Predicting Pitcher DL

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```
setwd("F:/Capstone_Workspace/predictDL/");
library('RODBC');

## Warning: package 'RODBC' was built under R version 3.2.5

library('DBI');
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

library('stringi');
library('sqldf');

## Warning: package 'sqldf' was built under R version 3.2.5

## Loading required package: gsubfn

## Warning: package 'gsubfn' was built under R version 3.2.5

## Loading required package: proto

## Loading required package: RSQLite

## Warning: package 'RSQLite' was built under R version 3.2.5

library('corrplot');

## Warning: package 'corrplot' was built under R version 3.2.5

library('reshape2');
library('ggplot2');

## Warning: package 'ggplot2' was built under R version 3.2.5

library('caret');

## Warning: package 'caret' was built under R version 3.2.5
```

```
## Loading required package: lattice

dbhandle <- odbcDriverConnect('driver={SQL
Server};server=localhost;database=PitchFx;trusted_connection=true');
query <-
'SELECT m.rsid, min(ms.nameLast) as nameLast, min(ms.nameFirst) as nameFirst,
        year(p.GameDate) as season,
        avg(p.x) as x,
        avg(p.y) as y,
        avg(p.start_speed) as start_speed,
        avg(p.end_speed) as end_speed,
        avg(p.sz_top) as sz_top,
        avg(p.sz_bot) as sz_bot,
        avg(p.pfx_x) as pfx_x,
        avg(p.pfx_z) as pfx_z,
        avg(p.px) as px,
        avg(p.pz) as pz,
        avg(p.x0) as x0,
        avg(p.y0) as y0,
        avg(p.z0) as z0,
        avg(p.vx0) as vx0,
        avg(p.vy0) as vy0,
        avg(p.vz0) as vz0,
        avg(p.ax) as ax,
        avg(p.ay) as ay,
        avg(p.az) as az,
        avg(p.break_y) as break_y,
        avg(p.break_angle) as break_angle,
        avg(p.break_length) as break_length,
        avg(p.spin_dir) as spin_dir,
        avg(p.spin_rate) as spin_rate,
        sum(p.num_pitches) as num_pitches
  FROM [PitchFx].[dbo].[GamesAtBatsAggregatePitches] p
  INNER JOIN [Mapping].[dbo].[RSID_MLBID_MAP] m on p.pitcher = m.mlbid
  INNER JOIN [Lahman].[dbo].[Master] ms on ms.retroID = m.rsID
  GROUP BY m.rsid, year(p.GameDate)'

pitches <- sqlQuery(dbhandle, query);
pitches <- pitches[complete.cases(pitches),];
close(dbhandle);

dbhandle <- odbcDriverConnect('driver={SQL
Server};server=localhost;database=PitchFx;trusted_connection=true');
query <- "
SELECT rsid, 2011 as season_dl, sum(days) as DLDays
  FROM [DisabledList].[dbo].[DL2011]
  WHERE Position in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
UNION
SELECT rsid, 2012 as season_dl, sum(days) as DLDays
```

```
  FROM [DisabledList].[dbo].[DL2012]
  WHERE Pos in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
UNION
SELECT rsid, 2013 as season_dl, sum(days) as DLDays
  FROM [DisabledList].[dbo].[DL2013]
  WHERE Position in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
UNION
SELECT rsid, 2014 as season_dl, sum(days) as DLDays
  FROM [DisabledList].[dbo].[DL2014]
  WHERE Position in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
UNION
SELECT rsid, 2015 as season_dl, sum(days) as DLDays
  FROM [DisabledList].[dbo].[DL2015]
  WHERE Position in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
UNION
SELECT rsid, 2016 as season_dl, sum(days) as DLDays
  FROM [DisabledList].[dbo].[DL2016]
  WHERE Position in ('LHP','RHP','RP','SP','P')
  GROUP BY rsid
";

dl <- sqlQuery(dbhandle, query);
dl <- dl[complete.cases(dl),];
dl$season_1 <- dl$season-1;
close(dbhandle);

#use previous season to predict DL in current season
pitches_dl <- merge(x=pitches, y=dl, by.x=c("rsid", "season"), by.y=c("rsid",
"season_1"), all.x = TRUE, all.y=FALSE)

pitches_dl[pitches_dl==""] <- NA; #replace blanks with NA

pitches_dl$DLDays[is.na(pitches_dl$DLDays)] <- 0; #no DL pitchers are on DL
for 0 days

drops <- c("season_dl");
pitches_dl <- pitches_dl[ , !(names(pitches_dl) %in% drops)];

pitches_dl <- pitches_dl[complete.cases(pitches_dl),];

pitches_dl_dataset <- pitches_dl[pitches_dl$season < 2016,]; #for modeling
pitches_dl_predict <- pitches_dl[pitches_dl$season == 2016,]; #for 2017
prediction
```

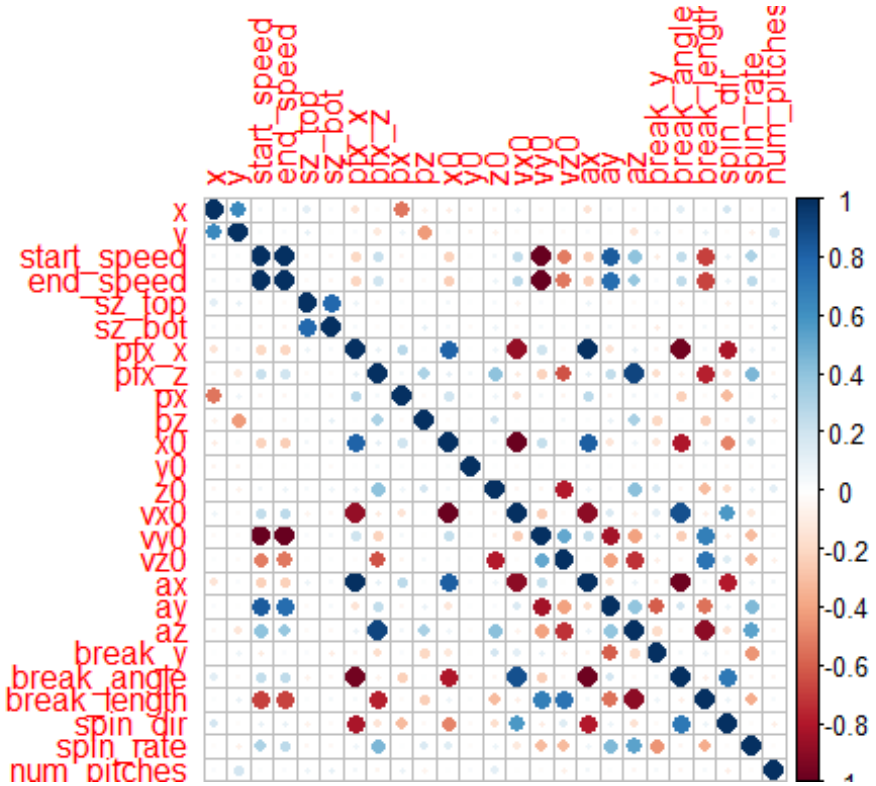
```
pitches_dl_dataset$OnDL <- as.factor(ifelse(pitches_dl_dataset$DLDays>0,
'YES', 'NO'));

summary(pitches_dl_dataset);
```

```
##        rsid          season          nameLast      nameFirst
##  abadf001:   6   Min.   :2010   Rodriguez:  37   Chris  :  97
##  adamm001:   6   1st Qu.:2011   Perez    :  27   Matt   :  92
##  affej001:   6   Median :2012   Hernandez:  26   Mike   :  72
##  albem001:   6   Mean   :2012   Ramirez  :  25   Scott  :  69
##  andeb004:   6   3rd Qu.:2014   Smith    :  24   David  :  68
##  arrij001:   6   Max.   :2015   Johnson  :  23   Josh   :  67
##  (Other) :4291                  (Other)  :4165   (Other):3862
##        x                y          start_speed      end_speed
##  Min.   : 64.74   Min.   :106.9   Min.   :53.77   Min.   :49.73
##  1st Qu.: 98.95   1st Qu.:143.7   1st Qu.:85.79   1st Qu.:79.19
##  Median :102.68   Median :147.2   Median :87.79   Median :81.05
##  Mean   :103.84   Mean   :148.9   Mean   :87.57   Mean   :80.80
##  3rd Qu.:107.32   3rd Qu.:150.9   3rd Qu.:89.74   3rd Qu.:82.77
##  Max.   :148.81   Max.   :191.6   Max.   :96.87   Max.   :89.96
##
##      sz_top          sz_bot          pfx_x             pfx_z
##  Min.   :0.000   Min.   :0.000   Min.   :-11.598   Min.   :-7.326
##  1st Qu.:3.391   1st Qu.:1.561   1st Qu.: -4.294   1st Qu.: 3.620
##  Median :3.416   Median :1.584   Median : -2.173   Median : 5.059
##  Mean   :3.412   Mean   :1.585   Mean   : -1.165   Mean   : 4.923
##  3rd Qu.:3.441   3rd Qu.:1.606   3rd Qu.:  2.050   3rd Qu.: 6.325
##  Max.   :3.737   Max.   :1.820   Max.   : 11.167   Max.   :13.316
##
##        px                pz              x0                y0
##  Min.   :-1.43400   Min.   :1.097   Min.   :-4.3108   Min.   :50
##  1st Qu.:-0.18681   1st Qu.:2.224   1st Qu.:-2.0329   1st Qu.:50
##  Median :-0.08090   Median :2.339   Median :-1.3939   Median :50
##  Mean   :-0.08393   Mean   :2.347   Mean   :-0.7184   Mean   :50
##  3rd Qu.: 0.02757   3rd Qu.:2.460   3rd Qu.: 1.0714   3rd Qu.:50
##  Max.   : 1.02925   Max.   :3.727   Max.   : 5.2931   Max.   :50
##
##        z0             vx0               vy0               vz0
##  Min.   :1.959   Min.   :-14.576   Min.   :-141.76   Min.   :-9.631
##  1st Qu.:5.655   1st Qu.: -4.067   1st Qu.:-131.32   1st Qu.:-5.305
##  Median :5.906   Median :  4.480   Median :-128.48   Median :-4.450
##  Mean   :5.866   Mean   :  2.066   Mean   :-128.16   Mean   :-4.258
##  3rd Qu.:6.148   3rd Qu.:  6.155   3rd Qu.:-125.58   3rd Qu.:-3.486
##  Max.   :7.287   Max.   : 11.062   Max.   : -78.81   Max.   : 9.976
##
##        ax                ay              az             break_y
##  Min.   :-20.400   Min.   :10.34   Min.   :-43.122   Min.   :23.66
##  1st Qu.: -7.991   1st Qu.:25.39   1st Qu.:-24.924   1st Qu.:23.78
##  Median : -4.285   Median :26.82   Median :-22.620   Median :23.80
##  Mean   : -2.338   Mean   :26.83   Mean   :-22.778   Mean   :23.80
```

