

# Baseball2.R

ROG

2021-07-20

```
library(tidyverse)
```

```
## -- Attaching packages ----- tidyverse 1.3.0 --
```

```
## v ggplot2 3.3.3      v purrr  0.3.4
## v tibble  3.0.6      v dplyr  1.0.4
## v tidyr   1.1.2      v stringr 1.4.0
## v readr   1.4.0      v forcats 0.5.1
```

```
## -- Conflicts ----- tidyverse_conflicts() --
```

```
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
```

```
library(Hmisc)
```

```
## Warning: package 'Hmisc' was built under R version 4.0.5
```

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

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

```
## Loading required package: Formula
```

```
##
```

```
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:dplyr':
```

```
##
```

```
##      src, summarize
```

```
## The following objects are masked from 'package:base':
```

```
##
```

```
##      format.pval, units
```

```
library(ggpubr)
```

```
## Warning: package 'ggpubr' was built under R version 4.0.5
```

```
library(Metrics)
```

```
## Warning: package 'Metrics' was built under R version 4.0.5
```

```
# Objectives
```

```
# This project aims to determine factors associated with game performance and  
# in particular whether tight defense is associated with increased game won, and  
# whether the conclusion that tight defenses increase game won is valid across  
# multiple time periods.
```

```
data <- read.csv('C:/Users/ROG/Desktop/baseball_teams.csv')  
head(data)
```

```
##   Year League Team Franchise Division Final_Standing Games_Played  X Games_Won  
## 1 1871  <NA>  BS1      BNA              3             31 NA         20  
## 2 1871  <NA>  CH1      CNA              2             28 NA         19  
## 3 1871  <NA>  CL1      CFC              8             29 NA         10  
## 4 1871  <NA>  FW1      KEK              7             19 NA          7  
## 5 1871  <NA>  NY2      NNA              5             33 NA         16  
## 6 1871  <NA>  PH1      PNA              1             28 NA         21  
##   Games_Lost X.1 X.2 League_Win World_Series Runs_Scored At_Bats Hits Doubles  
## 1         10 NA  NA      FALSE          NA        401   1372  426    70  
## 2          9 NA  NA      FALSE          NA        302   1196  323    52  
## 3         19 NA  NA      FALSE          NA        249   1186  328    35  
## 4         12 NA  NA      FALSE          NA        137    746  178    19  
## 5         17 NA  NA      FALSE          NA        302   1404  403    43  
## 6          7 NA  NA       TRUE          NA        376   1281  410    66  
##   Triples Home_Runs Walks Strike-Outs Stolen_Bases Caught_Stealing Hit_By_Pitch  
## 1        37         3   60          19          73           NA           NA  
## 2        21        10   60          22          69           NA           NA  
## 3        40         7   26          25          18           NA           NA  
## 4         8         2   33           9          16           NA           NA  
## 5        21         1   33          15          46           NA           NA  
## 6        27         9   46          23          56           NA           NA  
##   Sacrifice_Fly Runs_Against Earned_Runs Earned_Run_Average Complete_Games  
## 1             NA         303         109          3.55           22  
## 2             NA         241          77          2.76           25  
## 3             NA         341         116          4.11           23  
## 4             NA         243          97          5.17           19  
## 5             NA         313         121          3.72           32  
## 6             NA         266         137          4.95           27  
##   Shutout Saves Infield_Put_Outs Hits_Allowed Home_Run_Allowed Walks_Allowed  
## 1         1     3             828          367           2           42  
## 2         0     1             753          308           6           28  
## 3         0     0             762          346          13           53  
## 4         1     0             507          261           5           21  
## 5         1     0             879          373           7           42  
## 6         0     0             747          329           3           53  
##   Strikeouts_Allowed Errors Double_Plays Fielding_Percentage  
## 1                 23   225          NA          0.83  
## 2                 22   218          NA          0.82  
## 3                 34   223          NA          0.81  
## 4                 17   163          NA          0.80
```

```
## 5          22    227          NA          0.83
## 6          16    194          NA          0.84
##           Team_Name          Home_Ball_Park Attendance
## 1    Boston Red Stockings          South End Grounds I          NA
## 2  Chicago White Stockings          Union Base-Ball Grounds          NA
## 3  Cleveland Forest Citys National Association Grounds          NA
## 4    Fort Wayne Kekiongas          Hamilton Field          NA
## 5      New York Mutuals          Union Grounds (Brooklyn)          NA
## 6  Philadelphia Athletics          Jefferson Street Grounds          NA
```

```
df <- data[, c(1, 9, 10, 15:40)]
```

```
# Check missing point
apply(df, 2, function(x) sum(is.na(x)))
```

```
##           Year          Games_Won          Games_Lost          Runs_Scored
##           0              0              0              0
##           At_Bats          Hits              Doubles          Triples
##           0              0              0              0
##           Home_Runs          Walks          Strike-Outs          Stolen_Bases
##           0              0              120          144
##           Caught_Stealing          Hit_By_Pitch          Sacrifice_Fly          Runs_Against
##           859          2325          2325              0
##           Earned_Runs          Earned_Run_Average          Complete_Games          Shutout
##           0              0              0              0
##           Saves          Infield_Put-Outs          Hits_Allowed          Home_Run_Allowed
##           0              0              0              0
##           Walks_Allowed          Strikeouts_Allowed          Errors          Double_Plays
##           0              0              0          317
## Fielding_Percentage
##           0
```

```
# Period 1 - before 1920
df_before_1920 <- filter(df, Year < 1920)

# Period 2 - 1920 to 1960
df_1920_1960 <- filter(df, between(Year, 1920, 1960))

# Period 3 - 1960 to 1990
df_1960_1990 <- filter(df, between(Year, 1960, 1990))

# Period 4 - 1990 to 2010
df_1990_2010 <- filter(df, between(Year, 1990, 2010))

# Perform an exploratory data analysis to understand the statistical
# properties and distribution shapes of 8 key variables.
# Perform this analysis for a single dataset that spans 1960 to 2010

# Calculate the descriptive statistics for the 8 variables
df_1960_2010 <- filter(df, between(Year, 1960, 2010))
key_variables <- df_1960_2010[, c('Runs_Scored', 'At_Bats', 'Hits', 'Walks',
```

```

'Runs_Against', 'Earned_Run_Average',
'Fielding_Percentage',
'Saves'])

summary(key_variables)

