant further examination. I suspect the nearly piece-wise quadratic nature of the relationship between Teams and the response variable is involved in this.

From a baseball point of view, the results regarding these 2 variables (Teams and Ks/Game) are the most interesting. One would expect the number of teams, hence of hitters, to have had a more significant predictive role in the models. However, as we noticed, as the number of teams increased from 16 to 28, the number of 300 TB hitters tended to increase only slightly and with frequent fluctuations below the trend. It is only the onset of the steroid era that changes the trend line. One wonders if, assuming performance enhancing drugs (PEDs) are cleared out of the game (a large and perilous assumption), we will have a reversion all the way to the observed prior trend line or to some higher level of power hitters. Does going to 30 teams account at all for the increased power hitting?

Somewhat related to this, is the Ks/Game variable. Does its positive coefficient (which multiplies with a number around 10-14 for prediction) and significance indicate merely that power hitters strikeout marginally more than other hitters (an unremarkable finding) or is it a measure, in itself, of PED usage by pitchers? If the number goes down, perhaps by a dilution of pitching talent from having too many teams, will the number of 300 TB hitters likewise go down? This would be a counter-intuitive result. These are questions that require more consideration.

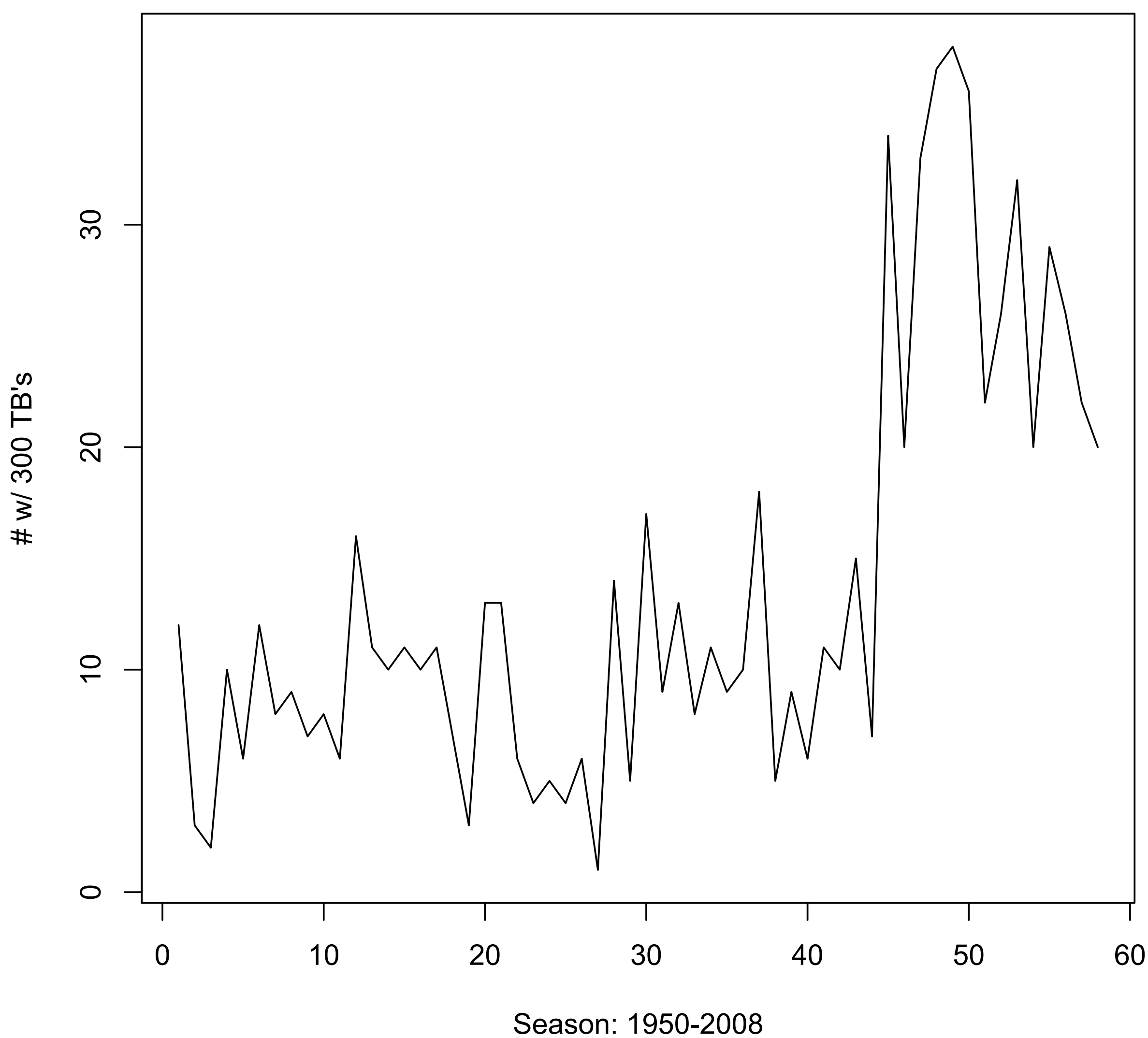
Finally, a lingering issue is whether MLB used a livelier ball after 1994 to boost fan interest. They deny it and, with the onset of the steroid era, this denial has plausibility. However, MLB denied going to a live ball in 1920, a season that marked the beginning of a power hitting era that rivals, if not surpasses, the steroid era, and that denial is widely considered implausible. We would like to know this, but, of course, cannot account for it in this study.

