

Paper 3 Analysis

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Paper 3 Analysis

#Read in the data #Fit a Bradley-Terry Model #Cleaning up data and creating data frame with rankings
#Thinking about home wins #ANOVA and determining outliers #Comparing models #Analysis for Version
2 of Papers 3 #Rankings comparison - for discussion section of paper #Cross Validation

#Reading in the data

```
NFL2020 <- read.csv('https://dept.stat.lsa.umich.edu/~bbh/s485/data/NFL2020-11-22.csv')
```

Fitting a Bradley-Terry model

```
library(dplyr)
```

```
## Warning: package 'dplyr' was built under R version 3.6.2
```

```
##
```

```
## 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
```

```
library(glmnet)
```

```
## Warning: package 'glmnet' was built under R version 3.6.2
```

```
## Loading required package: Matrix
```

```
## Loaded glmnet 4.0-2
```

```
library(brglm)
```

```
## Warning: package 'brglm' was built under R version 3.6.2
```

```
## Loading required package: profileModel
```

```
## 'brglm' will gradually be superseded by 'brglm2' (https://cran.r-project.org/package=brglm2), which
```

```
model1 <- glm(Home_Win ~ . - 1 - Lions, data = NFL2020, family = binomial)
model1
```

```
##
## Call: glm(formula = Home_Win ~ . - 1 - Lions, family = binomial, data = NFL2020)
##
## Coefficients:
##      X49ers      Bears      Bengals      Bills      Broncos
## -0.005185    0.896791   -0.965861    2.099828    0.501257
##      Browns    Buccaneers    Cardinals    Chargers    Chiefs
##  1.814106    2.012692    0.790848   -0.903180    3.408650
##      Colts     Cowboys     Dolphins     Eagles     Falcons
##  1.606423   -0.482966    0.734162   -0.464937   -0.239137
## Football.Team    Giants     Jaguars     Jets     Packers
## -0.860605   -0.763364   -2.044494  -17.859101    1.537843
##      Panthers    Patriots    Raiders     Rams     Ravens
##  0.339069    0.438670    2.154717    1.122098    1.732176
##      Saints     Seahawks     Steelers     Texans     Titans
##  2.476208    1.488895    19.191992   -0.156605    2.092592
##      Vikings
##  0.351118
##
## Degrees of Freedom: 159 Total (i.e. Null); 128 Residual
## Null Deviance:      220.4
## Residual Deviance: 139.7    AIC: 201.7
```

```
#Tidying up the data
```

```
library(dplyr)
data_frame <- cbind.data.frame(list(coef(model1)))
```

```
#Formatting data_frame to have columns with corresponding titles
```

```
data_frame <- cbind(Team = rownames(data_frame), data_frame)
rownames(data_frame) <- 1:nrow(data_frame)
names(data_frame)[2] <- "Bradley_Terry_Score"
```

```
#Adding reference team to data_frame
```

```
reference_team <- data.frame("Lions", 0.0)
names(reference_team) <- c("Team", "Bradley_Terry_Score")
data_frame <- rbind(data_frame, reference_team)
```

```
#Sort by Bradley_Terry_Score
```

```
sorted_Bradley_Terry <- data_frame[order(-data_frame$Bradley_Terry_Score),]
row.names(sorted_Bradley_Terry) <- NULL
```

```
sorted_Bradley_Terry$Rank <- rownames(sorted_Bradley_Terry)
sorted_Bradley_Terry
```

```
##           Team Bradley_Terry_Score Rank
## 1    Steelers      19.191992489     1
## 2      Chiefs       3.408649598     2
## 3     Saints       2.476208281     3
## 4    Raiders       2.154717234     4
## 5      Bills       2.099827875     5
## 6     Titans       2.092592108     6
## 7   Buccaneers     2.012692201     7
## 8      Browns      1.814105645     8
## 9     Ravens      1.732175591     9
## 10     Colts      1.606422824    10
## 11    Packers      1.537842855    11
## 12   Seahawks     1.488894980    12
## 13      Rams      1.122098019    13
## 14     Bears       0.896791006    14
## 15 Cardinals       0.790848432    15
## 16   Dolphins      0.734161790    16
## 17   Broncos       0.501257083    17
## 18   Patriots      0.438669840    18
## 19   Vikings       0.351118107    19
## 20   Panthers      0.339068881    20
## 21     Lions       0.000000000    21
## 22    X49ers      -0.005184647    22
## 23    Texans      -0.156605293    23
## 24   Falcons      -0.239137047    24
## 25    Eagles      -0.464936533    25
## 26   Cowboys      -0.482966194    26
## 27    Giants      -0.763364045    27
## 28 Football.Team  -0.860605471    28
## 29   Chargers      -0.903180450    29
## 30   Bengals      -0.965861198    30
## 31   Jaguars      -2.044493803    31
## 32     Jets      -17.859101055    32
```

```
knitr::kable(sorted_Bradley_Terry)
```