```

```

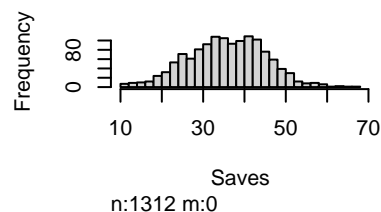
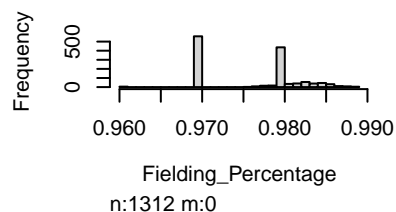
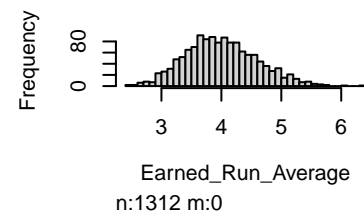
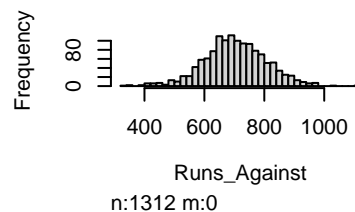
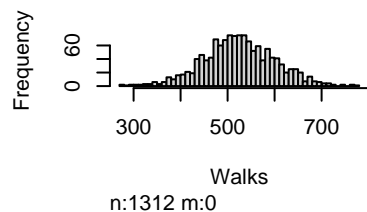
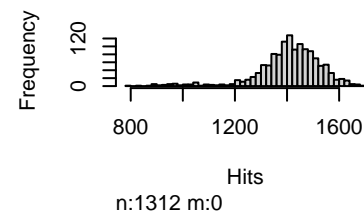
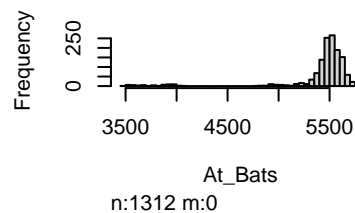
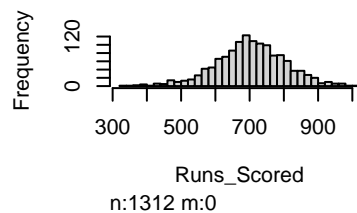
##   Runs_Scored      At_Bats      Hits      Walks
##   Min.    : 329.0   Min.    :3493   Min.    : 797   Min.    :275.0
##   1st Qu.: 641.0   1st Qu.:5441   1st Qu.:1357   1st Qu.:474.8
##   Median : 704.0   Median :5506   Median :1418   Median :523.0
##   Mean    : 703.4   Mean    :5428   Mean    :1409   Mean    :524.7
##   3rd Qu.: 771.0   3rd Qu.:5575   3rd Qu.:1489   3rd Qu.:575.2
##   Max.    :1009.0   Max.    :5781   Max.    :1684   Max.    :775.0
##   Runs_Against  Earned_Run_Average Fielding_Percentage  Saves
##   Min.    : 331.0   Min.    :2.450   Min.    :0.9600   Min.    :10.00
##   1st Qu.: 640.0   1st Qu.:3.580   1st Qu.:0.9700   1st Qu.:30.00
##   Median : 701.0   Median :3.970   Median :0.9800   Median :36.00
##   Mean    : 703.4   Mean    :4.007   Mean    :0.9764   Mean    :36.16
##   3rd Qu.: 770.2   3rd Qu.:4.390   3rd Qu.:0.9800   3rd Qu.:43.00
##   Max.    :1103.0   Max.    :6.380   Max.    :0.9890   Max.    :68.00

```

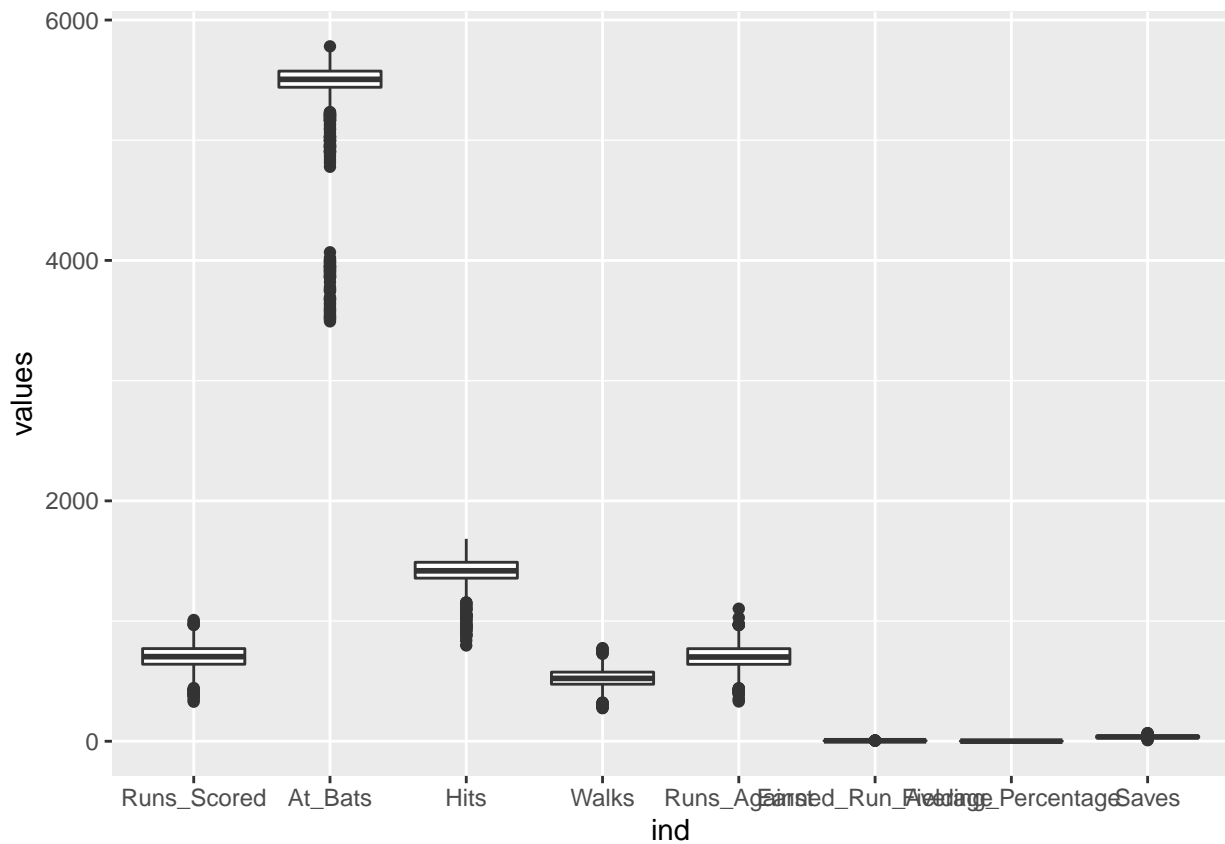
```

# histogram for each of the 8 variables
hist.data.frame(key_variables)