Appendix

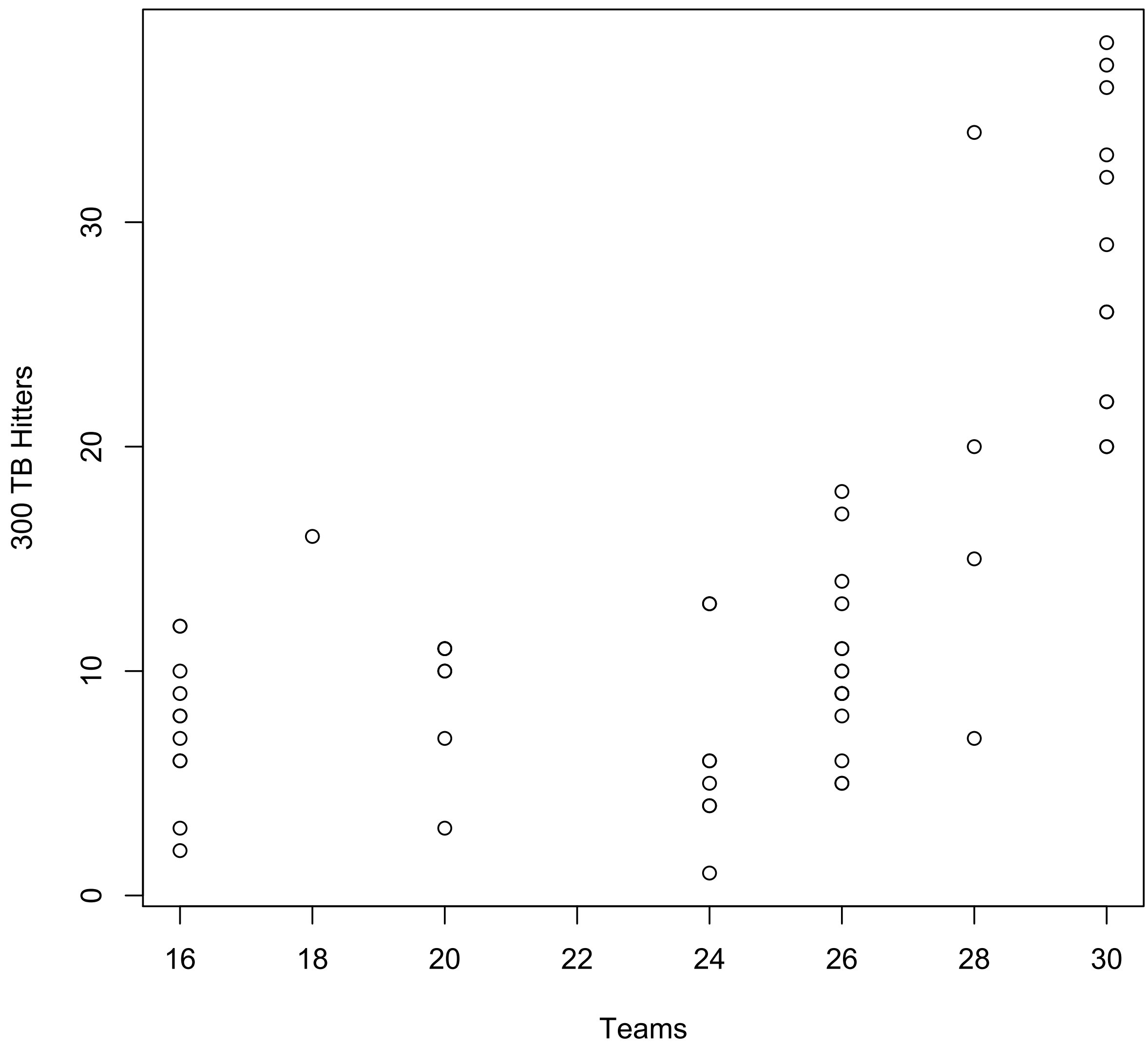
A. Data Frame

	Teams	Games	DH	Mound	Roids	Ks_per_Game	ThreeHundTB
1	16	0	0	0	0	8.2	12
2	16	0	0	0	0	7.8	3
3	16	0	0	0	0	8.5	2
4	16	0	0	0	0	8.8	10
5	16	0	0	0	0	8.9	6
6	16	0	0	0	0	9.1	12
7	16	0	0	0	0	9.5	8
8	16	0	0	0	0	9.9	9
9	16	0	0	0	0	10.0	7
10	16	0	0	0	0	10.5	8
11	16	0	0	0	0	10.8	6
12	18	8	0	0	0	11.1	16
13	20	8	0	0	0	11.7	11
14	20	8	0	0	0	11.9	10
15	20	8	0	0	0	11.6	11
16	20	8	0	-1	0	12.0	10
17	20	8	0	-1	0	11.8	11
18	20	8	0	-1	0	11.6	7
19	20	8	0	-1	0	11.4	3
20	24	8	0	1	0	11.5	13
21	24	8	0	1	0	11.4	13
22	24	8	0	1	0	11.4	6
23	24	8	0	1	0	10.5	4
24	24	8	1	1	0	10.5	5
25	24	8	1	1	0	10.4	4
26	24	8	1	1	0	10.1	6
27	24	8	1	1	0	10.1	1
28	26	8	1	1	0	9.6	14
29	26	8	1	1	0	9.5	5
30	26	8	1	1	0	10.0	17
31	26	8	1	1	0	9.7	9
32	26	8	1	1	0	9.9	13
33	26	8	1	1	0	10.0	8
34	26	8	1	1	0	10.6	11
35	26	8	1	1	0	11.4	9
36	26	8	1	1	0	11.5	10
37	26	8	1	1	0	11.5	18
38	26	8	1	1	0	11.5	5
39	26	8	1	1	0	11.4	9
40	26	8	1	1	0	11.5	6
41	26	8	1	1	0	11.5	11
42	26	8	1	1	0	11.2	10
43	28	8	1	1	0	11.7	15
44	28	8	1	1	0	12.0	7
45	28	8	1	1	1	12.6	34
46	28	8	1	1	1	13.0	20
47	30	8	1	1	1	13.2	33
48	30	8	1	1	1	13.1	37
49	30	8	1	1	1	13.1	38
50	30	8	1	1	1	13.1	36
51	30	8	1	1	1	13.0	22
52	30	8	1	1	1	13.1	26
53	30	8	1	1	1	13.2	32
54	30	8	1	1	1	12.8	20
55	30	8	1	1	1	13.1	29
56	30	8	1	1	1	13.3	26
57	30	8	1	1	0	13.6	22
58	30	8	1	1	0	14.0	20

B. Line Graph of Response Data



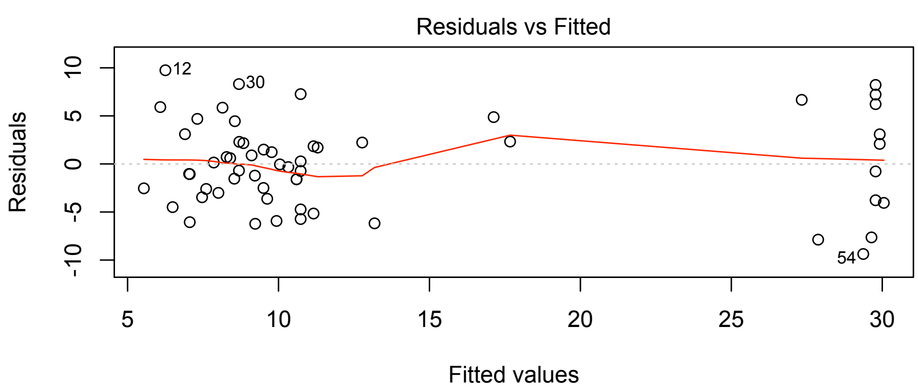
C. Plot of # of Teams vs. # of 300 TB Hitters

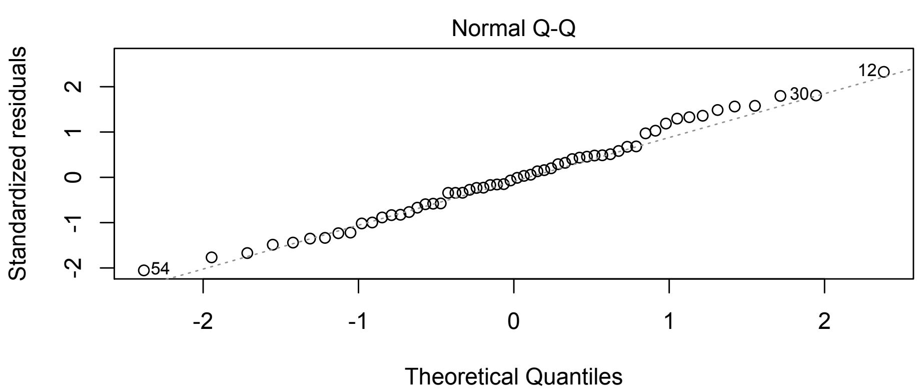


1. OLS - Full Model

```
Residuals:
    Min      1Q  Median      3Q     Max 
-9.3706 -3.3532 -0.1853  2.3212  9.7474 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -19.2185     8.9736  -2.142    0.037 *  
Teams         0.8833     0.6411   1.378    0.174    
Games        -0.6936     0.4236  -1.637    0.108    
DH           -2.3300     3.1590  -0.738    0.464    
Mound        -0.8012     2.2093  -0.363    0.718    
Roids        13.3335     2.5801   5.168 3.98e-06 ***
Ks_per_Game   1.3621     0.9033   1.508    0.138    
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.783 on 51 degrees of freedom
Multiple R-squared: 0.7778,   Adjusted R-squared: 0.7516 
F-statistic: 29.75 on 6 and 51 DF,  p-value: 4.959e-15
```