Team	Bradley_Terry_Score	Rank
Steelers	19.1919925	1
Chiefs	3.4086496	2
Saints	2.4762083	3
Raiders	2.1547172	4
Bills	2.0998279	5
Titans	2.0925921	6
Buccaneers	2.0126922	7
Browns	1.8141056	8
Ravens	1.7321756	9
Colts	1.6064228	10
Packers	1.5378429	11
Seahawks	1.4888950	12

Team	Bradley_Terry_Score	Rank
Rams	1.1220980	13
Bears	0.8967910	14
Cardinals	0.7908484	15
Dolphins	0.7341618	16
Broncos	0.5012571	17
Patriots	0.4386698	18
Vikings	0.3511181	19
Panthers	0.3390689	20
Lions	0.0000000	21
X49ers	-0.0051846	22
Texans	-0.1566053	23
Falcons	-0.2391370	24
Eagles	-0.4649365	25
Cowboys	-0.4829662	26
Giants	-0.7633640	27
Football.Team	-0.8606055	28
Chargers	-0.9031805	29
Bengals	-0.9658612	30
Jaguars	-2.0444938	31
Jets	-17.8591011	32

Part 2: Home wins

```

model2 <- glm(Home_Win~.-Lions, data = NFL2020, family = binomial)

#Tidying up the data
library(dplyr)
data_frame1 <- cbind.data.frame(list(coef(model2)))

#Formatting data_frame to have columns with corresponding titles
data_frame1 <- cbind(Team = rownames(data_frame1), data_frame1)
rownames(data_frame1) <- 1:nrow(data_frame1)
names(data_frame1)[2] <- "Bradley_Terry_Score"

#Adding reference team to data_frame
reference_team1 <- data.frame("Lions", 0.0)
names(reference_team1) <- c("Team", "Bradley_Terry_Score")
data_frame1 <- rbind(data_frame1, reference_team1)

#Sort by Bradley_Terry_Score
sorted_Bradley_Terry <- data_frame1[order(-data_frame1$Bradley_Terry_Score),]
row.names(sorted_Bradley_Terry) <- NULL
sorted_Bradley_Terry$Rank <- rownames(sorted_Bradley_Terry)
model2

##
## Call:  glm(formula = Home_Win ~ . - Lions, family = binomial, data = NFL2020)
##
## Coefficients:

```

```
##      (Intercept)      X49ers      Bears      Bengals      Bills
##      0.2769      -0.1484      0.8534      -1.1233      2.0383
##      Broncos      Browns      Buccaneers      Cardinals      Chargers
##      0.3715      1.6110      2.0195      0.6891      -0.9675
##      Chiefs      Colts      Cowboys      Dolphins      Eagles
##      3.3978      1.5599      -0.5676      0.6702      -0.5710
##      Falcons      Football.Team      Giants      Jaguars      Jets
##      -0.3428      -1.0437      -0.8552      -2.1088      -17.9732
##      Packers      Panthers      Patriots      Raiders      Rams
##      1.6033      0.1974      0.2371      2.0259      1.0682
##      Ravens      Saints      Seahawks      Steelers      Texans
##      1.6058      2.4570      1.4374      19.1358      -0.3764
##      Titans      Vikings
##      1.9731      0.2885
##
## Degrees of Freedom: 158 Total (i.e. Null); 127 Residual
## Null Deviance:      219.7
## Residual Deviance: 138.1      AIC: 202.1
```

```
knitr::kable(sorted_Bradley_Terry)
```

Team	Bradley_Terry_Score	Rank
Steelers	19.1357681	1
Chiefs	3.3977681	2
Saints	2.4569509	3
Bills	2.0382521	4
Raiders	2.0259368	5
Buccaneers	2.0194529	6
Titans	1.9731373	7
Browns	1.6109747	8
Ravens	1.6058112	9
Packers	1.6032797	10
Colts	1.5599389	11
Seahawks	1.4373955	12
Rams	1.0681765	13
Bears	0.8534065	14
Cardinals	0.6891205	15
Dolphins	0.6701943	16
Broncos	0.3714659	17
Vikings	0.2884700	18
(Intercept)	0.2768996	19
Patriots	0.2371447	20
Panthers	0.1974390	21
Lions	0.0000000	22
X49ers	-0.1483598	23
Falcons	-0.3427915	24
Texans	-0.3764003	25
Cowboys	-0.5675888	26
Eagles	-0.5709949	27
Giants	-0.8552391	28
Chargers	-0.9674913	29
Football.Team	-1.0437107	30
Bengals	-1.1232963	31

Team	Bradley_Terry_Score	Rank
Jaguars	-2.1087739	32
Jets	-17.9731979	33

ANOVA and determining outliers

```
library(stats)
#anova.glm(model1, model2, test = "Chisq")
anova(model1, test = "Chisq")

## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Home_Win
##
## Terms added sequentially (first to last)
##
##
```