```



```
# boxplot for each of the 8 variables
ggplot(stack(key_variables), aes(x = ind, y = values)) +
  geom_boxplot()
```



```
# validity of the assumption that each of the 8 variables is normally distributed
test <- matrix(0, nrow = ncol(key_variables), ncol = 2)
for (i in 1:ncol(key_variables)) {
  test[i, 1] <- names(key_variables)[i]
  test[i, 2] <- shapiro.test(key_variables[,i])[[2]]
}
tibble('variables' = test[,1], 'p_value' = test[,2])
```

```
## # A tibble: 8 x 2
##   variables      p_value
##   <chr>         <chr>
## 1 Runs_Scored  0.000244025534546546
## 2 At_Bats     1.76036455340308e-51
## 3 Hits       7.03424660341483e-28
## 4 Walks      0.139395243265944
## 5 Runs_Against 0.00637230131975897
## 6 Earned_Run_Average 2.95774045541599e-05
## 7 Fielding_Percentage 8.02485485174246e-37
## 8 Saves      0.0053189326971369
```

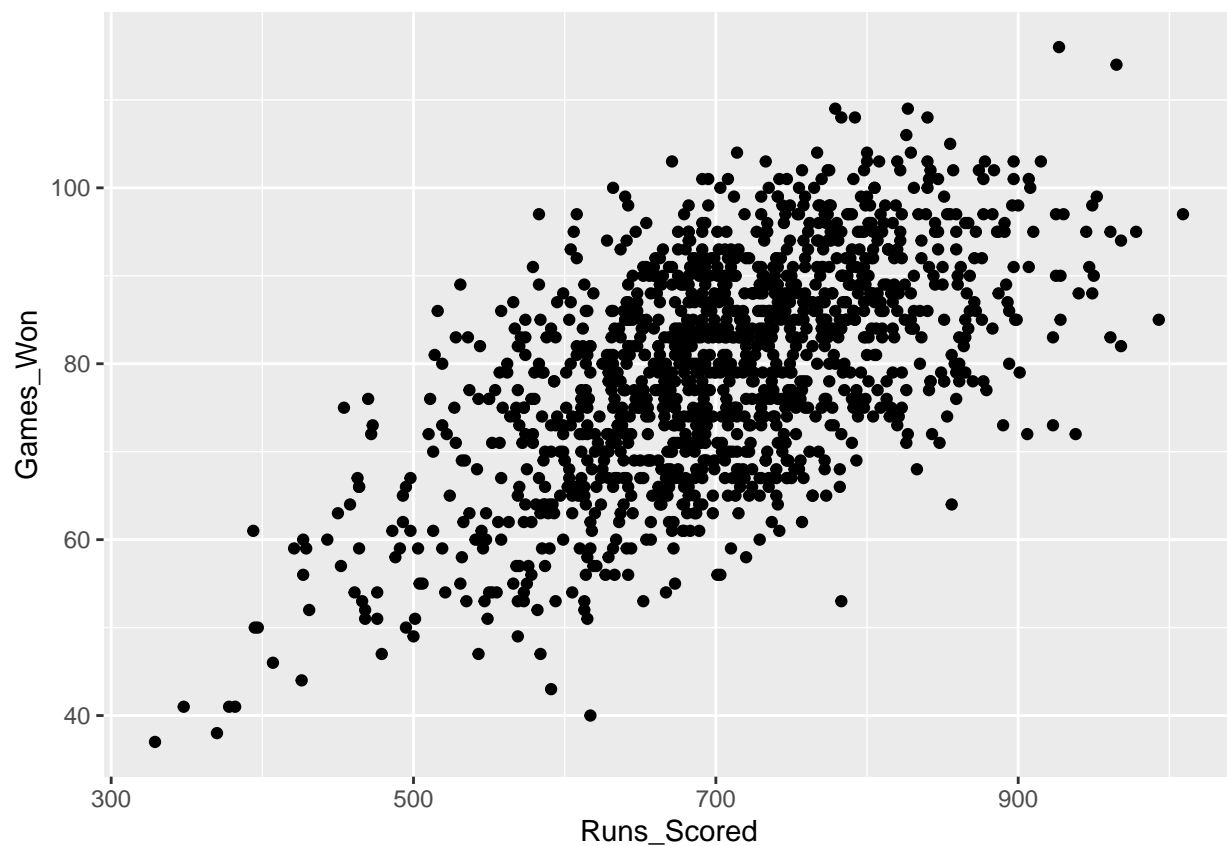
```
# if the p-value > 0.05 implying that the distribution of the data are not
# significantly different from normal distribution

# Correlation analysis for the following pairs of fields for the complete data
# spanning 1960 to 2010

# Games Won vs Runs Scored
cor(df_1960_2010$Games_Won, df_1960_2010$Runs_Scored)
```

```
## [1] 0.5958278
```