```
##  3rd Qu.:  3.734   3rd Qu.:28.36   3rd Qu.:-20.358   3rd Qu.:23.82
##  Max.   : 20.249   Max.   :35.35   Max.   : -7.535   Max.   :23.92
##
##   break_angle       break_length       spin_dir       spin_rate
##  Min.   :-50.123   Min.   : 3.004   Min.   :102.6   Min.   : 688.8
##  1st Qu.: -9.559   1st Qu.: 5.820   1st Qu.:165.5   1st Qu.:1577.0
##  Median : 10.904   Median : 6.500   Median :182.0   Median :1743.1
##  Mean   :  5.459   Mean   : 6.586   Mean   :183.0   Mean   :1737.9
##  3rd Qu.: 18.440   3rd Qu.: 7.222   3rd Qu.:200.0   3rd Qu.:1906.7
##  Max.   : 51.992   Max.   :16.967   Max.   :297.6   Max.   :3024.0
##
##   num_pitches         DLDays       OnDL
##  Min.   :   1.0   Min.   :  0.0   NO :3328
##  1st Qu.: 217.5   1st Qu.:  0.0   YES: 999
##  Median : 738.0   Median :  0.0
##  Mean   :1045.1   Mean   : 15.5
##  3rd Qu.:1325.0   3rd Qu.:  0.0
##  Max.   :4441.0   Max.   :200.0
##
```

```
numeric_dataset <- pitches_dl_dataset[sapply(pitches_dl_dataset,
is.numeric)];
#exclude season and DLDays
numeric_dataset <- numeric_dataset[2:(ncol(numeric_dataset)-1)];
m <- cor(numeric_dataset);
corrplot(m);
```



```
highlyCorrelated <- findCorrelation(m, cutoff=0.5);
lowCorrelatedCols <- colnames(numeric_dataset[-highlyCorrelated]);
print(lowCorrelatedCols);
```

```
##  [1] "y"           "sz_bot"      "pfx_z"       "pz"          "x0"
##  [6] "y0"          "z0"          "break_y"     "spin_dir"    "spin_rate"
## [11] "num_pitches"
```

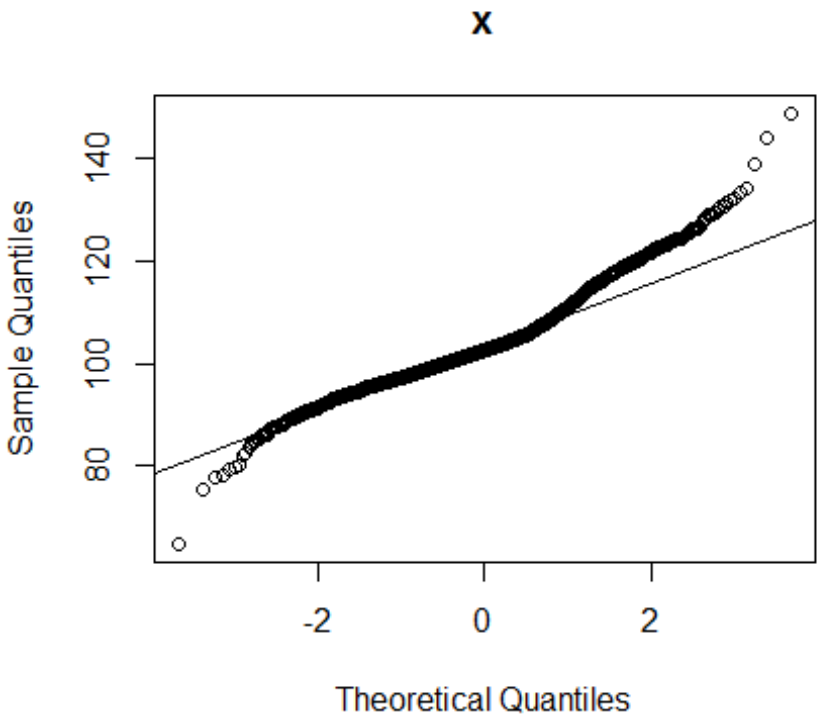
```
d <- melt(pitches_dl_dataset[sapply(pitches_dl_dataset, is.numeric)]);
```

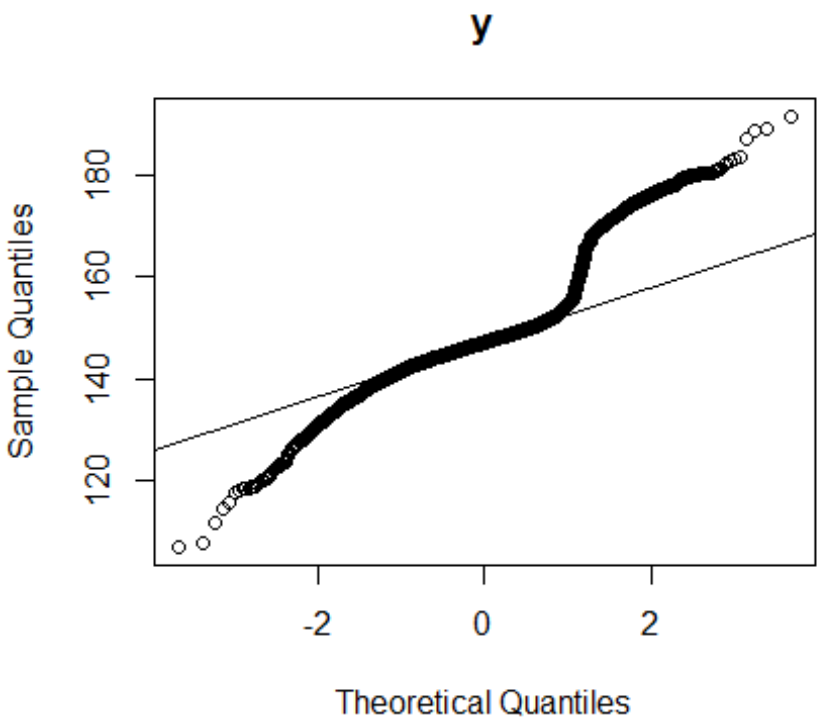
```
## No id variables; using all as measure variables
```

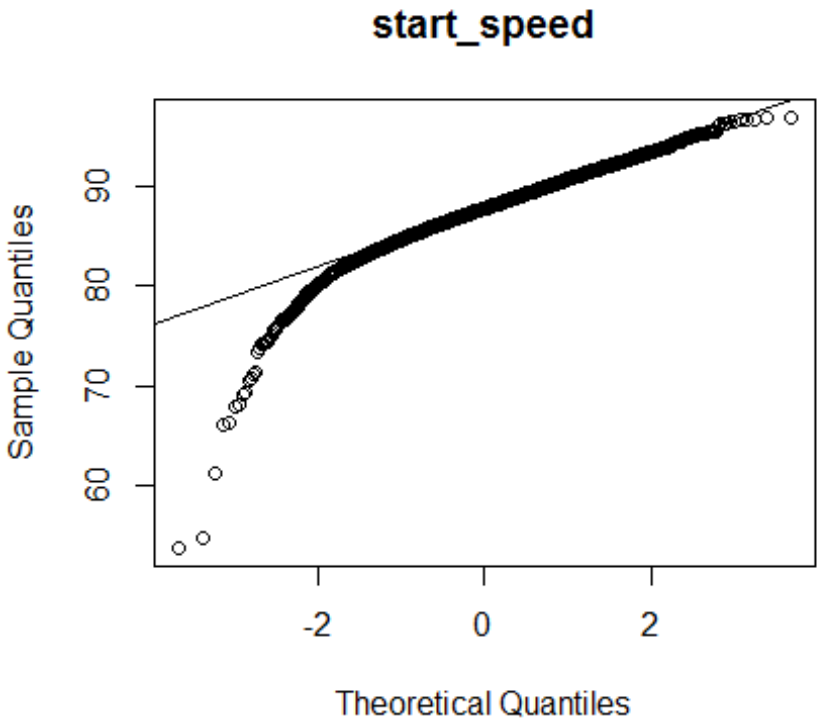
```
ggplot(d,aes(x = value)) + facet_wrap(~variable,scales = "free_x") +
geom_histogram();
```

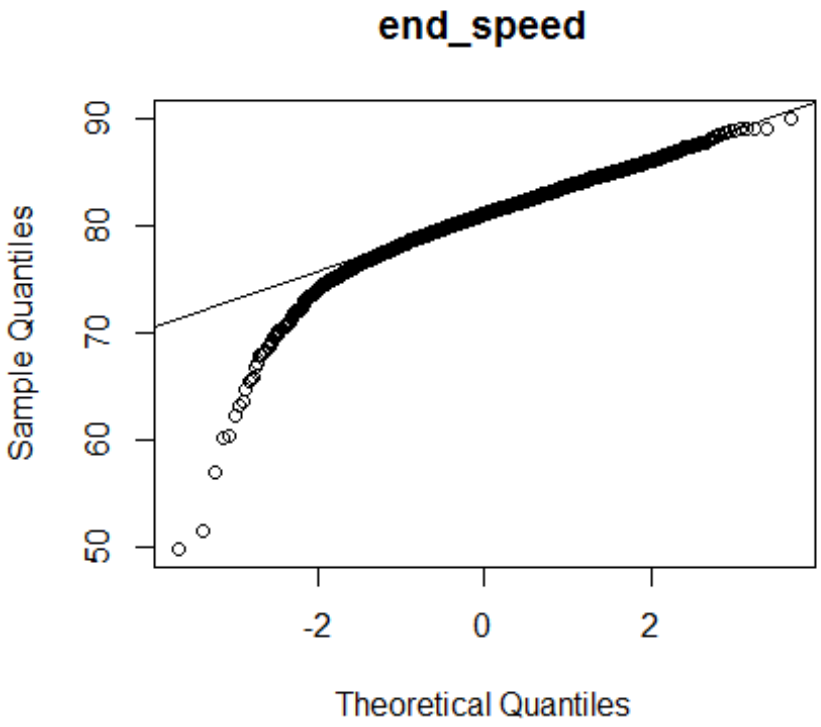
```
## `stat_bin()` using `bins = 30`. Pick better value with `binwidth`.
```

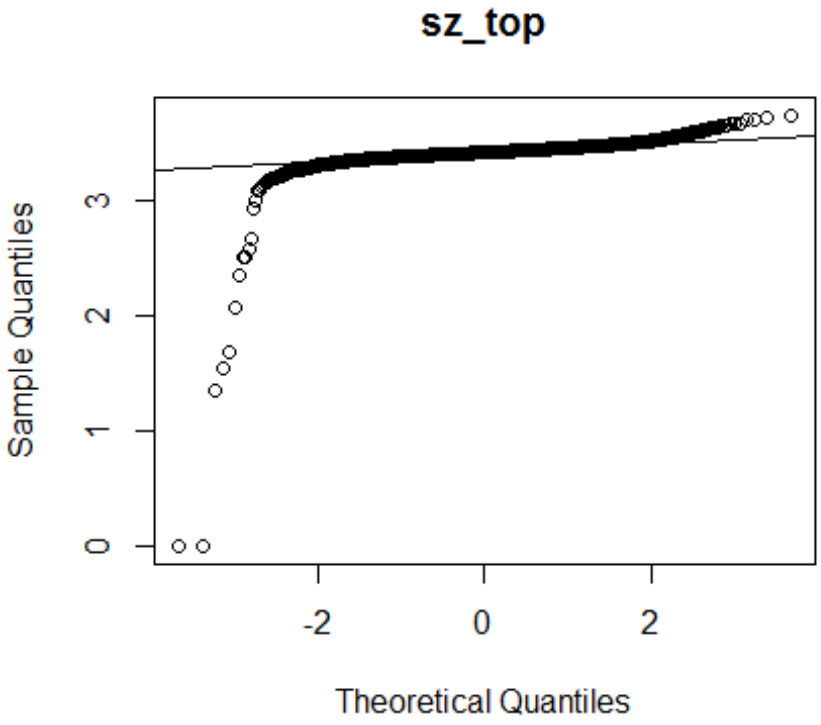