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
## NULL			159	220.42	
## X49ers	1	0.4027	158	220.02	0.525693
## Bears	1	0.0000	157	220.02	1.000000
## Bengals	1	2.9419	156	217.08	0.086307 .
## Bills	1	1.6457	155	215.43	0.199551
## Broncos	1	0.4027	154	215.03	0.525693
## Browns	1	0.9424	153	214.09	0.331664
## Buccaneers	1	1.5225	152	212.56	0.217235
## Cardinals	1	0.5064	151	212.06	0.476697
## Chargers	1	2.0373	150	210.02	0.153484
## Chiefs	1	7.4635	149	202.56	0.006296 **
## Colts	1	1.5971	148	200.96	0.206313
## Cowboys	1	1.2347	147	199.72	0.266494
## Dolphins	1	0.4629	146	199.26	0.496256
## Eagles	1	1.2196	145	198.04	0.269438
## Falcons	1	2.1109	144	195.93	0.146251
## Football.Team	1	2.7839	143	193.15	0.095214 .
## Giants	1	5.6878	142	187.46	0.017083 *
## Jaguars	1	9.5449	141	177.91	0.002005 **
## Jets	1	15.4588	140	162.46	8.432e-05 ***
## Packers	1	0.7165	139	161.74	0.397295
## Panthers	1	1.8235	138	159.91	0.176894
## Patriots	1	1.5014	137	158.41	0.220456
## Raiders	1	0.3794	136	158.03	0.537924
## Rams	1	0.1331	135	157.90	0.715204
## Ravens	1	0.0047	134	157.90	0.945252
## Saints	1	3.1434	133	154.75	0.076235 .
## Seahawks	1	0.4973	132	154.26	0.480708
## Steelers	1	9.6975	131	144.56	0.001845 **
## Texans	1	1.1757	130	143.38	0.278228
## Titans	1	3.5881	129	139.79	0.058195 .

```
## Vikings      1  0.1254      128      139.67  0.723218
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
anova(model2, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model: binomial, link: logit
##
## Response: Home_Win
##
## Terms added sequentially (first to last)
##
##
```

	Df	Deviance	Resid. Df	Resid. Dev	Pr(>Chi)
## NULL			158	219.66	
## X49ers	1	0.4046	157	219.25	0.524703
## Bears	1	0.0000	156	219.25	1.000000
## Bengals	1	2.8792	155	216.38	0.089730 .
## Bills	1	1.6530	154	214.72	0.198557
## Broncos	1	0.4046	153	214.32	0.524744
## Browns	1	0.8685	152	213.45	0.351380
## Buccaneers	1	1.6327	151	211.82	0.201333
## Cardinals	1	0.5095	150	211.31	0.475337
## Chargers	1	2.0475	149	209.26	0.152457
## Chiefs	1	7.4839	148	201.78	0.006225 **
## Colts	1	1.6242	147	200.15	0.202511
## Cowboys	1	1.2349	146	198.92	0.266447
## Dolphins	1	0.4846	145	198.43	0.486324
## Eagles	1	1.1852	144	197.25	0.276293
## Falcons	1	2.1047	143	195.14	0.146850
## Football.Team	1	3.0142	142	192.13	0.082537 .
## Giants	1	5.7483	141	186.38	0.016505 *
## Jaguars	1	9.4275	140	176.95	0.002138 **
## Jets	1	15.6596	139	161.29	7.583e-05 ***
## Packers	1	0.9477	138	160.34	0.330307
## Panthers	1	2.0245	137	158.32	0.154777
## Patriots	1	1.7020	136	156.62	0.192029
## Raiders	1	0.3251	135	156.29	0.568541
## Rams	1	0.1262	134	156.17	0.722417
## Ravens	1	0.0010	133	156.17	0.974294
## Saints	1	3.2965	132	152.87	0.069428 .
## Seahawks	1	0.4859	131	152.38	0.485763
## Steelers	1	9.4792	130	142.90	0.002078 **
## Texans	1	1.4380	129	141.47	0.230460
## Titans	1	3.3136	128	138.15	0.068707 .
## Vikings	1	0.0814	127	138.07	0.775445

```
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

```
#Comparing model1 and model2
#str(model1)
```

```
#str(model2)
anova(model1, model2)
```

```
## Analysis of Deviance Table
##
## Model 1: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
##   Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
##   Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
##   Jets + Lions + Packers + Panthers + Patriots + Raiders +
##   Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
##   Vikings) - 1 - Lions
## Model 2: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
##   Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
##   Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
##   Jets + Lions + Packers + Panthers + Patriots + Raiders +
##   Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
##   Vikings) - Lions
##   Resid. Df Resid. Dev Df Deviance
## 1      128      139.67
## 2      127      138.07  1    1.5973
```