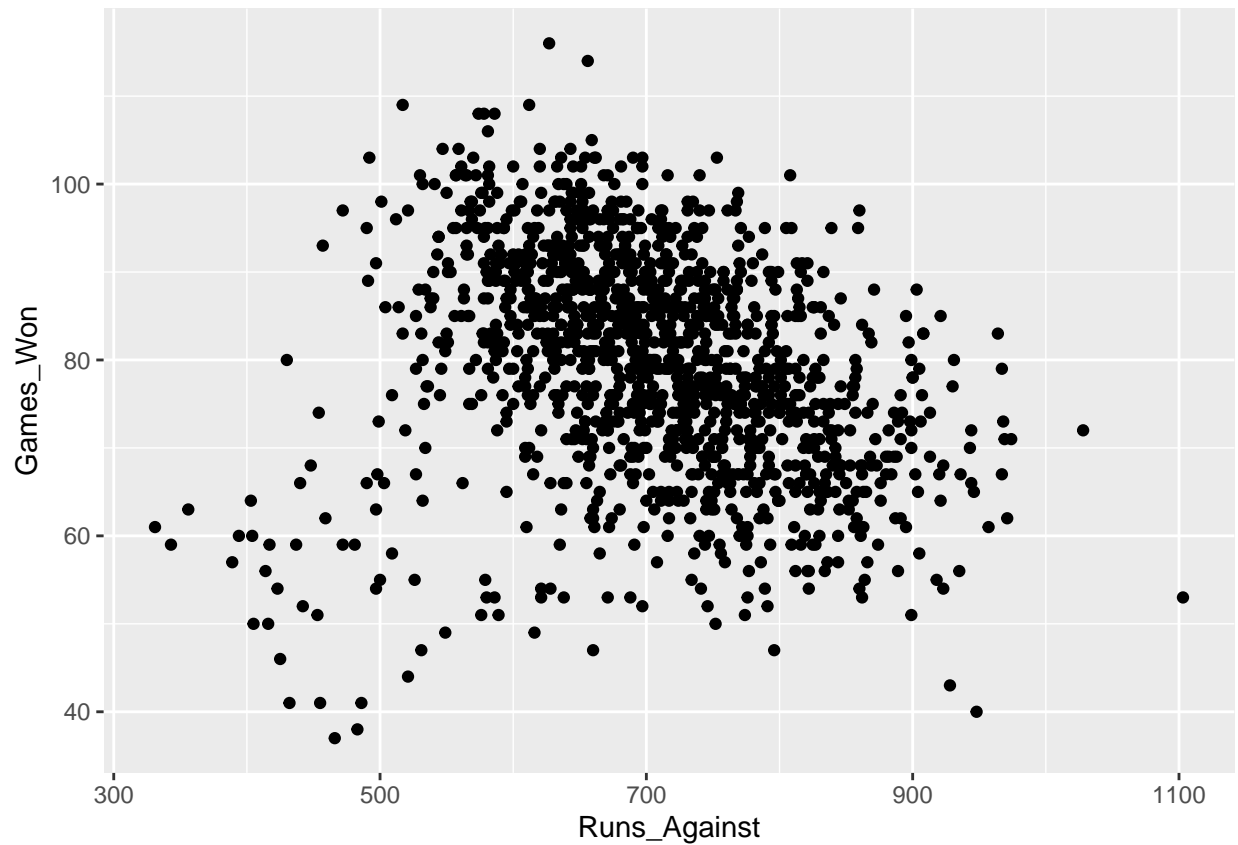
```
ggplot(df_1960_2010, aes(x = Runs_Scored, y = Games_Won)) +
  geom_point()
```



```
# Games Won vs Runs Against
cor(df_1960_2010$Games_Won, df_1960_2010$Runs_Against)
```

```
## [1] -0.2481575
```

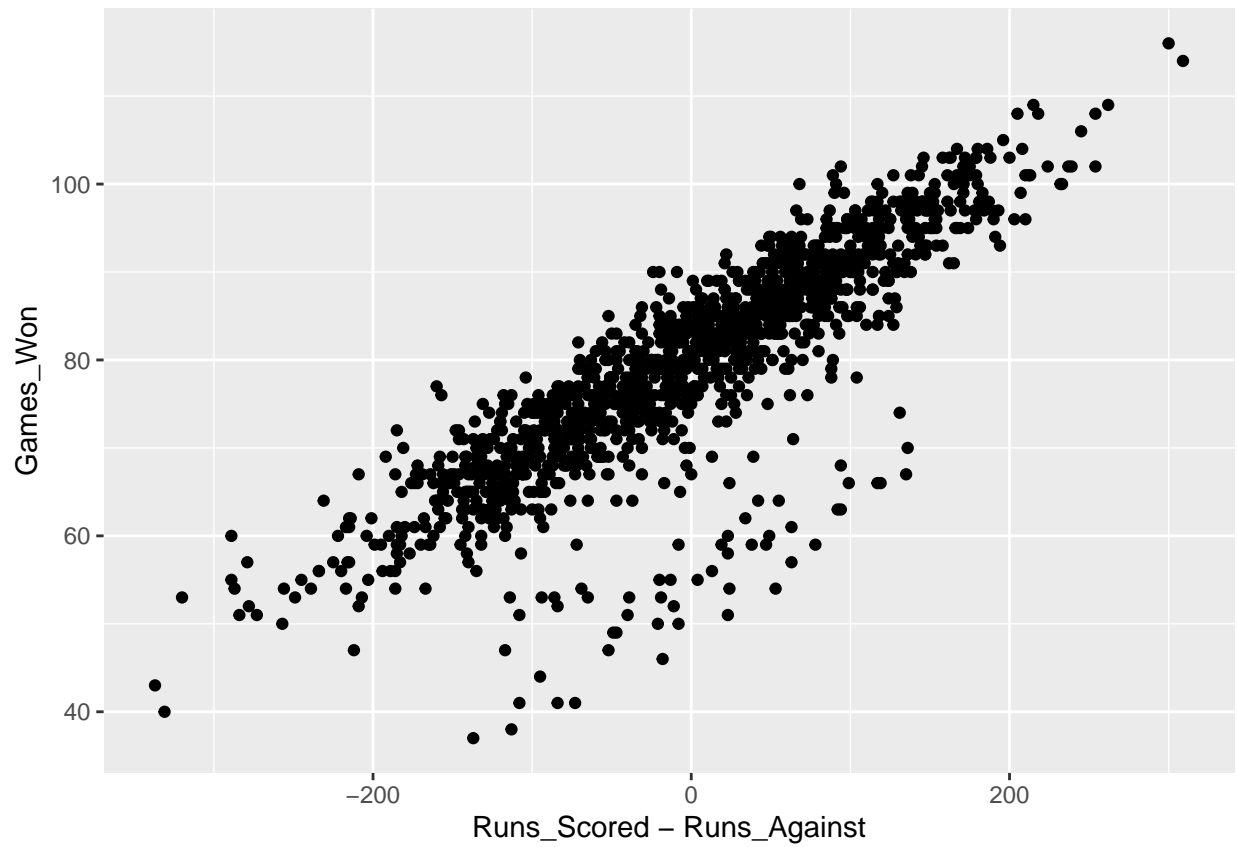
```
ggplot(df_1960_2010, aes(x = Runs_Against, y = Games_Won)) +
  geom_point()
```



```
# Games Won vs (Runs Scored minus Runs Against)  
cor(df_1960_2010$Games_Won, df_1960_2010$Runs_Scored - df_1960_2010$Runs_Against)
```

```
## [1] 0.8504114
```

```
ggplot(df_1960_2010, aes(x = Runs_Scored - Runs_Against, y = Games_Won)) +  
  geom_point()
```