```
par(mar=c(4,4,4,4))
#for (i in 5:ncol(pitches_dl_dataset[,1: ncol(pitches_dl_dataset) - 1 ])){
for (i in 5:(ncol(pitches_dl_dataset)-2)){
  tmp <- pitches_dl_dataset[, i];
  qqnorm(tmp, main = colnames(pitches_dl_dataset[i]));
  qqline(tmp);
}
```

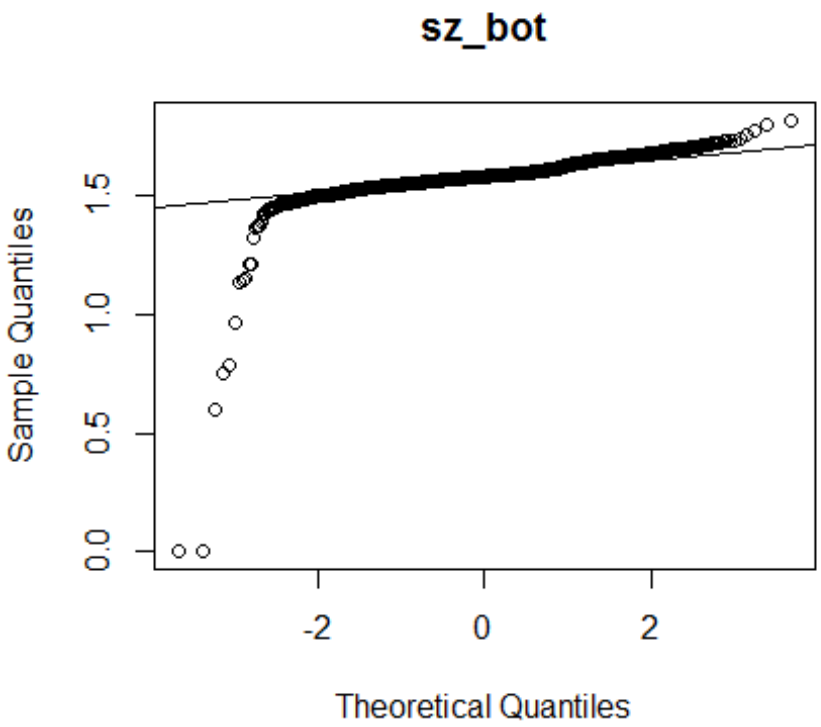

x
Sample Quantiles
80
100
120
140
-2
0
2
Theoretical Quantiles

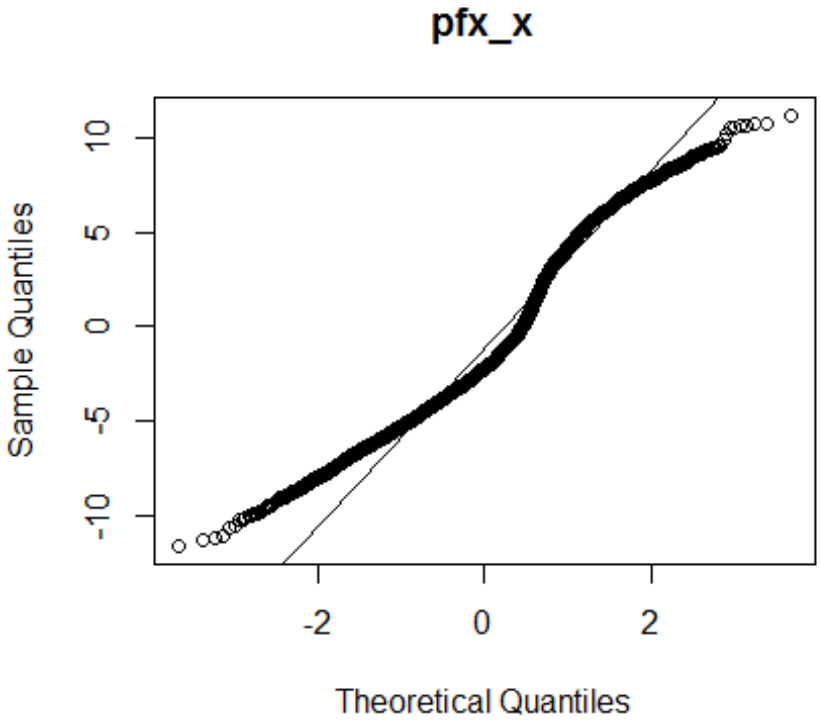

y
Sample Quantiles
120
140
160
180
-2
0
2
Theoretical Quantiles

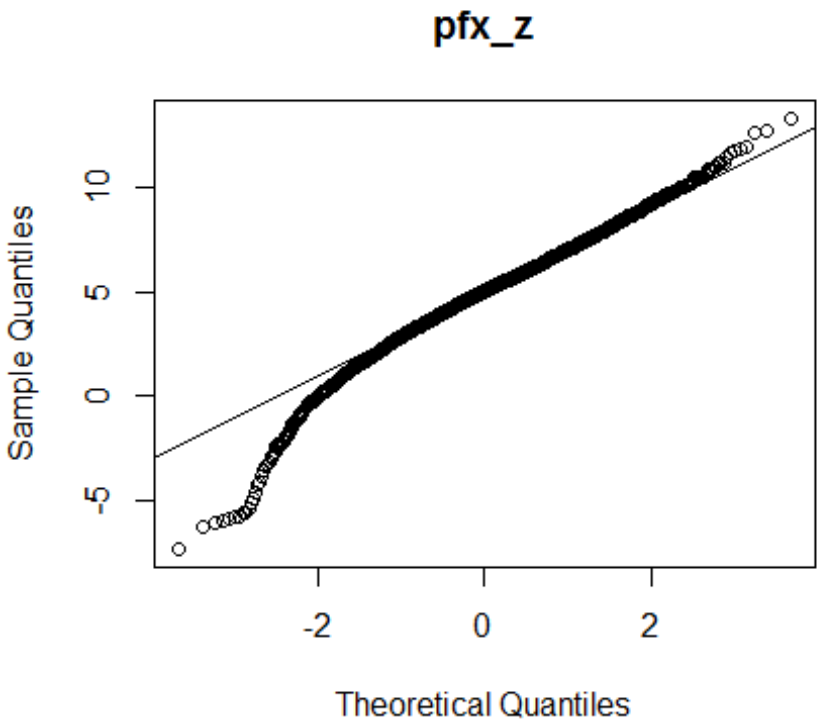

start_speed
Sample Quantiles
60
70
80
90
-2
0
2