```
#Comparing using Chi-squared
anova(model1, model2, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model 1: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
##   Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
##   Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
##   Jets + Lions + Packers + Panthers + Patriots + Raiders +
##   Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
##   Vikings) - 1 - Lions
## Model 2: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
##   Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
##   Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
##   Jets + Lions + Packers + Panthers + Patriots + Raiders +
##   Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
##   Vikings) - Lions
##   Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1      128      139.67
## 2      127      138.07  1    1.5973    0.2063
```

```
#Surprisingly, the below code yields the same results as a regular anova()
stats::anova.glm(model1, model2, test = "Chisq")
```

```
## Analysis of Deviance Table
##
## Model 1: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
##   Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
##   Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
##   Jets + Lions + Packers + Panthers + Patriots + Raiders +
##   Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
```



```
## Vikings) - 1 - Lions
## Model 2: Home_Win ~ (X49ers + Bears + Bengals + Bills + Broncos + Browns +
## Buccaneers + Cardinals + Chargers + Chiefs + Colts + Cowboys +
## Dolphins + Eagles + Falcons + Football.Team + Giants + Jaguars +
## Jets + Lions + Packers + Panthers + Patriots + Raiders +
## Rams + Ravens + Saints + Seahawks + Steelers + Texans + Titans +
## Vikings) - Lions
## Resid. Df Resid. Dev Df Deviance Pr(>Chi)
## 1 128 139.67
## 2 127 138.07 1 1.5973 0.2063
```

```
# General Linear Hypotheses
#install.packages('multcomp')
library(multcomp)
```

```
## Warning: package 'multcomp' was built under R version 3.6.2
```

```
## Loading required package: mvtnorm
```

```
## Warning: package 'mvtnorm' was built under R version 3.6.2
```

```
## Loading required package: survival
```

```
## Warning: package 'survival' was built under R version 3.6.2
```

```
## Loading required package: TH.data
```

```
## Loading required package: MASS
```

```
## Warning: package 'MASS' was built under R version 3.6.2
```

```
##
```

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

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

```
##
```

```
## select
```

```
##
```

```
## Attaching package: 'TH.data'
```

```
## The following object is masked from 'package:MASS':
```

```
##
```

```
## geyser
```

```
glht(model1)
```

```
##
##   General Linear Hypotheses
##
## Linear Hypotheses:
##           Estimate
## X49ers == 0      -0.005185
## Bears == 0       0.896791
## Bengals == 0     -0.965861
## Bills == 0       2.099828
## Broncos == 0     0.501257
## Browns == 0      1.814106
## Buccaneers == 0  2.012692
## Cardinals == 0   0.790848
## Chargers == 0    -0.903180
## Chiefs == 0      3.408650
## Colts == 0       1.606423
## Cowboys == 0     -0.482966
## Dolphins == 0    0.734162
## Eagles == 0     -0.464937
## Falcons == 0     -0.239137
## Football.Team == 0 -0.860605
## Giants == 0     -0.763364
## Jaguars == 0     -2.044494
## Jets == 0        -17.859101
## Packers == 0     1.537843
## Panthers == 0    0.339069
## Patriots == 0    0.438670
## Raiders == 0     2.154717
## Rams == 0        1.122098
## Ravens == 0      1.732176
## Saints == 0      2.476208
## Seahawks == 0    1.488895
## Steelers == 0    19.191992
## Texans == 0     -0.156605
## Titans == 0      2.092592
## Vikings == 0     0.351118
```