2. Residual Plots

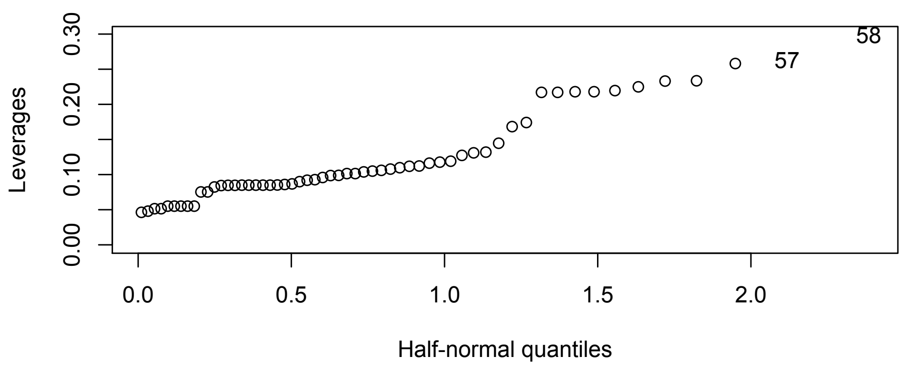


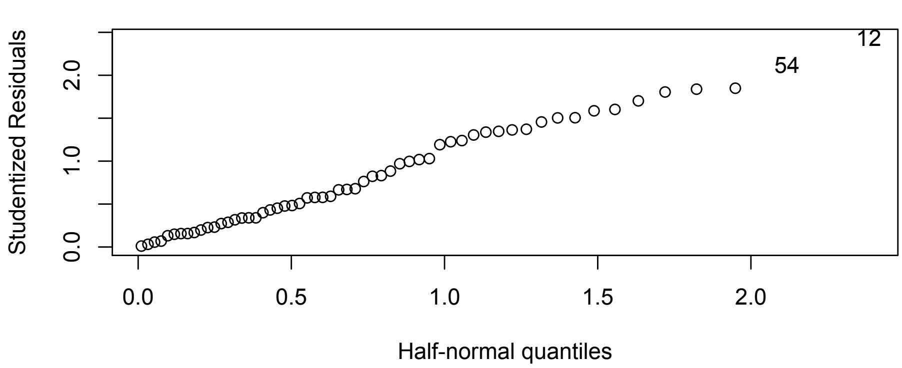


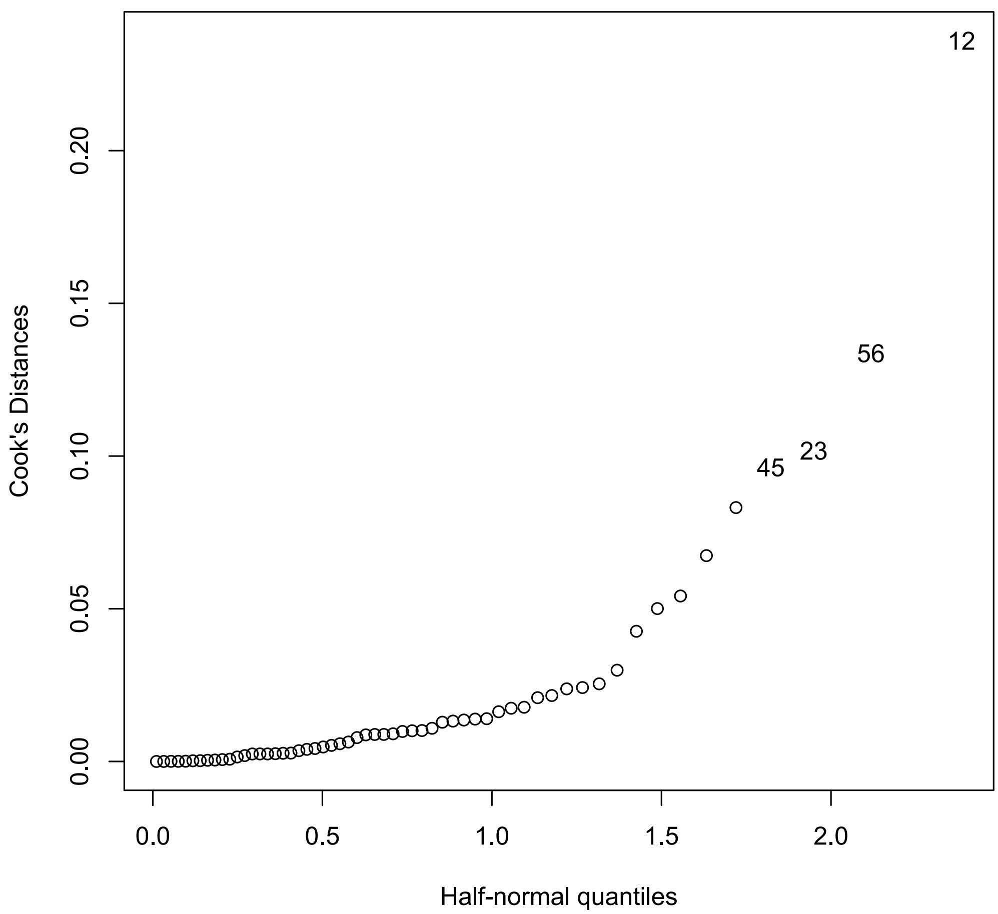
3. Variance Test and Shapiro Normality Test

```
F test to compare two variances

data:  residuals(tbfull)[tbfull$fitted > 20] and residuals(tbfull)[tbfull
$fitted < 20]
F = 2.6277, num df = 11, denom df = 45, p-value = 0.02217
alternative hypothesis: true ratio of variances is not equal to 1
95 percent confidence interval:
 1.145341 7.994218
sample estimates:
ratio of variances
          2.627741

Shapiro-Wilk normality test

data:  residuals(tbfull)
W = 0.9853, p-value = 0.7068
```

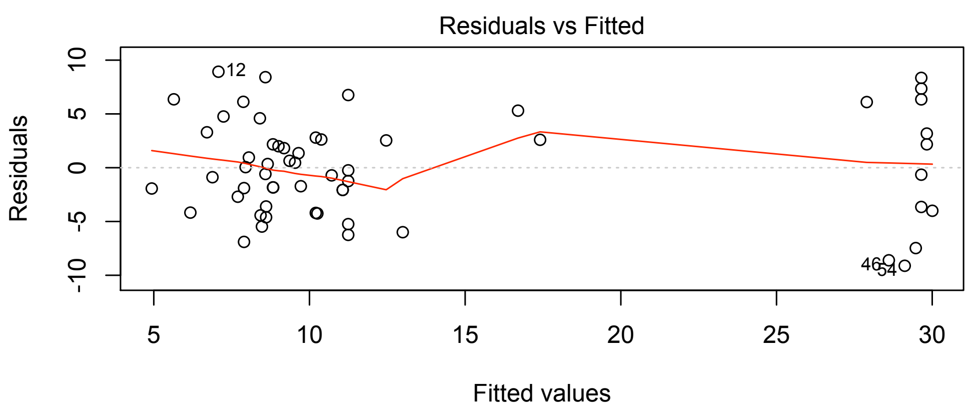
4. Half Normal Plots (Leverages, Studentized Residuals, & Cook's Dist.)