Theoretical Quantiles

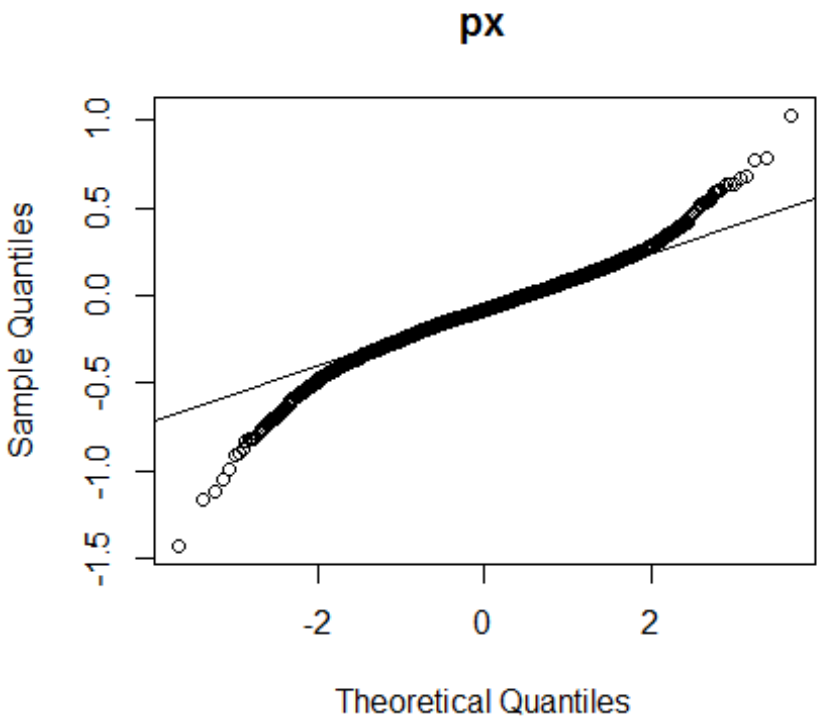

end_speed
Sample Quantiles
50
60
70
80
90
-2
0
2
Theoretical Quantiles

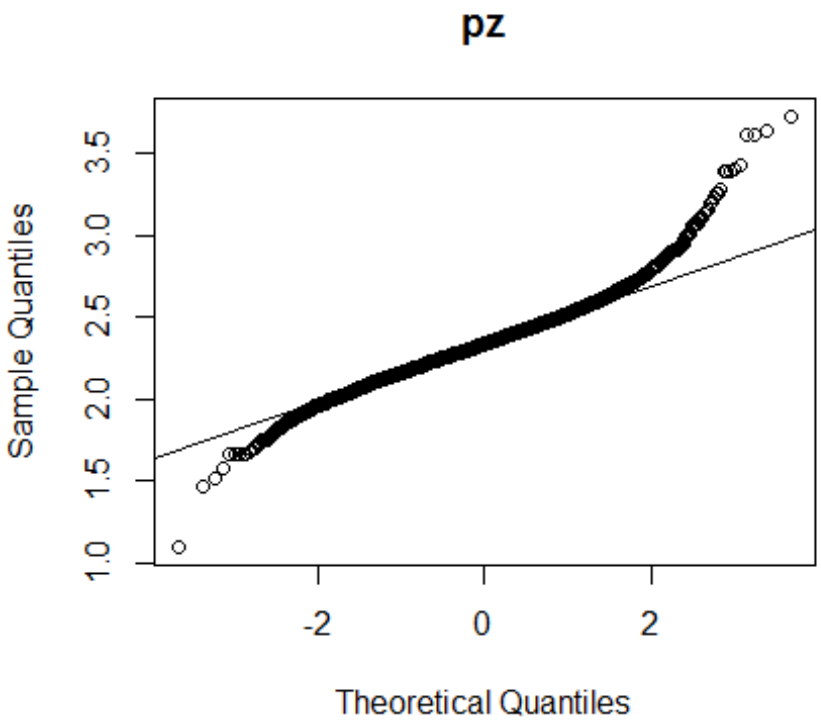

sz_top
Sample Quantiles
0
1
2
3
-2
0
2
Theoretical Quantiles

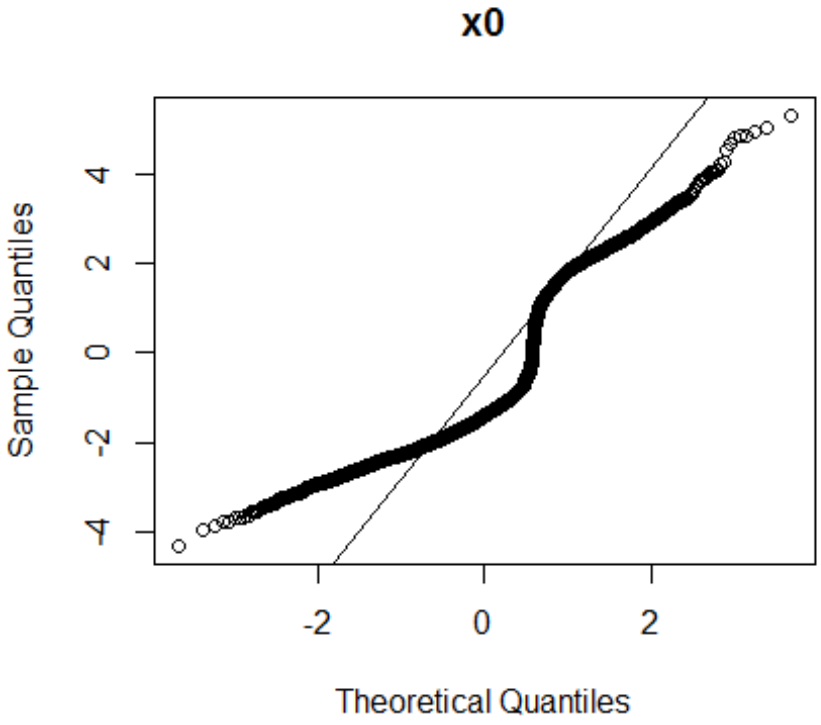

sz_bot
Sample Quantiles
0.0
0.5
1.0
1.5
-2
0
2
Theoretical Quantiles

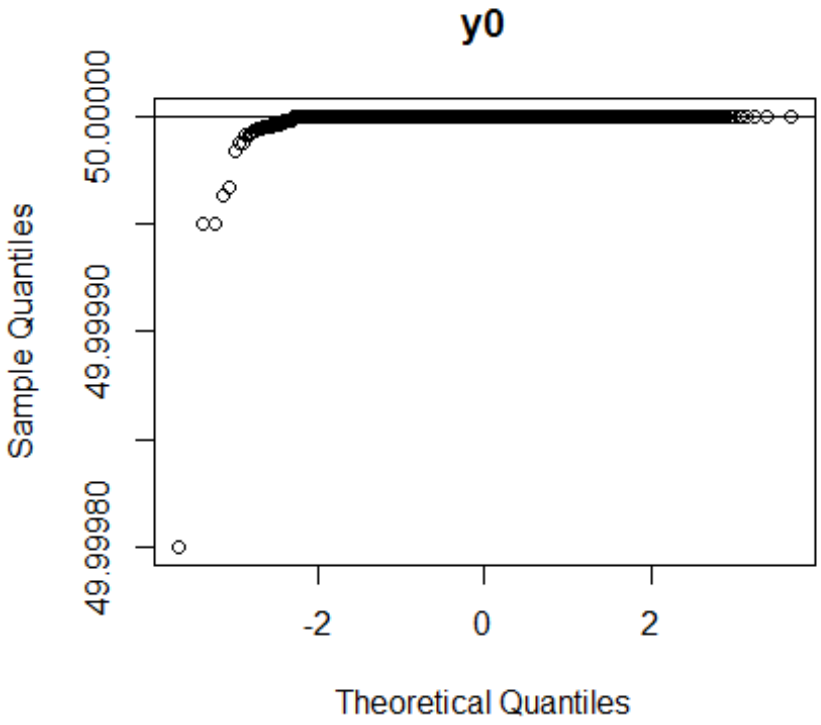

pfx_x
Sample Quantiles
10
5
0
-5
-10
-2
0
2
Theoretical Quantiles

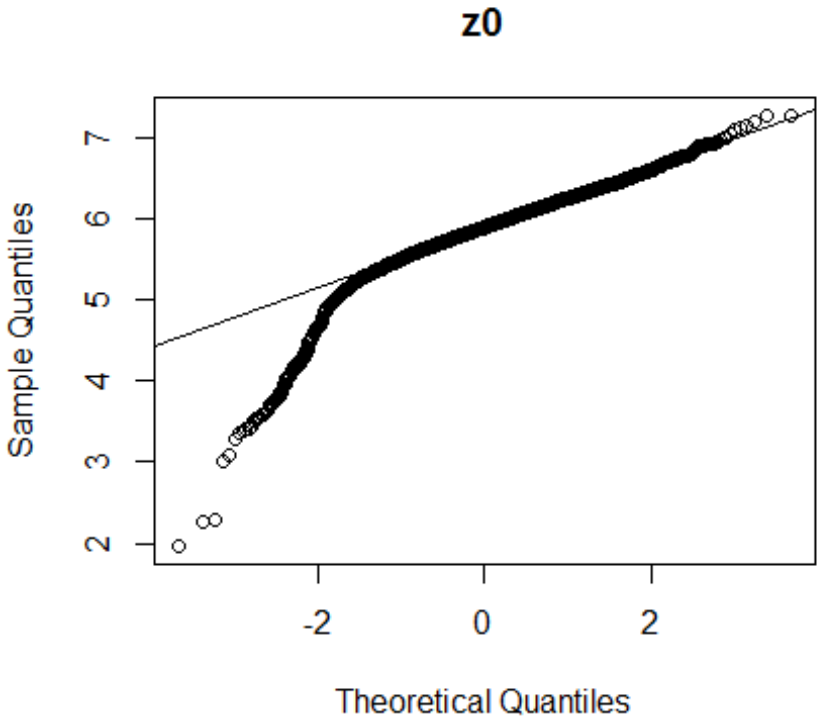

pfx_z
Sample Quantiles
10
5
0
-5
-2
0
2
Theoretical Quantiles