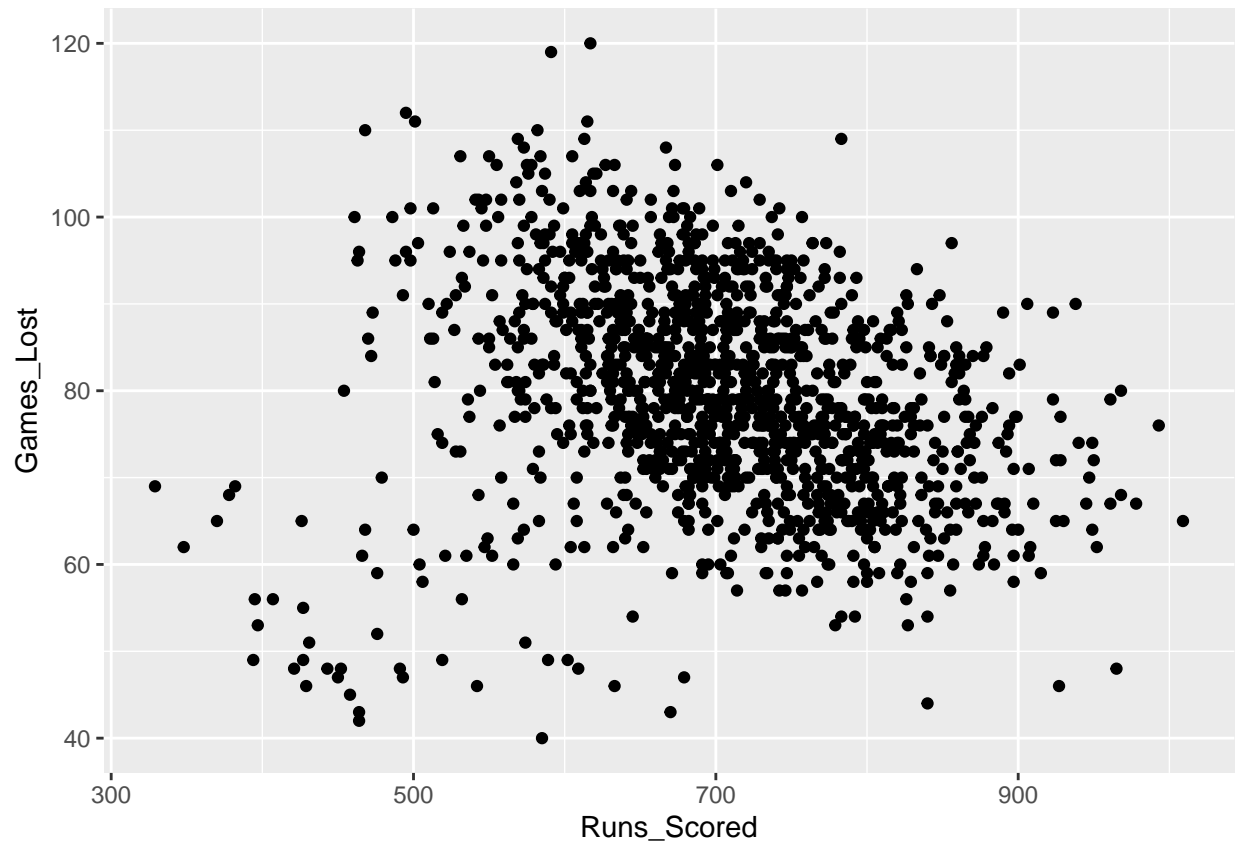
```
# Games Lost vs Runs Scored
```

```
cor(df_1960_2010$Games_Lost, df_1960_2010$Runs_Scored)
```

```
## [1] -0.2267723
```

```
ggplot(df_1960_2010, aes(x = Runs_Scored, y = Games_Lost)) +  
  geom_point()
```



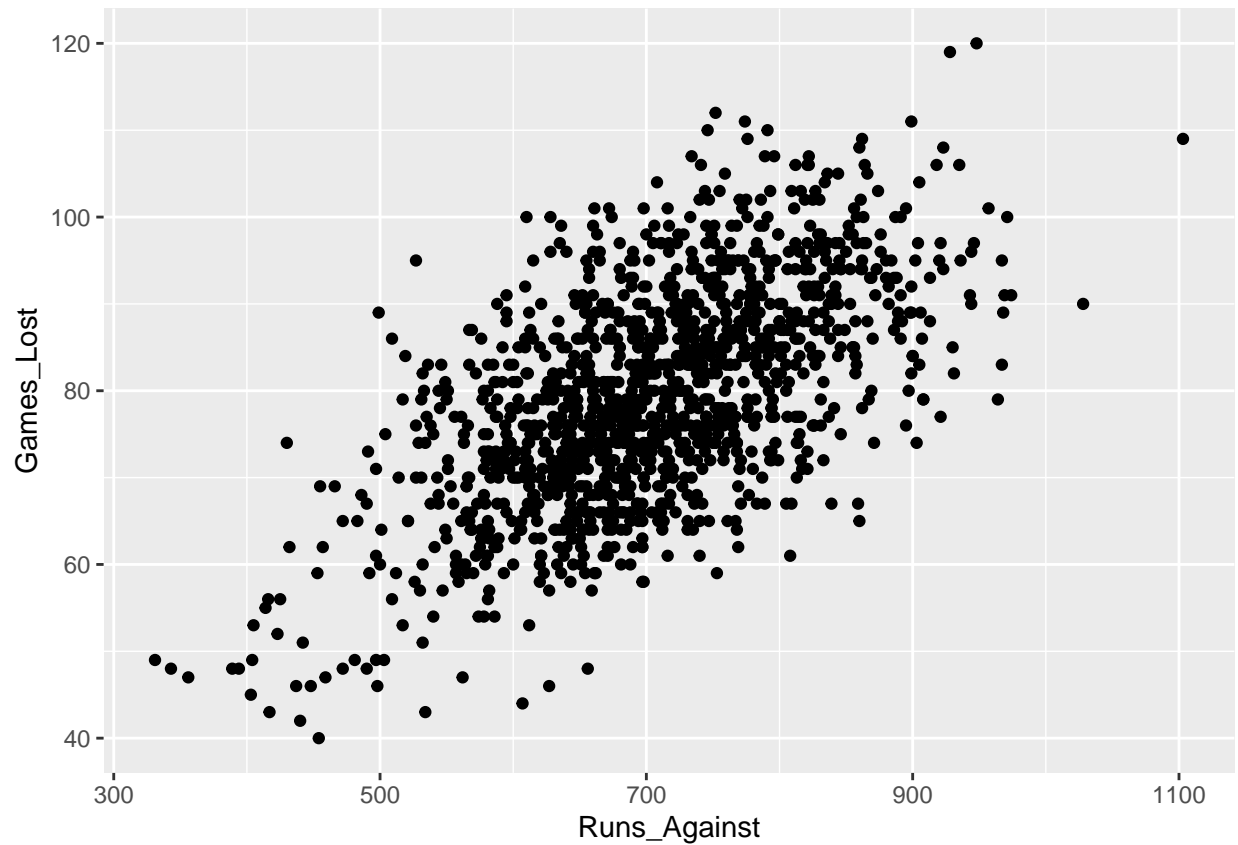


```
# Games Lost vs Runs Against
```

```
cor(df_1960_2010$Games_Lost, df_1960_2010$Runs_Against)
```

```
## [1] 0.6111768
```