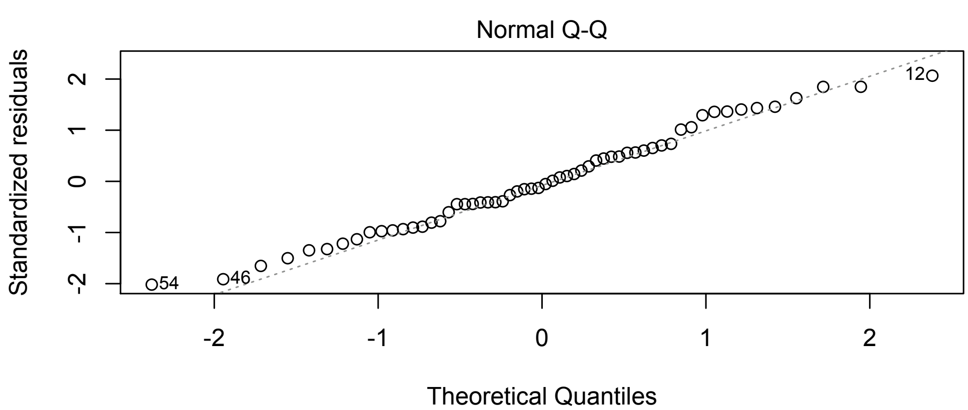




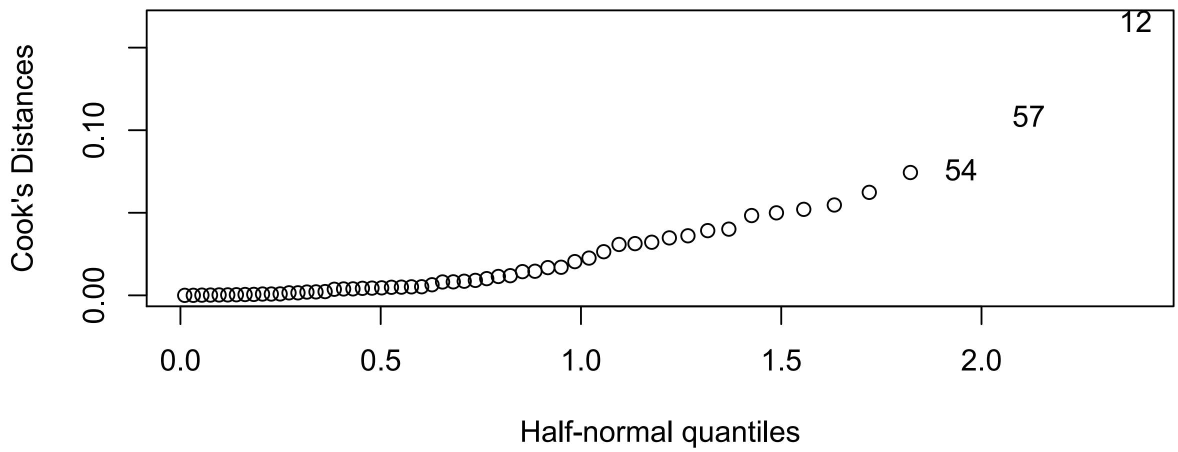

12
56
45
23
0.00
0.05
0.10
0.15
0.20
Cook's Distances
0.0
0.5
1.0
1.5
2.0
Half-normal quantiles

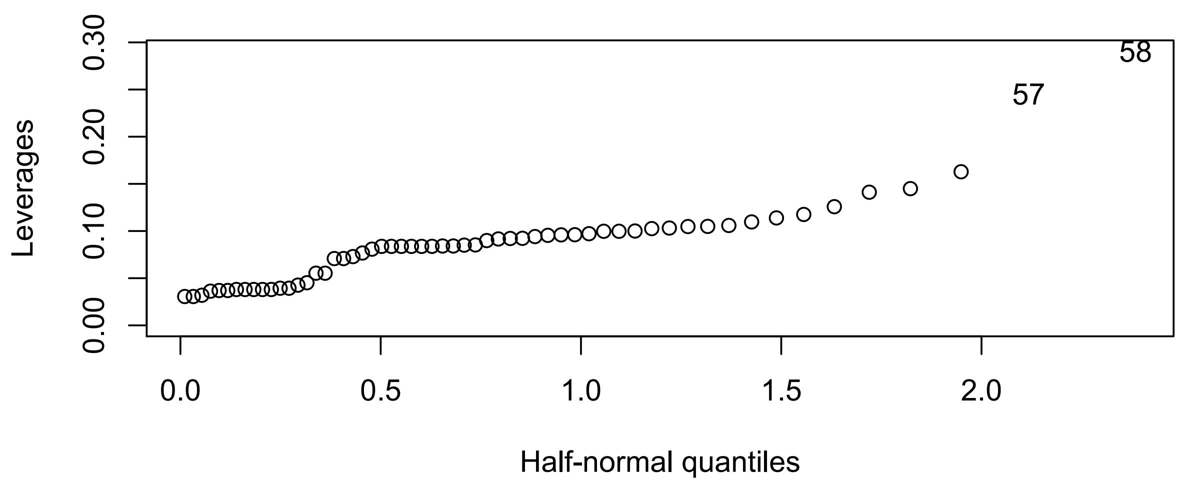
```
5. OLS - AIC selected variables

Residuals:
    Min      1Q  Median      3Q     Max 
-9.1175 -3.6388 -0.4148  2.7531  8.9237 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -15.8145     7.7581  -2.038   0.0465 *  
Teams         0.4324     0.2686   1.610   0.1133    
Games        -0.5717     0.3787  -1.510   0.1371    
Roids        13.8383     2.4412   5.669 6.07e-07 ***
Ks_per_Game   1.7731     0.7188   2.467   0.0169 *  
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 

Residual standard error: 4.723 on 53 degrees of freedom
Multiple R-squared: 0.7749,   Adjusted R-squared: 0.7579 
F-statistic:  45.6 on 4 and 53 DF,  p-value: < 2.2e-16 

6. Residual Plots (OLS w/ AIC)
```