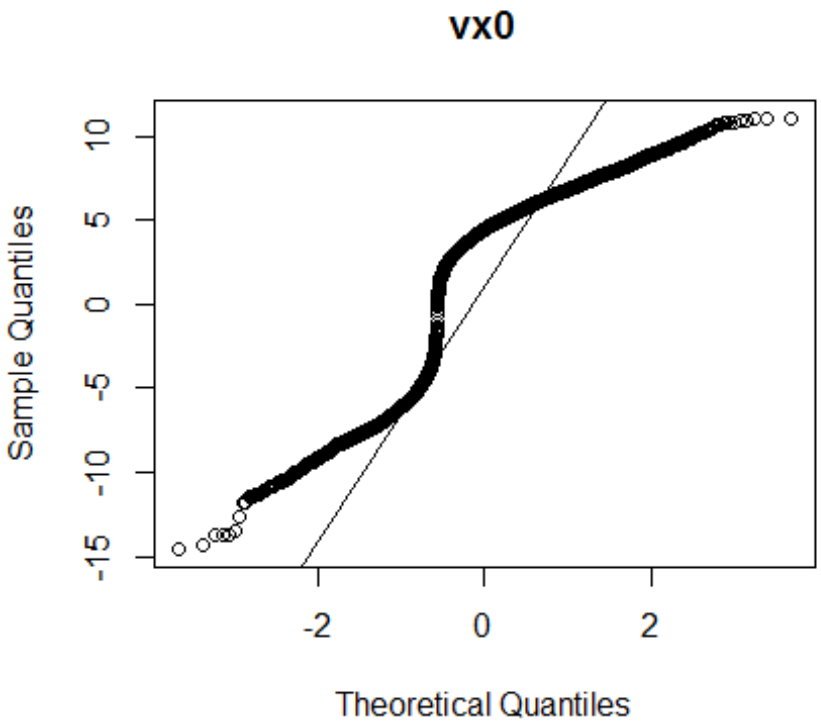

px
Sample Quantiles
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2
0
2
Theoretical Quantiles

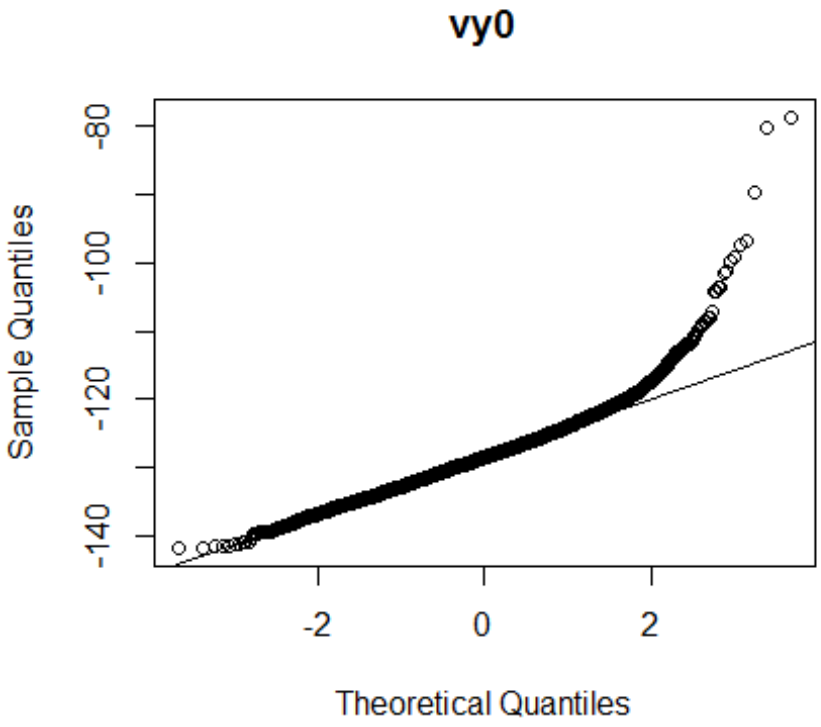

pz
Sample Quantiles
3.5
3.0
2.5
2.0
1.5
1.0
-2
0
2
Theoretical Quantiles

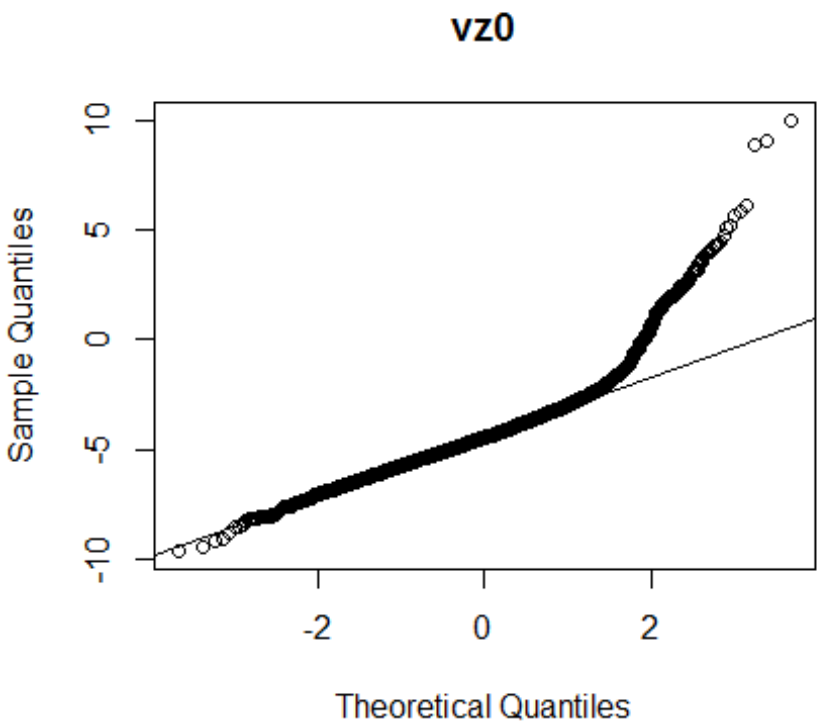

x0
Sample Quantiles
4
2
0
-2
-4
-2
0
2
Theoretical Quantiles

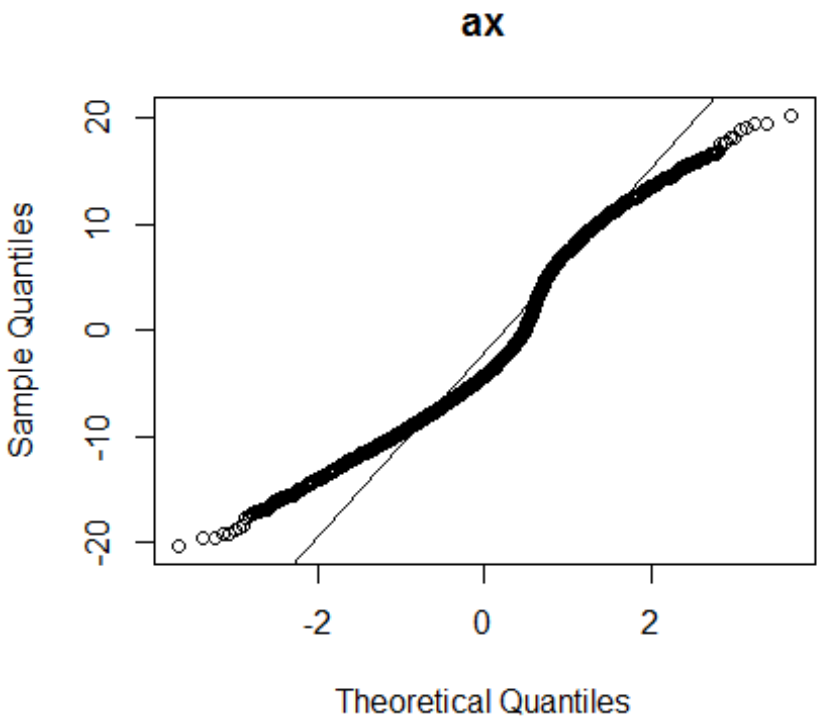

y0
Sample Quantiles
50.00000
49.99990
49.99980
-2
0
2
Theoretical Quantiles

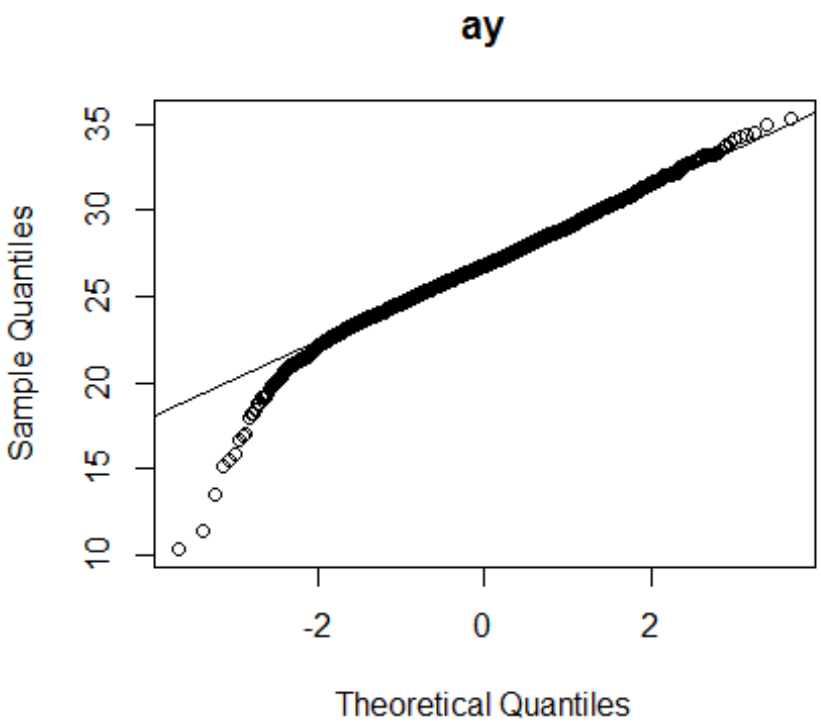

z0
Sample Quantiles
2