```
glht(model2)
```

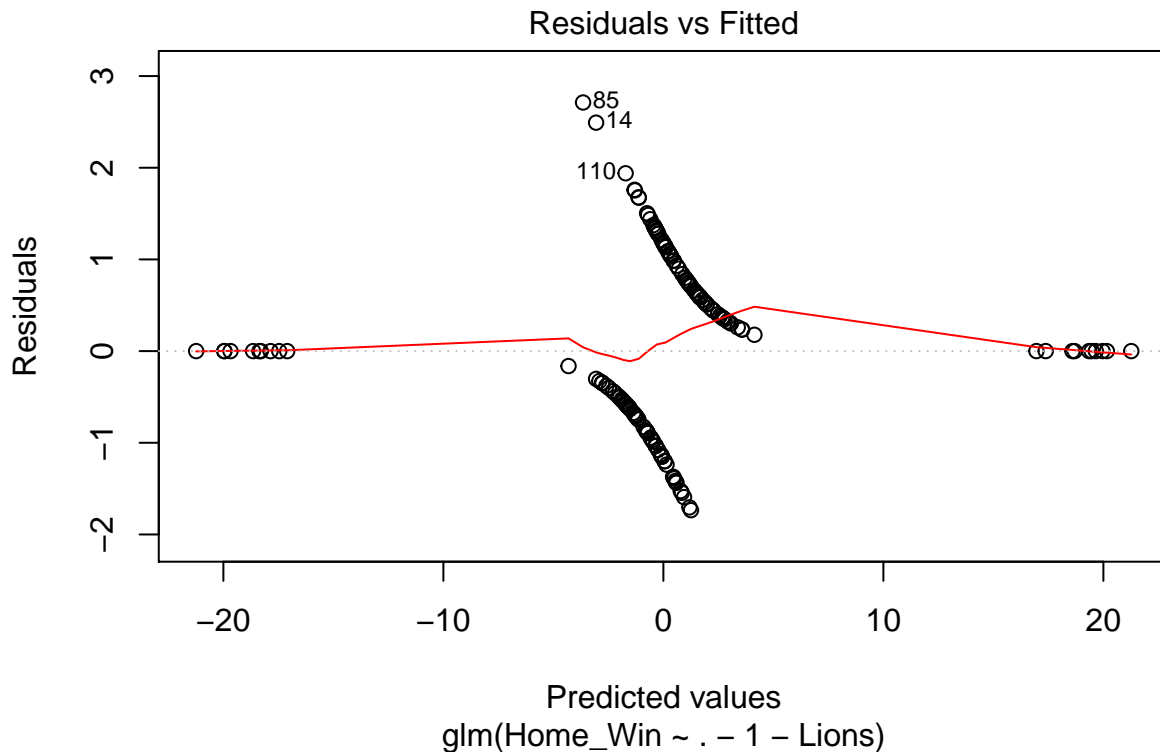
```
##
##   General Linear Hypotheses
##
## Linear Hypotheses:
##           Estimate
## (Intercept) == 0   0.2769
## X49ers == 0       -0.1484
## Bears == 0        0.8534
## Bengals == 0     -1.1233
## Bills == 0        2.0383
## Broncos == 0      0.3715
## Browns == 0       1.6110
## Buccaneers == 0   2.0195
## Cardinals == 0    0.6891
## Chargers == 0    -0.9675
```

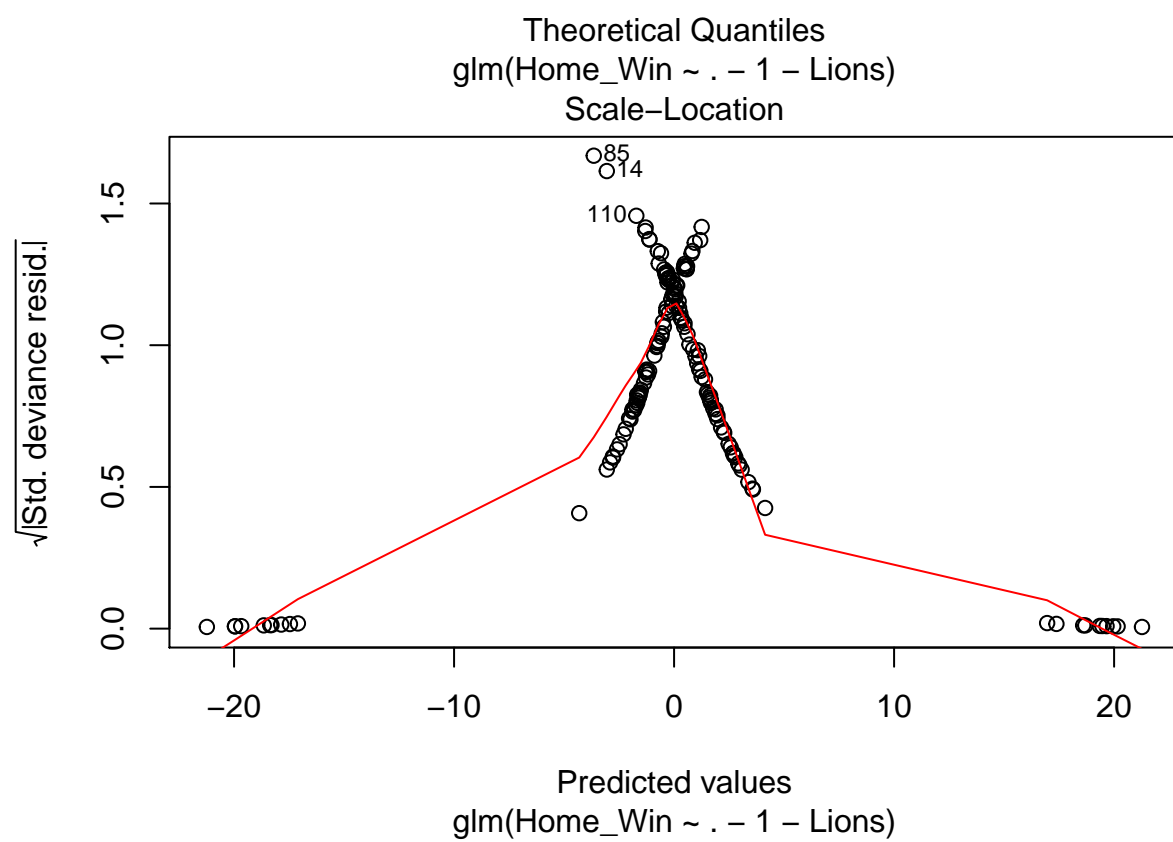
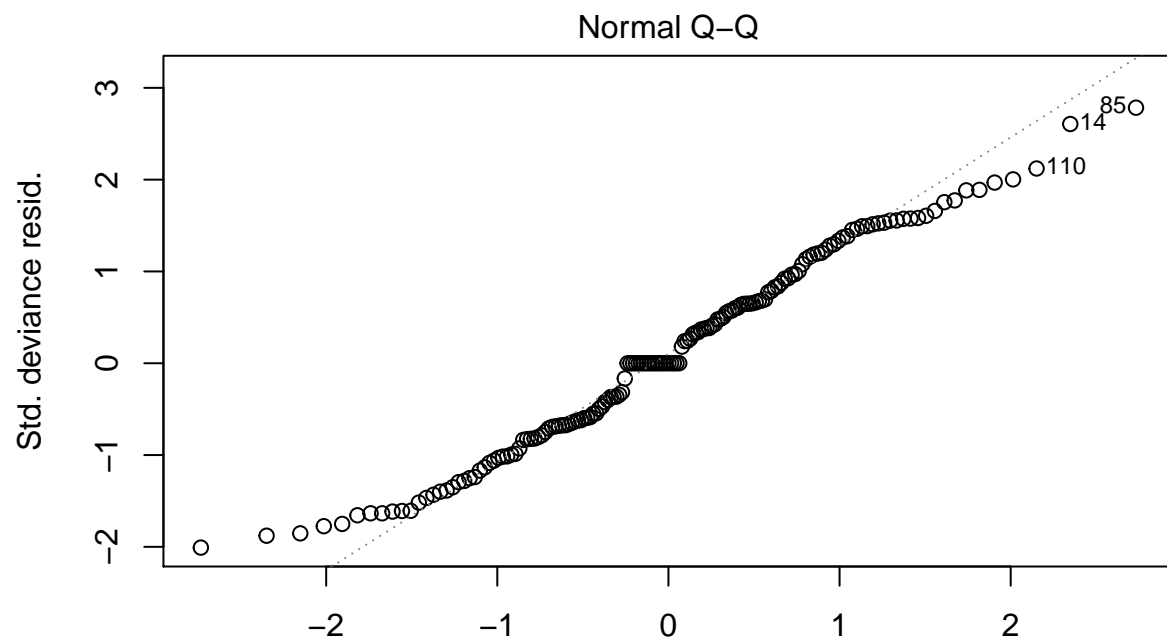
```
## Chiefs == 0          3.3978
## Colts == 0           1.5599
## Cowboys == 0         -0.5676
## Dolphins == 0        0.6702
## Eagles == 