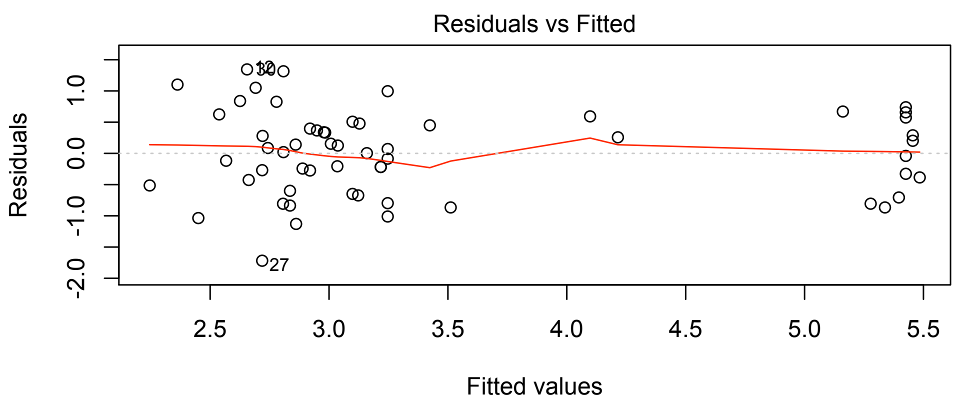


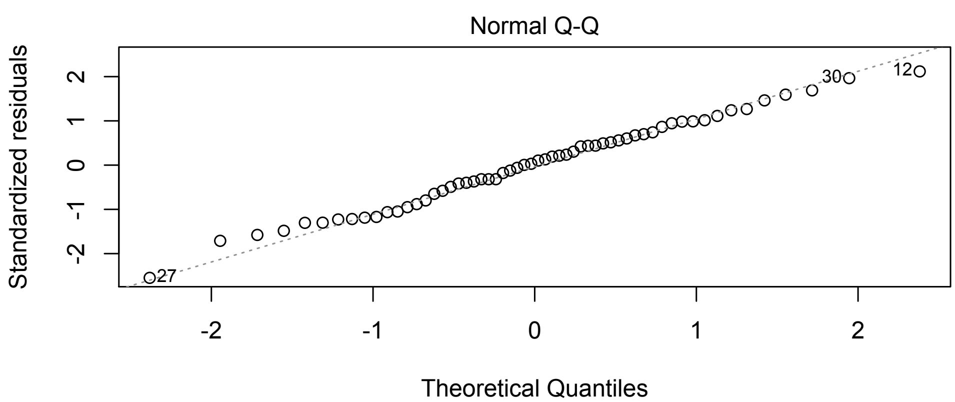
7. Half Normal Plots (AIC) - Cook’s and Leverages





```
8. OLS w/ AIC selected variables and Square Root Transformation of Response

Residuals:
    Min      1Q  Median      3Q     Max 
-1.7189 -0.4918  0.0450  0.4704  1.3448 

Coefficients:
            Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.98365    1.14019  -0.863 0.392187    
Teams        0.05933    0.03947   1.503 0.138724    
Games       -0.08423    0.05566  -1.513 0.136138    
Roids        1.47405    0.35878   4.109 0.000139 ***
Ks_per_Game  0.29232    0.10565   2.767 0.007774 ** 
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.6941 on 53 degrees of freedom
Multiple R-squared: 0.7092,   Adjusted R-squared: 0.6872 
F-statistic: 32.31 on 4 and 53 DF,  p-value: 1.209e-13

9. Residual Plots
```





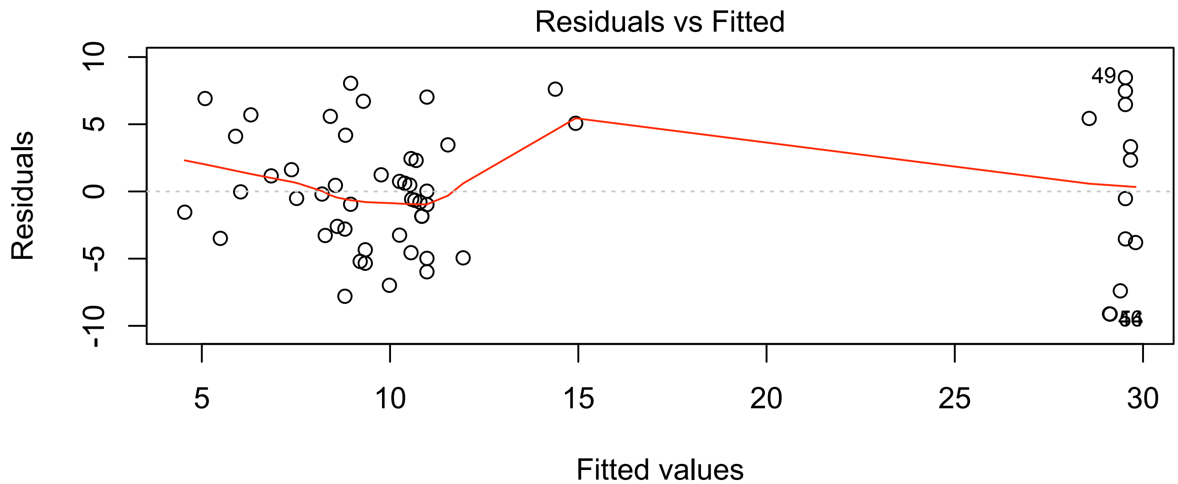
10. Colinearity Tests - AIC Model (no transformation)

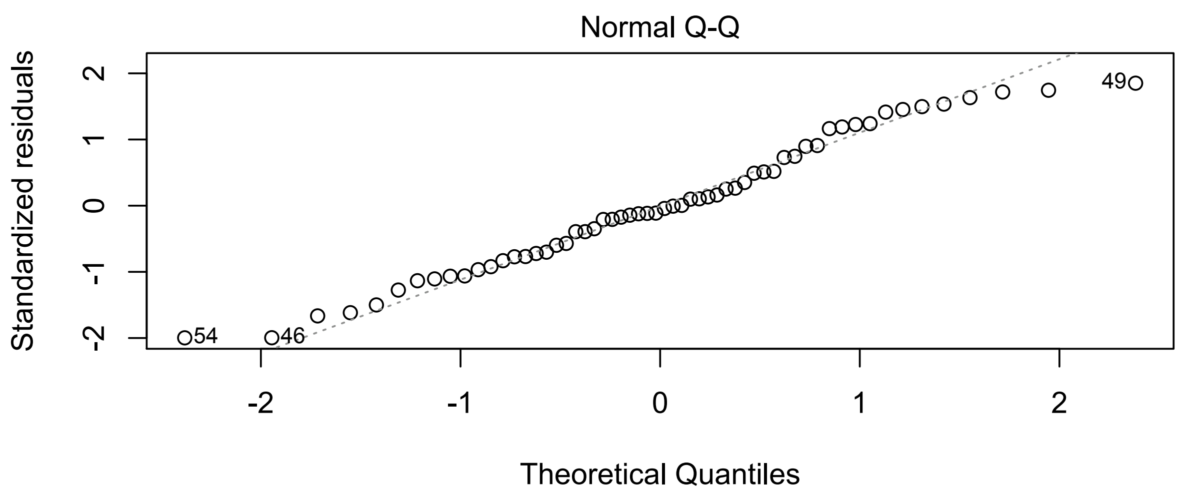
```
Correlations
            Teams Games Roids Ks_per_Game ThreeHundTB
Teams       1.000 0.779 0.595       0.725       0.626
Games       0.779 1.000 0.247       0.635       0.305
Roids       0.595 0.247 1.000       0.642       0.852
Ks_per_Game 0.725 0.635 0.642       1.000       0.695
ThreeHundTB 0.626 0.305 0.852       0.695       1.000

Condition Numbers
  1.00000 12.00291 21.28137 75.30500

Variance Inflation Factors
      Teams       Games       Roids Ks_per_Game
   4.552402    3.668469    2.543062    2.905563
```