3
4
5
6
7
-2
0
2
Theoretical Quantiles

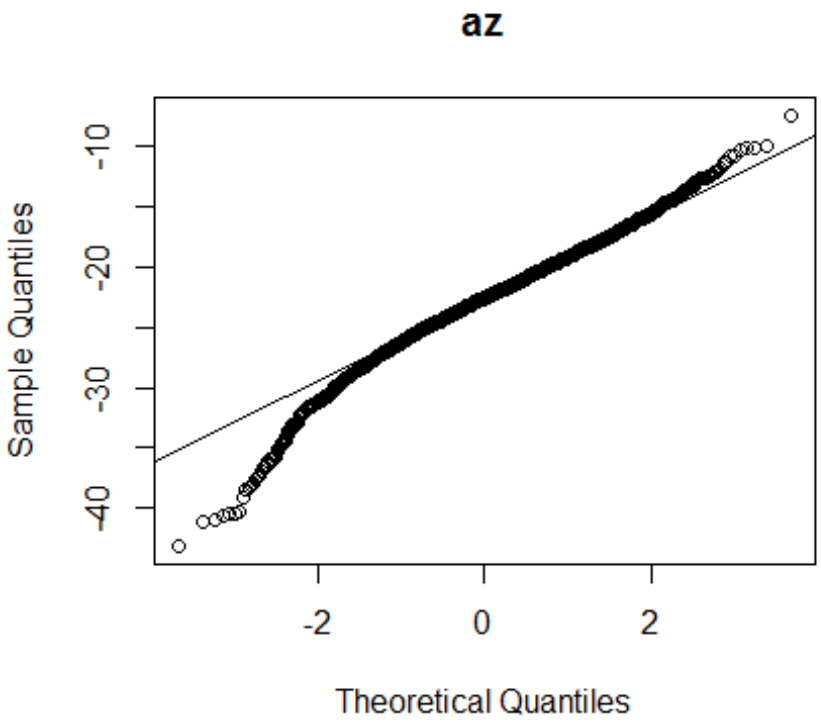

vx0
Sample Quantiles
-15
-10
-5
0
5
10
-2
0
2
Theoretical Quantiles

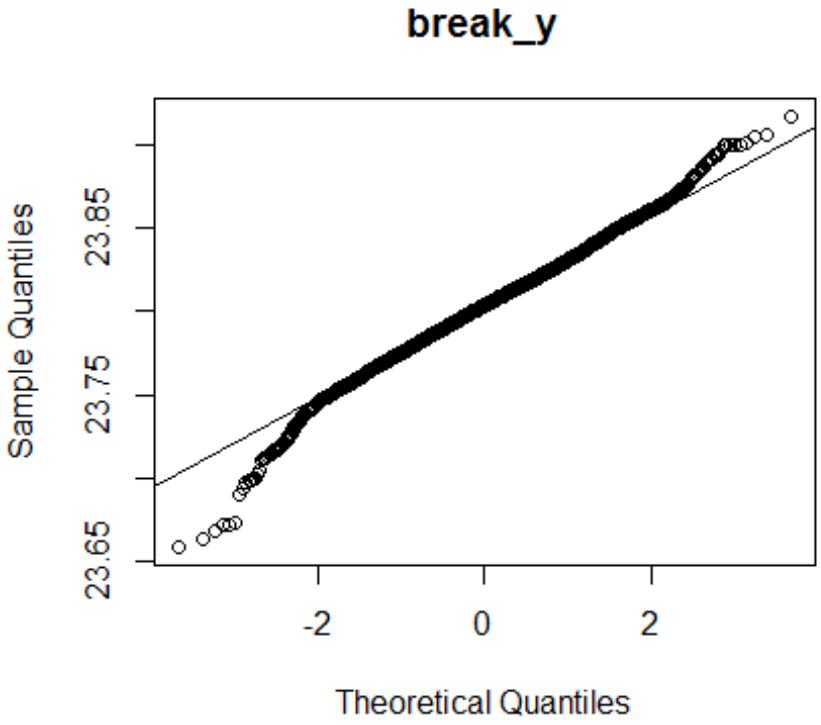

vy0
Sample Quantiles
-80
-100
-120
-140
-2
0
2
Theoretical Quantiles

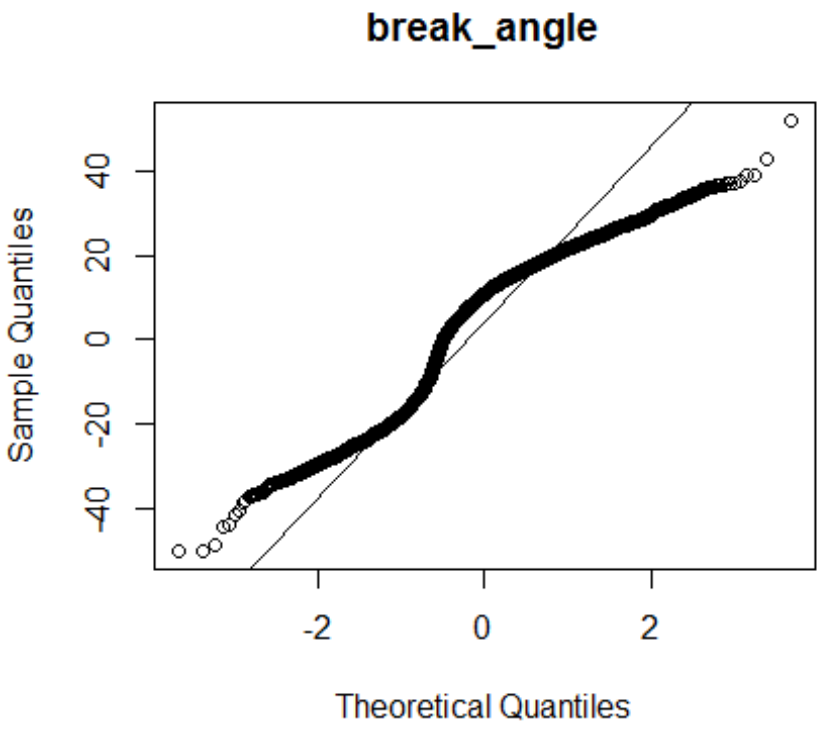

vz0
Sample Quantiles
10
5
0
-5
-10
-2
0
2
Theoretical Quantiles

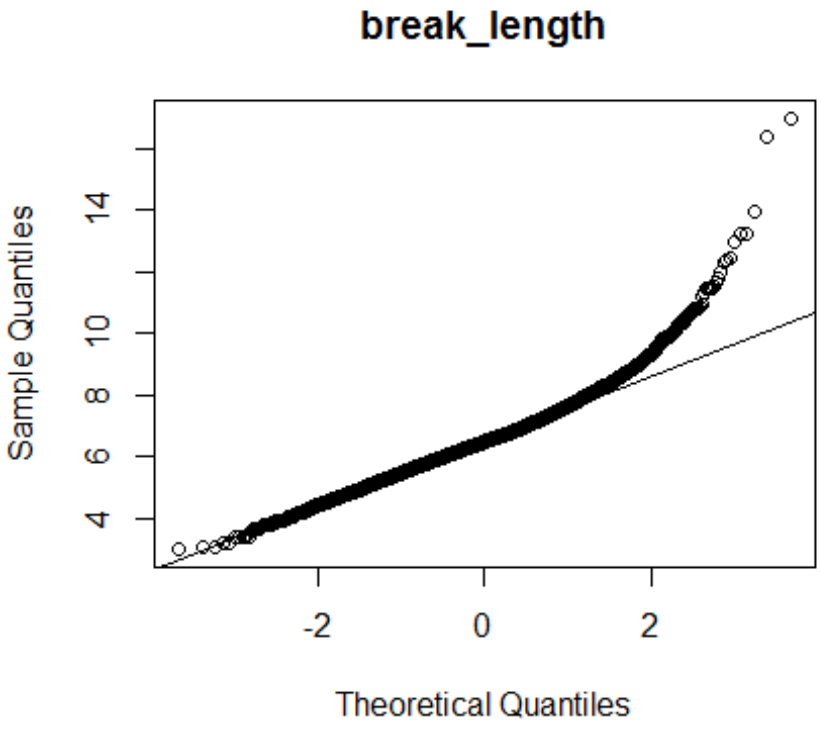

ax
Sample Quantiles
20
10
0
-10
-20
-2
0
2
Theoretical Quantiles

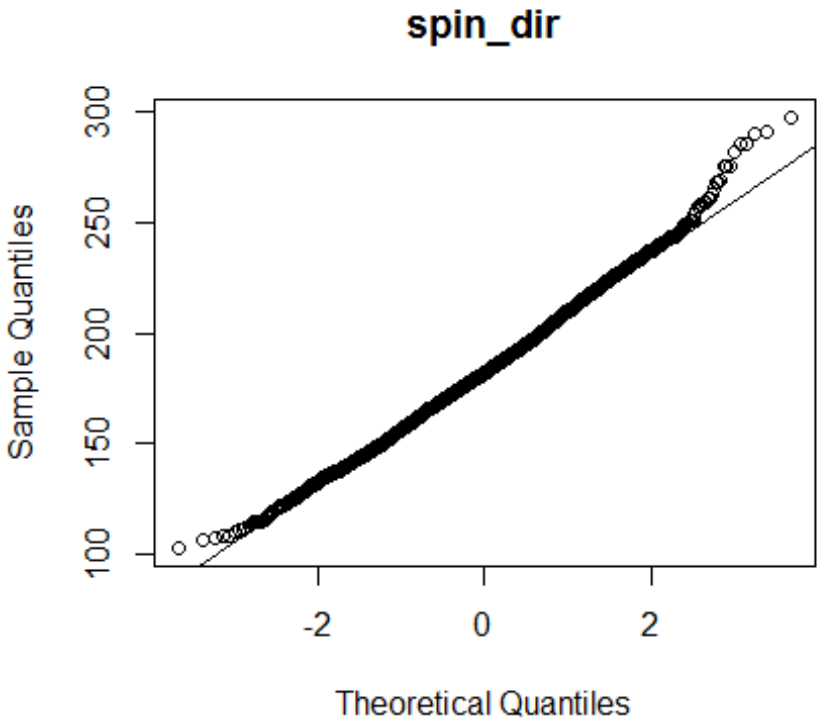

ay
Sample Quantiles
35
30
25
20
15