0          -0.5710
## Falcons == 0         -0.3428
## Football.Team == 0   -1.0437
## Giants == 0          -0.8552
## Jaguars == 0         -2.1088
## Jets == 0            -17.9732
## Packers == 0         1.6033
## Panthers == 0        0.1974
## Patriots == 0        0.2371
## Raiders == 0         2.0259
## Rams == 0            1.0682
## Ravens == 0          1.6058
## Saints == 0          2.4570
## Seahawks == 0        1.4374
## Steelers == 0        19.1358
## Texans == 0          -0.3764
## Titans == 0          1.9731
## Vikings == 0         0.2885
```

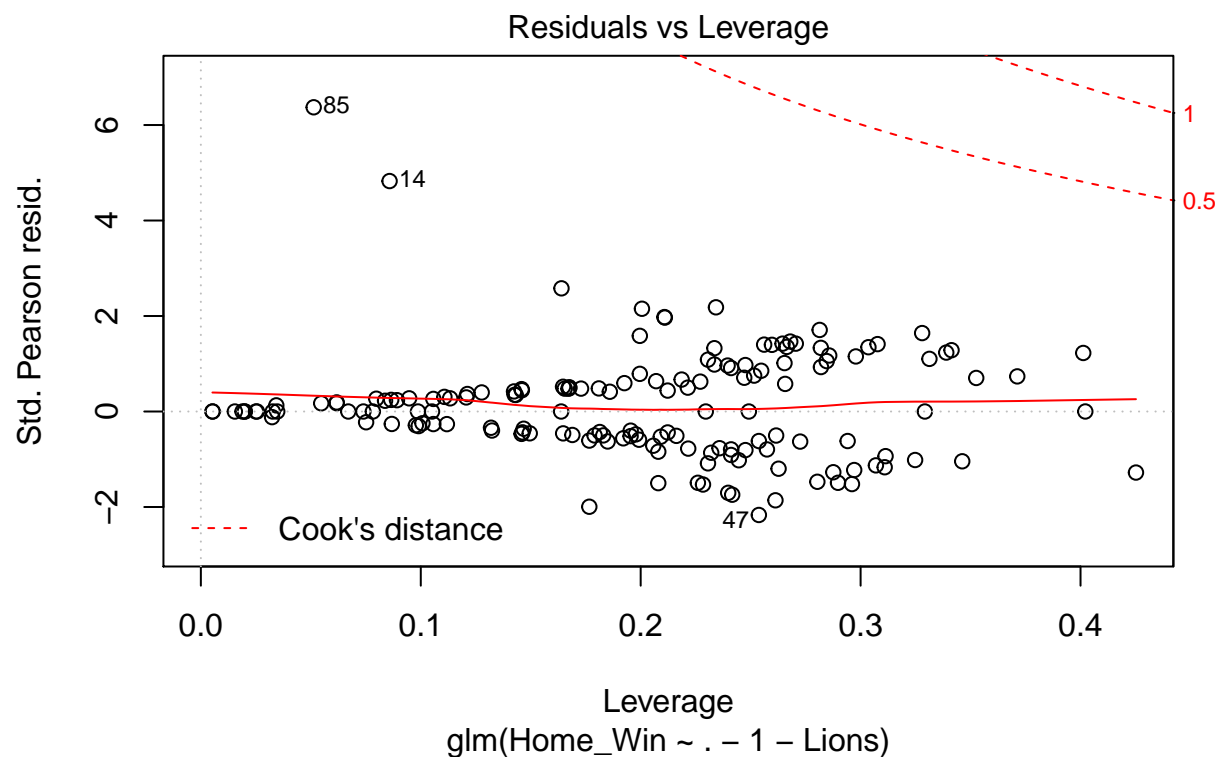
```
#vignette('multcomp-examples', package = 'multcomp')
```