11. Final OLS Model

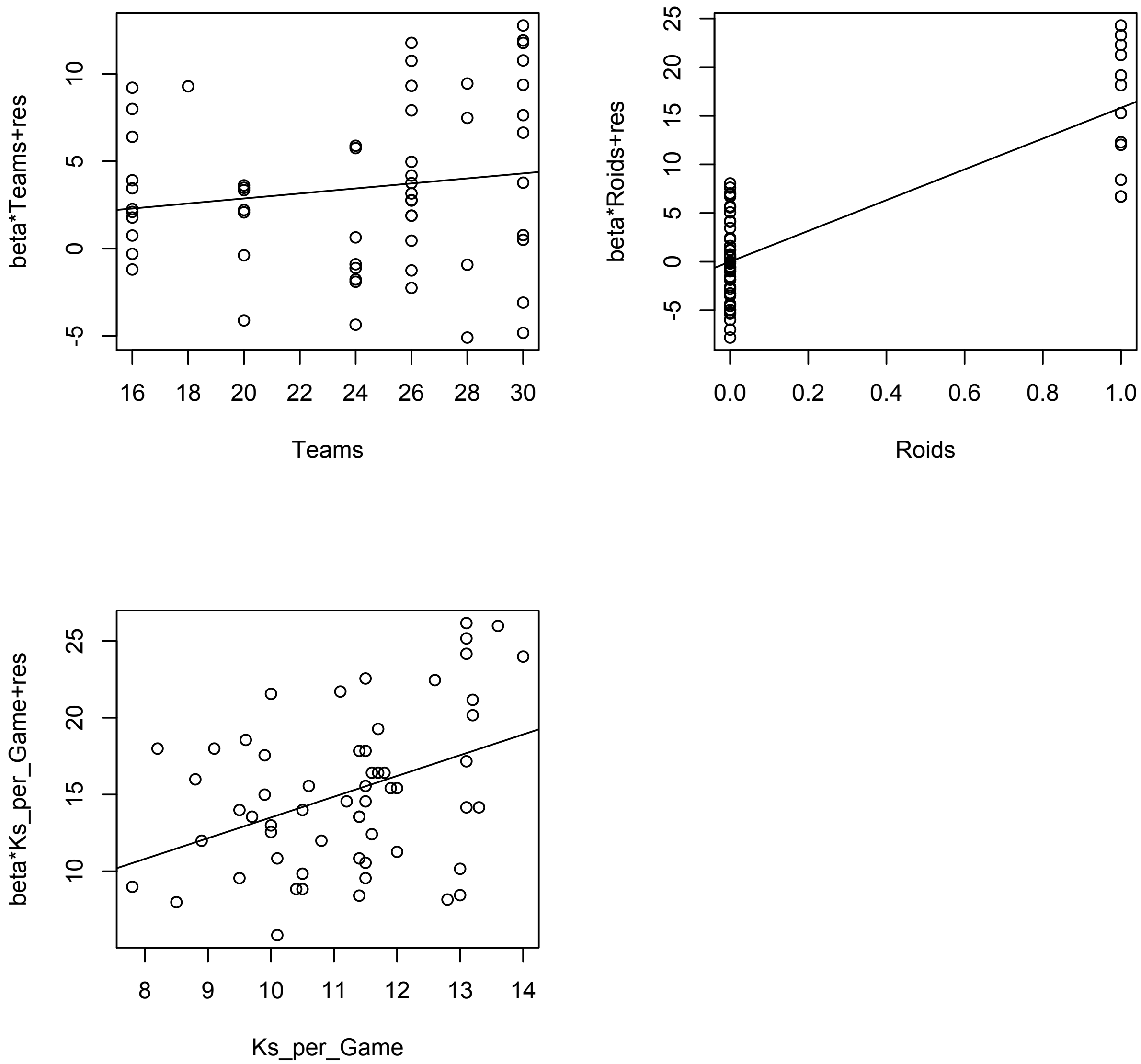
```
lm(formula = ThreeHundTB ~ Teams + Roids + Ks_per_Game)

Residuals:
    Min      1Q  Median      3Q     Max
-9.1268 -3.4379 -0.3551  3.4311  8.4679

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  -8.2864     6.0134  -1.378   0.1739
Teams         0.1435     0.1907   0.753   0.4549
Roids        15.8178     2.0834   7.592 4.51e-10 ***
Ks_per_Game   1.3507     0.6699   2.016   0.0488 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 4.778 on 54 degrees of freedom
Multiple R-squared: 0.7652,   Adjusted R-squared: 0.7521
F-statistic: 58.65 on 3 and 54 DF,  p-value: < 2.2e-16
```

12. Residual Plots of Final OLS Model



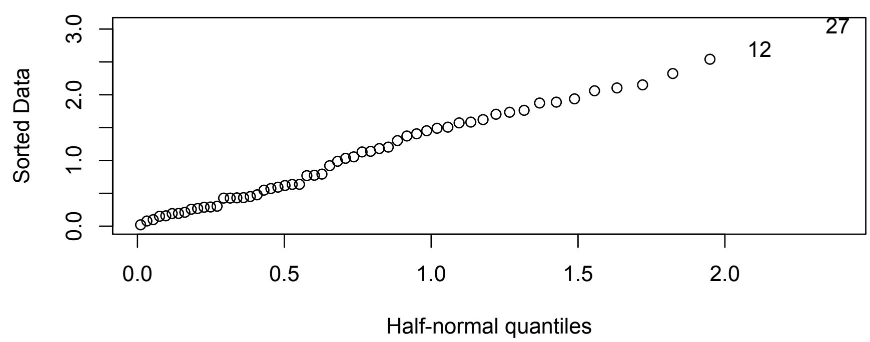


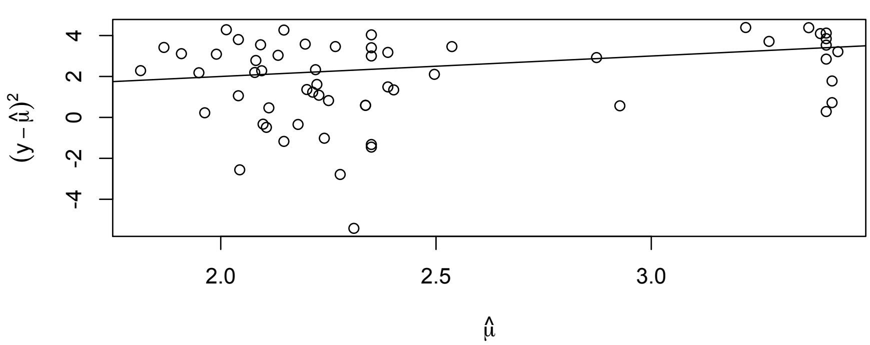
13. Partial Residual Plots of Final Model



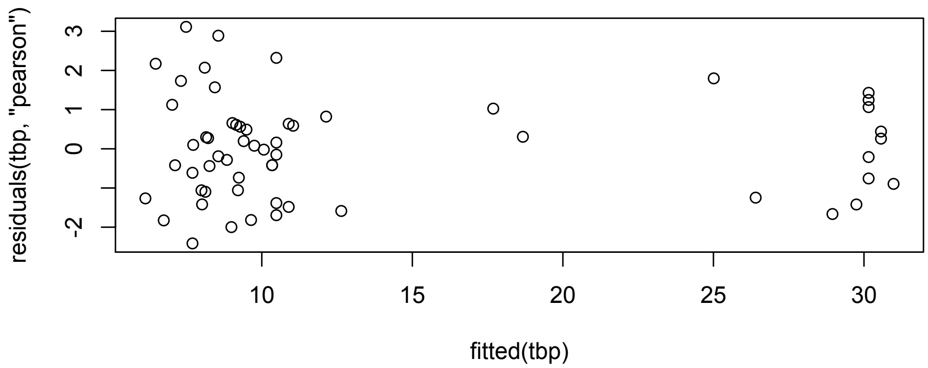
14. Poisson Regression w/ Half Normal Residual and Variance Plots

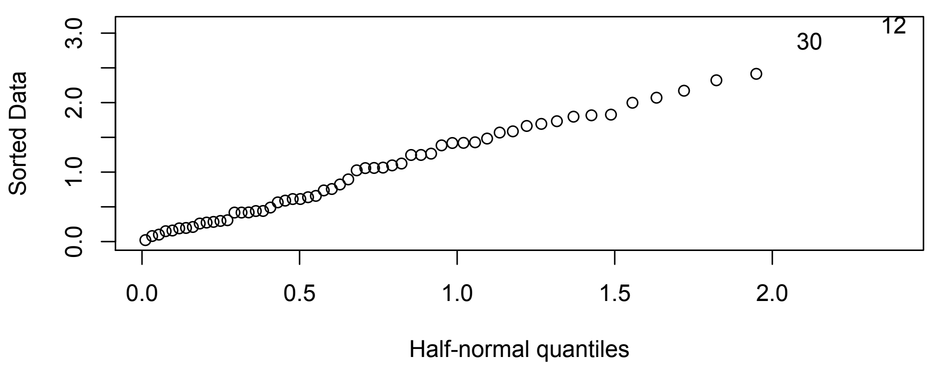
```
Deviance Residuals:
     Min        1Q    Median        3Q       Max
-3.05186  -1.13670   0.02906   0.63144   2.69801

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -0.19689    0.51818  -0.380   0.7040
Teams        0.05965    0.04080   1.462   0.1437
Games       -0.04589    0.02700  -1.700   0.0892 .
DH          -0.17115    0.20387  -0.839   0.4012
Mound       -0.02333    0.14624  -0.160   0.8733
Roids        0.60119    0.12935   4.648 3.36e-06 ***
Ks_per_Game  0.13543    0.06069   2.232   0.0256 *
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 353.528  on 57  degrees of freedom
Residual deviance:  96.533  on 51  degrees of freedom
AIC: 355.08

Number of Fisher Scoring iterations: 4
```