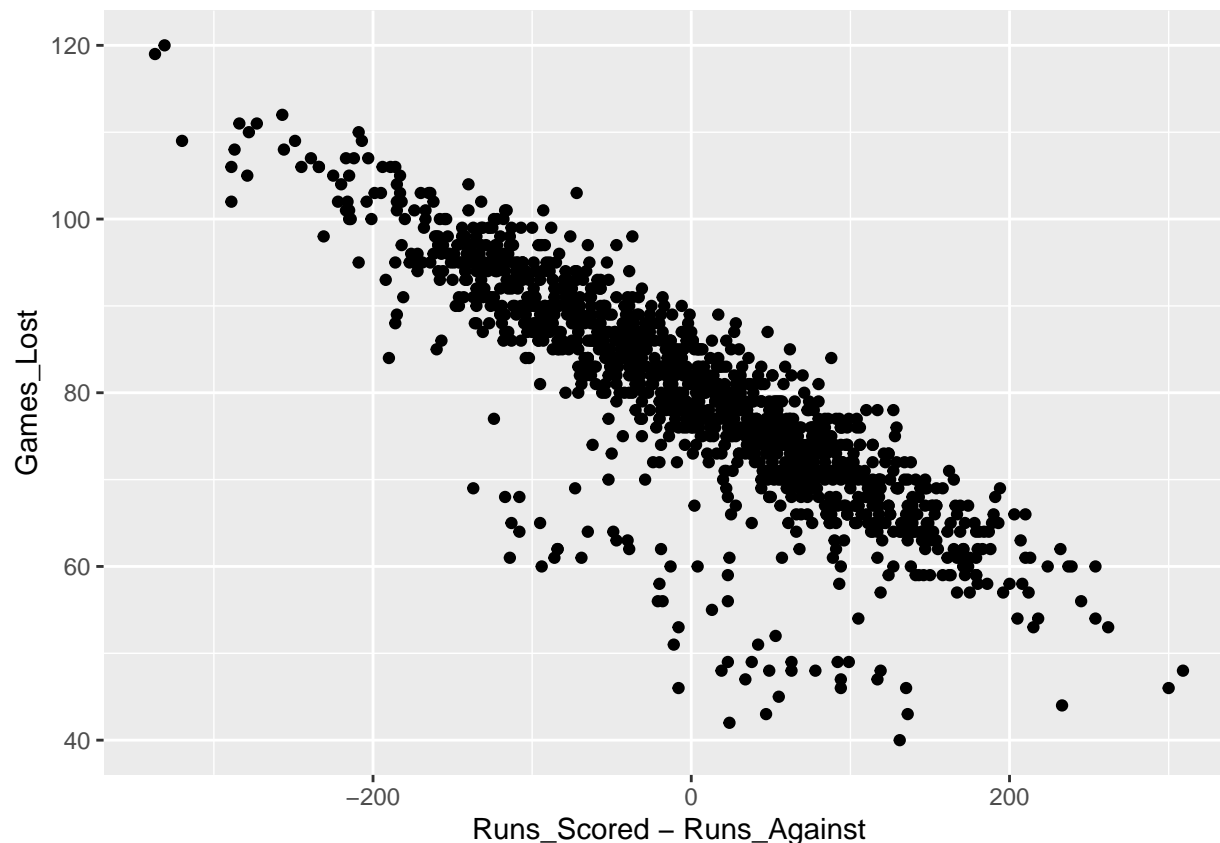
```
ggplot(df_1960_2010, aes(x = Runs_Against, y = Games_Lost)) +  
  geom_point()
```



```
# Games Lost vs (Runs Scored minus Runs Against)  
cor(df_1960_2010$Games_Lost, df_1960_2010$Runs_Scored - df_1960_2010$Runs_Against)
```

```
## [1] -0.8493582
```

```
ggplot(df_1960_2010, aes(x = Runs_Scored - Runs_Against, y = Games_Lost)) +  
  geom_point()
```



*# Create a multiple linear regression model for each of the 4 time periods noted  
# above and select the independent variables that are good predictors of games won*

*# Period 1 - before 1920*

```
df_p1 <- drop_na(df_before_1920[, colSums(is.na(df_before_1920)) <
                                     nrow(df_before_1920)])[-c(1, 3)]
```

*## Forward stepwise regression*

```
null_modelp1 <- lm(Games_Won ~ 1, data = df_p1)
```

```
full_modelp1 <- lm(Games_Won ~ ., data = df_p1)
```

```
step(null_modelp1, direction = "forward", scope = formula(full_modelp1))
```