```
#Determining outliers
```

```
plot(model1)
```







Analysis for Version 2 of paper 3

```
#install.packages('brglm')
library('brglm')

#install.packages("glmnet")
library("glmnet")
summary(glmnet(model2))
```

```
## Warning in RET$pfuction("adjusted", ...): Completion with error > abseps
## Warning in RET$pfuction("adjusted", ...): Completion with error > abseps

##
## Simultaneous Tests for General Linear Hypotheses
##
## Fit: glm(formula = Home_Win ~ . - Lions, family = binomial, data = NFL2020)
##
## Linear Hypotheses:
##              Estimate Std. Error z value Pr(>|z|)
## (Intercept) == 0      0.2769    0.2213   1.251   0.989
## X49ers == 0         -0.1484    1.1661  -0.127   1.000
## Bears == 0           0.8534    0.9892   0.863   1.000
## Bengals == 0        -1.1233    1.3826  -0.812   1.000
## Bills == 0           2.0383    1.1936   1.708   0.808
## Broncos == 0         0.3715    1.2087   0.307   1.000
## Browns == 0          1.6110    1.2733   1.265   0.988
```

```
## Buccaneers == 0      2.0195      1.1433      1.766      0.764
## Cardinals == 0       0.6891      1.0685      0.645      1.000
## Chargers == 0      -0.9675      1.3302     -0.727      1.000
## Chiefs == 0         3.3978      1.4533      2.338      0.318
## Colts == 0          1.5599      1.0917      1.429      0.953
## Cowboys == 0       -0.5676      1.1389     -0.498      1.000
## Dolphins == 0       0.6702      1.1457      0.585      1.000
## Eagles == 0        -0.5710      1.2305     -0.464      1.000
## Falcons == 0       -0.3428      1.0039     -0.341      1.000
## Football.Team == 0  -1.0437      1.1425     -0.914      1.000
## Giants == 0        -0.8552      1.2028     -0.711      1.000
## Jaguars == 0       -2.1088      1.3701     -1.539      0.909
## Jets == 0         -17.9732    1835.4398     -0.010      1.000
## Packers == 0        1.6033      1.1079      1.447      0.947
## Panthers == 0       0.1974      1.0180      0.194      1.000
## Patriots == 0       0.2371      1.1973      0.198      1.000
## Raiders == 0       2.0259      1.1601      1.746      0.780
## Rams == 0          1.0682      1.1676      0.915      1.000
## Ravens == 0        1.6058      1.2102      1.327      0.978
## Saints == 0        2.4570      1.1833      2.076      0.511
## Seahawks == 0       1.4374      1.1310      1.271      0.987
## Steelers == 0      19.1358    1784.4403      0.011      1.000
## Texans == 0       -0.3764      1.2712     -0.296      1.000
## Titans == 0        1.9731      1.2045      1.638      0.854
## Vikings == 0        0.2885      1.0141      0.284      1.000
## (Adjusted p values reported -- single-step method)
```

```
## For version 2 of the paper, we use brglm
model_BRGLM <- brglm(Home_Win~.-1-Lions, data = NFL2020, family = binomial)
data_frame123 <- cbind.data.frame(list(coef(model_BRGLM)))