15. Pearson’s Residuals vs. Fitted and Half Normal Plot of Pearson’s

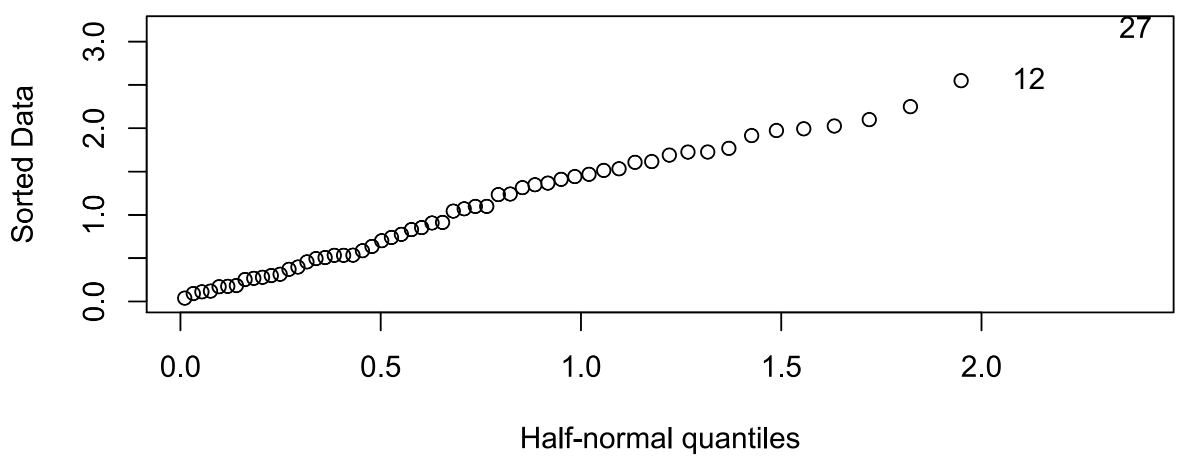


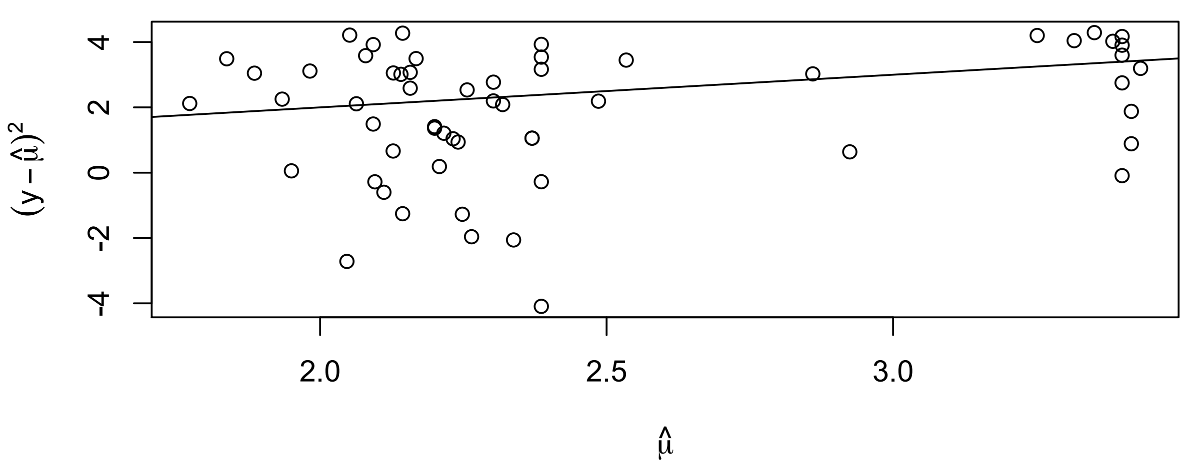


16. Poisson with AIC Predictors

```
Deviance Residuals:
     Min        1Q    Median        3Q       Max
-3.16669  -1.19999  -0.03625   0.84736   2.57518

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -0.02605    0.46562  -0.056 0.955378
Teams        0.03374    0.01759   1.918 0.055093 .
Games       -0.04010    0.02489  -1.611 0.107135
Roids        0.62049    0.12434   4.990 6.04e-07 ***
Ks_per_Game  0.16137    0.04693   3.439 0.000584 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 353.528  on 57  degrees of freedom
Residual deviance:  97.255  on 53  degrees of freedom
AIC: 351.8

Number of Fisher Scoring iterations: 4
```

17. Residual and Variance Plots for AIC Poisson





18. LAD Regression - Full Model, AIC variables, Final Model

a. Full Model

Coefficients:

	coefficients	lower bd	upper bd
(Intercept)	-31.12500	-42.15349	6.86881
Teams	1.62500	0.30123	3.49652
Games	-0.96875	-1.56334	0.09210
DH	-6.00000	-13.56045	1.03278
Mound	-1.37500	-3.31723	2.15920
Roids	10.12500	5.51238	22.09540
Ks_per_Game	1.25000	-1.92312	2.87399

b. AIC

Coefficients:

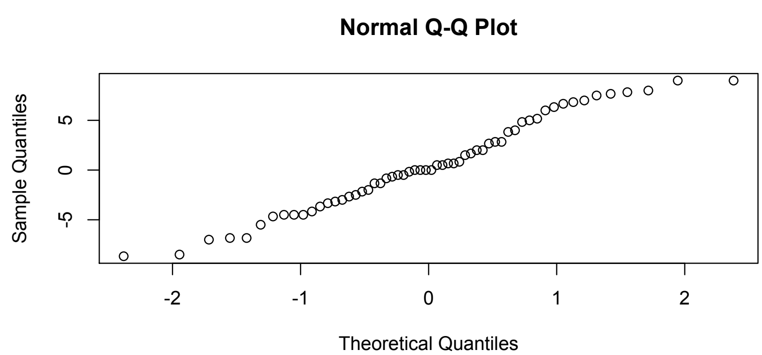
	coefficients	lower bd	upper bd
(Intercept)	-25.76190	-28.23420	29.51178
Teams	0.40476	-0.12165	0.83394
Games	-0.82738	-1.82406	0.35654
Roids	11.80952	6.01191	25.31892
Ks_per_Game	2.85714	-0.67769	3.01185

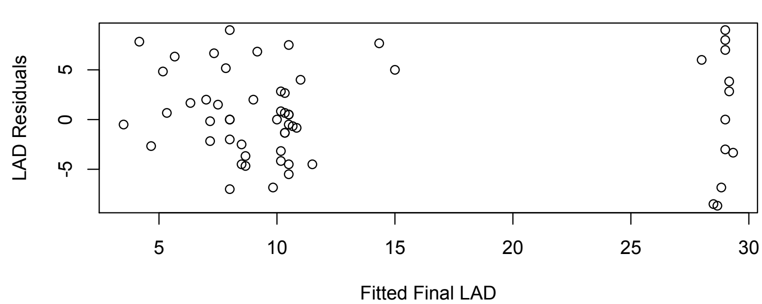
c. Final

Coefficients:

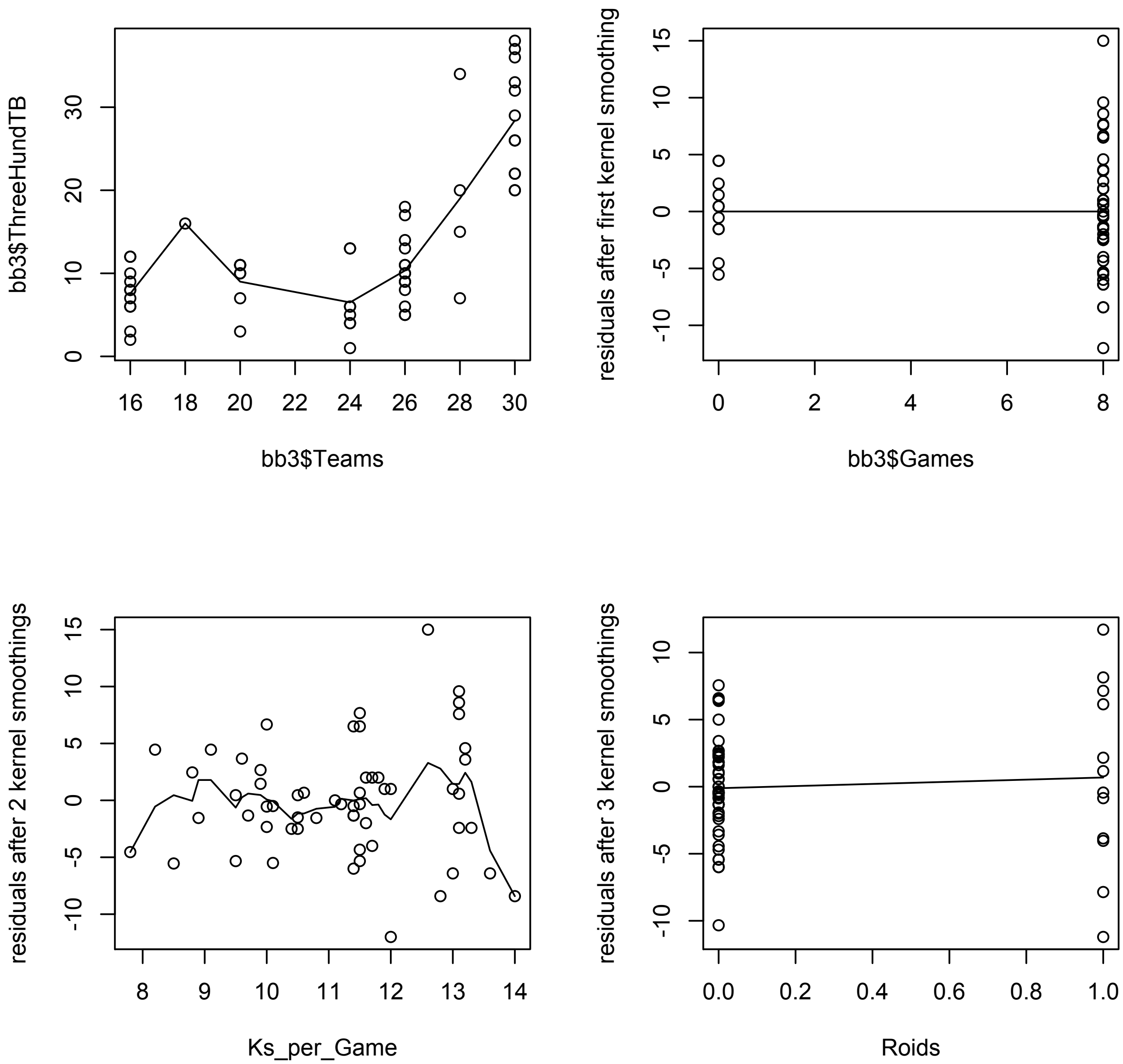
	coefficients	lower bd	upper bd
(Intercept)	-10.83333	-18.78992	3.32080
Teams	0.08333	-0.22661	0.23899
Roids	15.50000	9.85295	22.17104
Ks_per_Game	1.66667	0.38791	2.30206

19. Residual Plots for Final LAD model

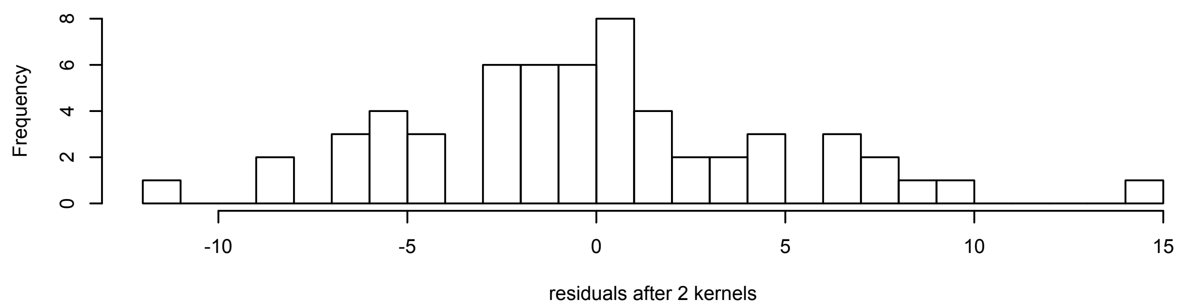


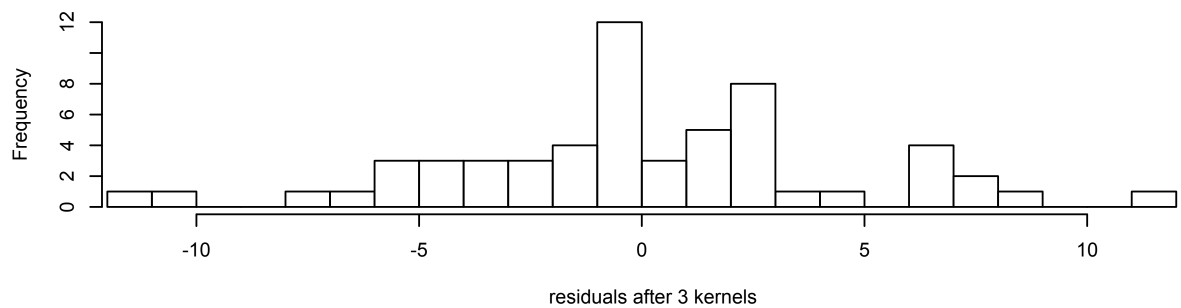


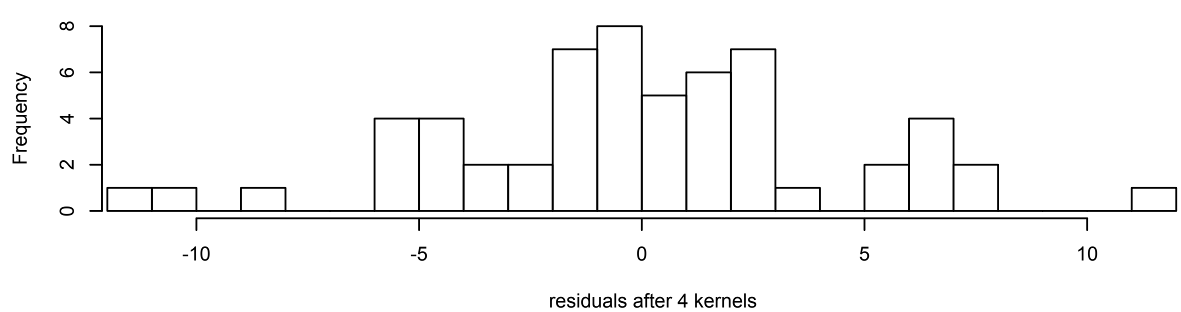
20. Ksmooth (Kernel Regression) Plots



21. Kernel Regression Histograms







This page intentionally left blank.