10
-2
0
2
Theoretical Quantiles

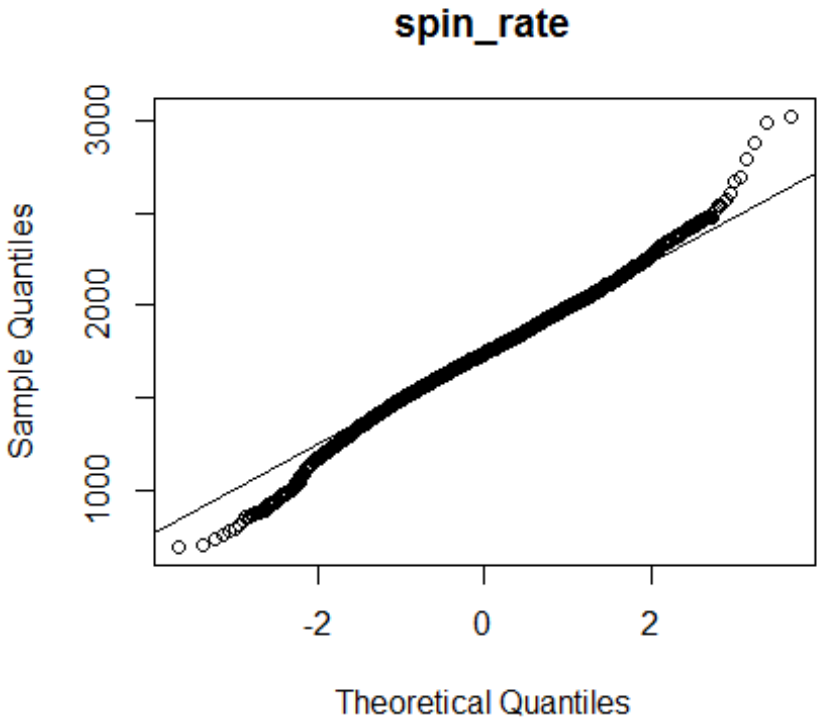

az
Sample Quantiles
-10
-20
-30
-40
-2
0
2
Theoretical Quantiles

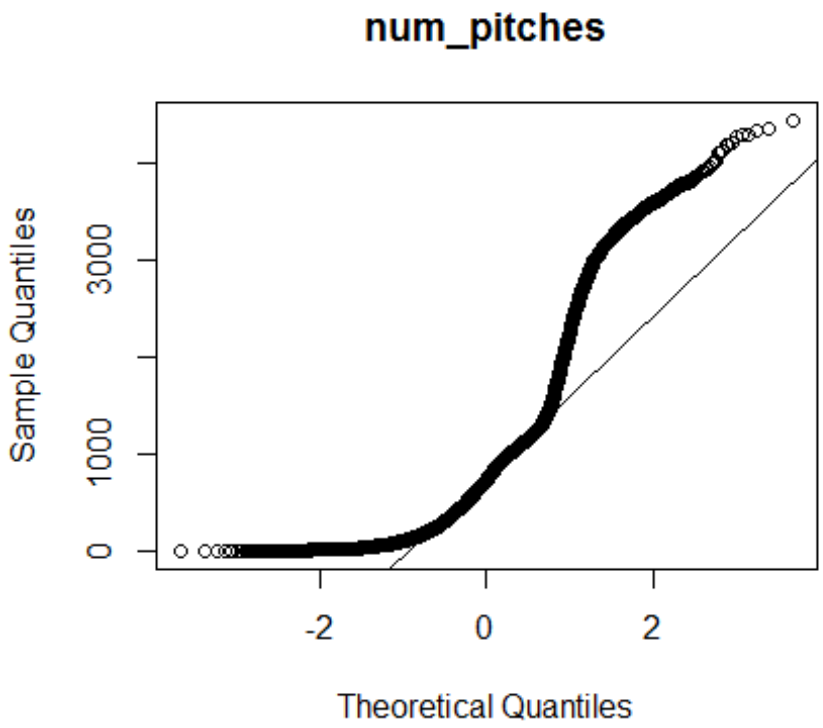

break_y
Sample Quantiles
23.85
23.75
23.65
-2
0
2
Theoretical Quantiles


break_angle
Sample Quantiles
-40
-20
0
20
40
-2
0
2
Theoretical Quantiles


break_length
Sample Quantiles
4
6
8
10
14
-2
0
2
Theoretical Quantiles


spin_dir
Sample Quantiles
100
150
200
250
300
-2
0
2
Theoretical Quantiles


spin_rate
Sample Quantiles
1000
2000
3000
-2
0
2
Theoretical Quantiles