#Formatting data_frame123 to have columns with corresponding titles
data_frame123 <- cbind(Team = rownames(data_frame123), data_frame123)
rownames(data_frame123) <- 1:nrow(data_frame123)
names(data_frame123)[2] <- "Bias_Reduced_Bradley_Terry_Score"

#Adding reference team to data_frame123
reference_team123 <- data.frame("Lions", 0.0)
names(reference_team123) <- c("Team", "Bias_Reduced_Bradley_Terry_Score")
data_frame123 <- rbind(data_frame123, reference_team123)

#Sort by Bias_Reduced_Bradley_Terry_Score
sorted_BRGLM_Bradley_Terry <- data_frame123[order(-data_frame123$Bias_Reduced_Bradley_Terry_Score),]
row.names(sorted_BRGLM_Bradley_Terry) <- NULL
sorted_BRGLM_Bradley_Terry$Rank <- rownames(sorted_BRGLM_Bradley_Terry)
#sortedBRGLM_Bradley_Terry

knitr::kable(sorted_BRGLM_Bradley_Terry)
```

Team	Bias_Reduced_Bradley_Terry_Score	Rank
Steelers	3.4579673	1
Chiefs	2.6006800	2
Saints	1.9561957	3

Team	Bias_Reduced_Bradley_Terry_Score	Rank
Raiders	1.6850172	4
Bills	1.6521881	5
Titans	1.6207203	6
Buccaneers	1.5935669	7
Browns	1.4013502	8
Ravens	1.3438402	9
Colts	1.2553224	10
Packers	1.2253238	11
Seahawks	1.1979458	12
Rams	0.9038080	13
Bears	0.7141639	14
Cardinals	0.6310920	15
Dolphins	0.5913823	16
Broncos	0.4144446	17
Patriots	0.3555813	18
Vikings	0.2769467	19
Panthers	0.2725184	20
X49ers	0.0112036	21
Lions	0.0000000	22
Texans	-0.0777117	23
Falcons	-0.1926909	24
Eagles	-0.3325689	25
Cowboys	-0.3637297	26
Giants	-0.5757615	27
Chargers	-0.6166390	28
Football.Team	-0.6543324	29
Bengals	-0.6770942	30
Jaguars	-1.4627027	31
Jets	-2.3486378	32

Paper 2 analysis: Cross Validation and Hypothesis test comparing two teams

```
model1 <- glm(Home_Win~.-1-Lions, data = NFL2020, family = binomial)
#Comparing CV across penalized and glm fit
library(boot)
```

```
## Warning: package 'boot' was built under R version 3.6.2
```

```
##
```

```
## Attaching package: 'boot'
```

```
## The following object is masked from 'package:survival':
```

```
##
```

```
## aml
```

```
summary(cv.glm(data = NFL2020, glmfit = model_BRGLM, K = 159))
```

```
## Length Class Mode
```

```
## call      4    -none- call
## K         1    -none- numeric
## delta    2    -none- numeric
## seed    626    -none- numeric
```

```
summary(cv.glm(data = NFL2020, glmfit = model1, K = 159))
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
```

```
##      Length Class  Mode
## call      4    -none- call
## K         1    -none- numeric
## delta    2    -none- numeric
## seed    626    -none- numeric
```

```
#install.packages("Perc")
#library(Perc)
#bt.test(data.matrix(NFL2020), baseline = 1, maxLength = 2, reps = 1000)
```

Rankings comparision - for Discussion section of paper

```
Teams <- c("Steelers", "Chiefs", "Saints", "Raiders", "Bills", "Titans", "Buccaneers", "Browns", "Ravens", "Colts")
BT <- c(1:10)
ESPN <- c(1, 2, 3, 15, 5, 7, 8, 12, 11, 9)
NFL <- c(2, 1, 3, 11, 7, 6, 9, 13, 12, 10)
CBS <- c(1, 2, 3, 13, 6, 7, 11, 8, 14, 9)
BRBT <- c(1:10)

rankings<-data.frame(Teams, BT, ESPN, NFL, CBS, BRBT)
knitr::kable(rankings)
```

Teams	BT	ESPN	NFL	CBS	BRBT
Steelers	1	1	2	1	1
Chiefs	2	2	1	2	2
Saints	3	3	3	3	3
Raiders	4	15	11	13	4
Bills	5	5	7	6	5
Titans	6	7	6	7	6
Buccaneers	7	8	9	11	7
Browns	8	12	13	8	8
Ravens	9	11	12	14	9
Colts	10	9	10	9	10

Cross Validation in NFL Data

```
(NFL2020[,-1L] != 0) %>% # remove col 1, create T/F matrix saying whether nonzero  
colSums() %>% #count nonzero cell entries, by column  
table() # tabulate game counts.
```

```
## .  
##  9 10 11  
##  3 28  1
```