## Start: AIC=130.71

## Games\_Won ~ 1

##

| ## |                       | Df | Sum of Sq | RSS    | AIC    |
|----|-----------------------|----|-----------|--------|--------|
| ## | + Runs_Against        | 1  | 3269.6    | 1850.4 | 108.28 |
| ## | + Earned_Run_Average  | 1  | 2885.9    | 2234.0 | 112.80 |
| ## | + Earned_Runs         | 1  | 2791.3    | 2328.6 | 113.80 |
| ## | + Runs_Scored         | 1  | 2737.3    | 2382.7 | 114.35 |
| ## | + Fielding_Percentage | 1  | 2306.0    | 2814.0 | 118.34 |
| ## | + Saves               | 1  | 2274.6    | 2845.4 | 118.61 |
| ## | + Hits_Allowed        | 1  | 2232.7    | 2887.2 | 118.96 |
| ## | + Shutout             | 1  | 2081.8    | 3038.1 | 120.18 |
| ## | + Errors              | 1  | 1952.5    | 3167.4 | 121.18 |

```

## + Strike_Outs      1      1687.8 3432.2 123.11
## + Walks_Allowed    1      1686.1 3433.8 123.12
## + Hits             1      1266.4 3853.5 125.89
## + Infield_Put_Outs 1      1184.8 3935.2 126.39
## + Complete_Games   1      1156.1 3963.9 126.57
## + Walks            1       938.1 4181.9 127.85
## <none>              5120.0 130.71
## + Doubles          1       362.7 4757.3 130.94
## + Double_Plays     1       334.9 4785.1 131.09
## + Triples          1       292.0 4827.9 131.30
## + At_Bats          1       259.8 4860.1 131.46
## + Stolen_Bases     1       246.4 4873.5 131.52
## + Home_Runs        1       239.0 4880.9 131.56
## + Home_Run_Allowed 1       209.0 4910.9 131.71
## + Caught_Stealing  1       203.3 4916.6 131.74
## + Strikeouts_Allowed 1      164.6 4955.4 131.92
##
## Step:  AIC=108.28
## Games_Won ~ Runs_Against
##
##              Df Sum of Sq    RSS    AIC
## + Runs_Scored  1   1383.36  467.03  77.240
## + Hits         1    866.66  983.73  95.119
## + Strike_Outs  1    510.42 1339.97 102.536
## + Saves        1    509.29 1341.10 102.557
## + Walks        1    449.11 1401.28 103.610
## + Triples      1    232.77 1617.63 107.056
## + Doubles      1    220.58 1629.81 107.236
## <none>          1850.39 108.282
## + Home_Run_Allowed 1    143.10 1707.29 108.351
## + Infield_Put_Outs 1    106.04 1744.35 108.866
## + Walks_Allowed  1     65.74 1784.65 109.414
## + Stolen_Bases   1     46.26 1804.13 109.675
## + Earned_Runs    1     37.30 1813.09 109.794
## + Hits_Allowed   1     23.81 1826.58 109.972
## + Shutout        1     22.48 1827.91 109.989
## + Complete_Games 1     22.29 1828.11 109.992
## + Fielding_Percentage 1    21.41 1828.99 110.003
## + Home_Runs      1     17.64 1832.75 110.052
## + Earned_Run_Average 1    13.46 1836.94 110.107
## + Caught_Stealing 1     11.00 1839.40 110.139
## + At_Bats        1     10.06 1840.33 110.152
## + Errors          1      0.31 1850.08 110.278
## + Strikeouts_Allowed 1      0.21 1850.18 110.280
## + Double_Plays   1      0.05 1850.34 110.282
##
## Step:  AIC=77.24
## Games_Won ~ Runs_Against + Runs_Scored
##
##              Df Sum of Sq    RSS    AIC
## + Errors      1    99.486 367.55 73.491
## + Doubles     1    85.518 381.52 74.386
## + Hits_Allowed 1    66.750 400.28 75.539
## + Infield_Put_Outs 1    66.288 400.75 75.567

```

```

## + Earned_Run_Average 1 65.281 401.75 75.627
## + Saves 1 60.478 406.56 75.912
## + Hits 1 59.231 407.80 75.986
## + Strike_Outs 1 51.657 415.38 76.427
## + Fielding_Percentage 1 48.697 418.34 76.598
## + Earned_Runs 1 39.268 427.77 77.133
## <none> 467.03 77.240
## + Shutout 1 34.467 432.57 77.400
## + At_Bats 1 28.463 438.57 77.731
## + Stolen_Bases 1 26.478 440.56 77.840
## + Walks_Allowed 1 18.224 448.81 78.285
## + Walks 1 15.101 451.93 78.452
## + Strikeouts_Allowed 1 11.603 455.43 78.637
## + Home_Run_Allowed 1 11.524 455.51 78.641
## + Complete_Games 1 4.099 462.93 79.029
## + Caught_Stealing 1 3.878 463.16 79.040
## + Double_Plays 1 3.853 463.18 79.042
## + Home_Runs 1 2.745 464.29 79.099
## + Triples 1 0.271 466.76 79.226
##
## Step: AIC=73.49
## Games_Won ~ Runs_Against + Runs_Scored + Errors
##
## Df Sum of Sq RSS AIC
## + Strike_Outs 1 114.897 252.65 66.495
## + Stolen_Bases 1 85.443 282.10 69.141
## + Doubles 1 85.354 282.19 69.149
## + Caught_Stealing 1 42.583 324.96 72.536
## + Hits 1 35.479 332.07 73.055
## + Shutout 1 31.594 335.95 73.334
## <none> 367.55 73.491
## + At_Bats 1 29.076 338.47 73.513
## + Strikeouts_Allowed 1 27.340 340.21 73.636
## + Infield_Put_Outs 1 26.418 341.13 73.701
## + Saves 1 21.211 346.34 74.065
## + Hits_Allowed 1 20.114 347.43 74.140
## + Walks 1 19.995 347.55 74.149
## + Home_Run_Allowed 1 6.865 360.68 75.039
## + Double_Plays 1 5.927 361.62 75.101
## + Complete_Games 1 5.394 362.15 75.136
## + Walks_Allowed 1 3.961 363.59 75.231
## + Earned_Run_Average 1 3.300 364.25 75.275
## + Home_Runs 1 2.197 365.35 75.347
## + Fielding_Percentage 1 1.807 365.74 75.373
## + Triples 1 1.323 366.23 75.405
## + Earned_Runs 1 0.153 367.39 75.481
##
## Step: AIC=66.49
## Games_Won ~ Runs_Against + Runs_Scored + Errors + Strike_Outs
##
## Df Sum of Sq RSS AIC
## + Doubles 1 56.471 196.18 62.424
## + Strikeouts_Allowed 1 41.917 210.73 64.141
## + Complete_Games 1 32.353 220.30 65.206