```
#outliers <- mvOutlier(numeric_dataset, qqplot = TRUE, method = "quan");

train <- createDataPartition(pitches_dl_dataset$OnDL, p=0.65, list=FALSE);
training <- pitches_dl_dataset[train,];
testing <- pitches_dl_dataset[-train,];

selected_variables <-lowCorrelatedCols; #c('x', 'start_speed', 'y0',
'break_y', 'spin_dir', 'spin_rate');

selected_i <- which(colnames(pitches_dl_dataset) %in%selected_variables);

formula_text <- paste(names(pitches_dl_dataset)[ncol(pitches_dl_dataset)],
"~",
                      paste(names(pitches_dl_dataset)[selected_i],
collapse="+"));
formula <- as.formula(formula_text);

mod_fit <- train(formula,  data=training, method="glm", family="binomial");

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

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

## Warning: glm.fit: fitted probabilities numerically 0 or 1 occurred
summary(mod_fit);

##
## Call:
## NULL
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.5718  -0.7010  -0.5825  -0.4440   2.2786
##
## Coefficients:
##                Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.340e+07  7.453e+06  -1.799 0.072088 .
## y            1.930e-02  5.122e-03   3.768 0.000165 ***
## sz_bot       4.136e-01  8.607e-01   0.481 0.630862
## pfx_z       -3.440e-03  2.809e-02  -0.122 0.902536
## pz           2.055e-01  2.998e-01   0.685 0.493071
## x0          -7.304e-02  3.218e-02  -2.270 0.023223 *
## y0           2.681e+05  1.491e+05   1.799 0.072089 .
## z0           1.537e-01  1.288e-01   1.193 0.232805
## break_y      1.717e+00  2.026e+00   0.848 0.396674
## spin_dir    -3.658e-03  2.132e-03  -1.716 0.086127 .
## spin_rate    1.807e-04  2.303e-04   0.785 0.432663
```

```
## num_pitches  5.104e-04  4.262e-05  11.974  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3041.7  on 2813  degrees of freedom
## Residual deviance: 2834.5  on 2802  degrees of freedom
## AIC: 2858.5
##
## Number of Fisher Scoring iterations: 7
```

```
coef(mod_fit$finalModel);
```

```
##   (Intercept)             y        sz_bot         pfx_z            pz
## -1.340381e+07  1.929894e-02  4.135992e-01 -3.440232e-03  2.054610e-01
##            x0            y0            z0       break_y      spin_dir
## -7.304069e-02  2.680753e+05  1.536583e-01  1.717493e+00 -3.658373e-03
##     spin_rate   num_pitches
##  1.807063e-04  5.103559e-04
```

```
pred <- predict(mod_fit, newdata=testing);
confusionMatrix(data=pred, reference=testing$OnDL);
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   NO  YES
##        NO  1116  318
##        YES   48   31
##
##                Accuracy : 0.7581
##                  95% CI : (0.7357, 0.7795)
##     No Information Rate : 0.7693
##     P-Value [Acc > NIR] : 0.8571
##
##                   Kappa : 0.0653
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.95876
##             Specificity : 0.08883
##          Pos Pred Value : 0.77824
##          Neg Pred Value : 0.39241
##              Prevalence : 0.76933
##          Detection Rate : 0.73761
##    Detection Prevalence : 0.94779
##       Balanced Accuracy : 0.52379
##
##        'Positive' Class : NO
##
```

```
formula <- as.formula('OnDL ~ y + x0 + spin_dir + spin_rate + num_pitches');

mod_fit <- train(formula,  data=training, method="glm", family="binomial");
summary(mod_fit);

##
## Call:
## NULL
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.5158  -0.7015  -0.5817  -0.4656   2.2049
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -3.510e+00  8.363e-01  -4.197  2.7e-05 ***
## y            1.512e-02  4.540e-03   3.330 0.000868 ***
## x0          -7.694e-02  3.165e-02  -2.431 0.015043 *
## spin_dir    -4.368e-03  2.095e-03  -2.084 0.037117 *
## spin_rate    9.715e-05  1.839e-04   0.528 0.597304
## num_pitches  5.218e-04  4.183e-05  12.473  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3041.7  on 2813  degrees of freedom
## Residual deviance: 2844.2  on 2808  degrees of freedom
## AIC: 2856.2
##
## Number of Fisher Scoring iterations: 4

coef(mod_fit$finalModel);

##   (Intercept)             y            x0      spin_dir     spin_rate
## -3.510194e+00  1.512088e-02 -7.694398e-02 -4.367558e-03  9.715415e-05
##   num_pitches
##  5.217593e-04

pred <- predict(mod_fit, newdata=testing);
confusionMatrix(data=pred, reference=testing$OnDL);

## Confusion Matrix and Statistics
##
##           Reference
## Prediction   NO  YES
##        NO  1120  318
##        YES   44   31
##
##                Accuracy : 0.7607
##                  95% CI : (0.7384, 0.782)
```

```
##     No Information Rate : 0.7693
##     P-Value [Acc > NIR] : 0.7955
##
##                   Kappa : 0.0704
##  Mcnemar's Test P-Value : <2e-16
##
##             Sensitivity : 0.96220
##             Specificity : 0.08883
##          Pos Pred Value : 0.77886
##          Neg Pred Value : 0.41333
##              Prevalence : 0.76933
##          Detection Rate : 0.74025
##    Detection Prevalence : 0.95043
##       Balanced Accuracy : 0.52551
##
##        'Positive' Class : NO
##
```

```
prediction <- predict(mod_fit, newdata=pitches_dl_predict, type='prob');
prediction <- cbind(pitches_dl_predict, prediction);

prediction_df <- as.data.frame(prediction);
prediction_df <- prediction_df[order(prediction_df$YES, decreasing = TRUE),];
head(prediction_df[c('nameFirst', 'nameLast', 'num_pitches', 'YES')]);
```

```
##      nameFirst  nameLast num_pitches       YES
## 2299     Corey    Kluber        3950 0.6592647
## 4010       Max  Scherzer        3876 0.6538087
## 124       Jake   Arrieta        3599 0.6472258
## 4531    Justin Verlander        3788 0.6279692
## 3697    Tanner     Roark        3606 0.6230110
## 2245       Ian   Kennedy        3588 0.6104734
```

```
selected_variables <- lowCorrelatedCols; #c('x', 'start_speed', 'y0',
'break_y', 'spin_dir','num_pitches');

selected_i <- which(colnames(pitches_dl_dataset) %in% selected_variables);

formula_text <- paste(names(pitches_dl_dataset)[ncol(pitches_dl_dataset)],
"~",
                      paste(names(pitches_dl_dataset)[selected_i],
collapse="+"));
formula <- as.formula(formula_text);

mod_1 = glm(formula = formula , family=binomial(logit), data=training);

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

summary(mod_1);
```

```
##
## Call:
## glm(formula = formula, family = binomial(logit), data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -1.5718  -0.7010  -0.5825  -0.4440   2.2786
##
## Coefficients:
##               Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.340e+07  7.453e+06  -1.799 0.072088 .
## y            1.930e-02  5.122e-03   3.768 0.000165 ***
## sz_bot       4.136e-01  8.607e-01   0.481 0.630862
## pfx_z       -3.440e-03  2.809e-02  -0.122 0.902536
## pz           2.055e-01  2.998e-01   0.685 0.493071
## x0          -7.304e-02  3.218e-02  -2.270 0.023223 *
## y0           2.681e+05  1.491e+05   1.799 0.072089 .
## z0           1.537e-01  1.288e-01   1.193 0.232805
## break_y      1.717e+00  2.026e+00   0.848 0.396674
## spin_dir    -3.658e-03  2.132e-03  -1.716 0.086127 .
## spin_rate    1.807e-04  2.303e-04   0.785 0.432663
## num_pitches  5.104e-04  4.262e-05  11.974  < 2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3041.7  on 2813  degrees of freedom
## Residual deviance: 2834.5  on 2802  degrees of freedom
## AIC: 2858.5
##
## Number of Fisher Scoring iterations: 7
```

```
pred <- ifelse(predict(mod_1, testing, type='response') > 0.5, 'YES', 'NO')
confusionMatrix(data=pred, reference=testing$OnDL);
```

```
## Confusion Matrix and Statistics
##
##           Reference
## Prediction   NO  YES
##        NO  1116  318
##        YES   48   31
##
##                Accuracy : 0.7581
##                  95% CI : (0.7357, 0.7795)
##     No Information Rate : 0.7693
##     P-Value [Acc > NIR] : 0.8571
##
##                   Kappa : 0.0653
##  Mcnemar's Test P-Value : <2e-16
```

```
##
##             Sensitivity : 0.95876
##             Specificity : 0.08883
##          Pos Pred Value : 0.77824
##          Neg Pred Value : 0.39241
##              Prevalence : 0.76933
##          Detection Rate : 0.73761
##    Detection Prevalence : 0.94779
##       Balanced Accuracy : 0.52379
##
##        'Positive' Class : NO
##
```

```
formula_text <- paste(names(training)[ncol(training)], "~1");
formula <- as.formula(formula_text);


mod_nothing = glm(formula = formula , family=binomial(logit), data=training);

summary(mod_nothing);
```

```
##
## Call:
## glm(formula = formula, family = binomial(logit), data = training)
##
## Deviance Residuals:
##     Min       1Q   Median       3Q      Max
## -0.7248  -0.7248  -0.7248  -0.7248   1.7120
##
## Coefficients:
##             Estimate Std. Error z value Pr(>|z|)
## (Intercept) -1.20274    0.04473  -26.89   <2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## (Dispersion parameter for binomial family taken to be 1)
##
##     Null deviance: 3041.7  on 2813  degrees of freedom
## Residual deviance: 3041.7  on 2813  degrees of freedom
## AIC: 3043.7
##
## Number of Fisher Scoring iterations: 4
```

```
#backward <- step(glm.out);

#summary(backwards);

#forward <- step(glm.out, direction = "forward");

#summary(forward);
```