```

```

## <none>                252.65 66.495
## + Stolen_Bases        1      18.948 233.70 66.624
## + Home_Run_Allowed    1      18.111 234.54 66.710
## + Infield_Put_Outs    1      17.722 234.93 66.749
## + Triples             1      11.976 240.68 67.329
## + Caught_Stealing     1       8.270 244.38 67.696
## + Double_Plays        1       8.006 244.64 67.722
## + Earned_Runs         1       5.798 246.85 67.938
## + Saves               1       5.293 247.36 67.987
## + At_Bats             1       3.755 248.90 68.136
## + Walks_Allowed       1       2.883 249.77 68.219
## + Hits_Allowed        1       2.607 250.04 68.246
## + Shutout             1       2.555 250.10 68.251
## + Earned_Run_Average  1       1.732 250.92 68.330
## + Hits                1       1.067 251.58 68.393
## + Walks               1       0.398 252.25 68.457
## + Fielding_Percentage 1       0.121 252.53 68.483
## + Home_Runs           1       0.001 252.65 68.495
##
## Step:  AIC=62.42
## Games_Won ~ Runs_Against + Runs_Scored + Errors + Strike_Outs +
##      Doubles
##
##              Df Sum of Sq   RSS   AIC
## + Strikeouts_Allowed  1    33.506 162.67 59.929
## + Complete_Games      1    27.983 168.20 60.730
## <none>                  196.18 62.424
## + Home_Run_Allowed    1    13.450 182.73 62.719
## + Walks_Allowed       1    11.615 184.56 62.959
## + Earned_Runs         1     7.738 188.44 63.458
## + Infield_Put_Outs    1     7.073 189.11 63.542
## + Home_Runs           1     5.432 190.75 63.750
## + Triples             1     5.132 191.05 63.787
## + Earned_Run_Average  1     4.980 191.20 63.806
## + Double_Plays        1     4.585 191.59 63.856
## + Hits_Allowed        1     3.133 193.05 64.037
## + Saves               1     2.367 193.81 64.132
## + Stolen_Bases        1     1.239 194.94 64.271
## + Walks               1     0.811 195.37 64.324
## + Shutout             1     0.223 195.96 64.396
## + Caught_Stealing     1     0.119 196.06 64.409
## + At_Bats             1     0.037 196.14 64.419
## + Fielding_Percentage 1     0.020 196.16 64.421
## + Hits                1     0.014 196.17 64.422
##
## Step:  AIC=59.93
## Games_Won ~ Runs_Against + Runs_Scored + Errors + Strike_Outs +
##      Doubles + Strikeouts_Allowed
##
##              Df Sum of Sq   RSS   AIC
## + Walks_Allowed       1    27.0759 135.60 57.559
## + Shutout             1    14.5177 148.16 59.685
## <none>                  162.67 59.929
## + Triples             1    12.4567 150.22 60.017

```

```

## + Complete_Games      1    11.0223 151.65 60.245
## + Earned_Runs         1    10.7548 151.92 60.287
## + Hits_Allowed        1    10.3340 152.34 60.353
## + Earned_Run_Average  1     9.4484 153.23 60.493
## + Saves               1     9.2265 153.45 60.527
## + Double_Plays        1     6.3907 156.28 60.967
## + Infield_Put_Outs    1     4.8059 157.87 61.209
## + Home_Run_Allowed    1     4.3548 158.32 61.277
## + Stolen_Bases        1     3.0471 159.63 61.475
## + Home_Runs           1     2.5379 160.14 61.551
## + Hits                1     1.0426 161.63 61.774
## + Caught_Stealing     1     0.6840 161.99 61.828
## + Walks               1     0.2258 162.45 61.895
## + Fielding_Percentage 1     0.1894 162.49 61.901
## + At_Bats             1     0.0861 162.59 61.916
##
## Step:  AIC=57.56
## Games_Won ~ Runs_Against + Runs_Scored + Errors + Strike_Outs +
##      Doubles + Strikeouts_Allowed + Walks_Allowed
##
##              Df Sum of Sq   RSS   AIC
## + Home_Run_Allowed    1   14.7339 120.86 56.799
## + Triples             1   11.4117 124.19 57.450
## <none>                 135.60 57.559
## + Earned_Runs         1    6.6476 128.95 58.353
## + Earned_Run_Average  1    6.3129 129.28 58.415
## + Saves               1    6.1126 129.49 58.452
## + Shutout             1    5.8194 129.78 58.507
## + Complete_Games      1    4.7737 130.82 58.699
## + Stolen_Bases        1    4.6943 130.90 58.714
## + Infield_Put_Outs    1    2.1364 133.46 59.178
## + Hits_Allowed        1    1.3395 134.26 59.321
## + Hits                1    1.2918 134.31 59.330
## + Double_Plays        1    1.0232 134.57 59.378
## + Home_Runs           1    0.4940 135.10 59.472
## + Walks               1    0.3127 135.29 59.504
## + Caught_Stealing     1    0.2440 135.35 59.516
## + At_Bats             1    0.1983 135.40 59.524
## + Fielding_Percentage 1    0.0878 135.51 59.544
##
## Step:  AIC=56.8
## Games_Won ~ Runs_Against + Runs_Scored + Errors + Strike_Outs +
##      Doubles + Strikeouts_Allowed + Walks_Allowed + Home_Run_Allowed
##
##              Df Sum of Sq   RSS   AIC
## <none>                 120.86 56.799
## + Saves               1    8.0047 112.86 57.154
## + Home_Runs           1    6.6322 114.23 57.444
## + Stolen_Bases        1    6.1119 114.75 57.553
## + Triples             1    2.9043 117.96 58.215
## + Shutout             1    2.8147 118.05 58.233
## + Infield_Put_Outs    1    1.8888 118.97 58.421
## + Complete_Games      1    1.8499 119.01 58.429
## + Hits_Allowed        1    1.7721 119.09 58.444

```

```
## + Hits          1      1.6218 119.24 58.475
## + At_Bats        1      1.0927 119.77 58.581
## + Caught_Stealing 1      0.8605 120.00 58.627
## + Walks          1      0.6093 120.25 58.677
## + Double_Plays   1      0.1850 120.68 58.762
## + Fielding_Percentage 1 0.1666 120.70 58.766
## + Earned_Run_Average 1 0.0267 120.84 58.793
## + Earned_Runs    1      0.0050 120.86 58.798

##
## Call:
## lm(formula = Games_Won ~ Runs_Against + Runs_Scored + Errors +
##      Strike_Outs + Doubles + Strikeouts_Allowed + Walks_Allowed +
##      Home_Run_Allowed, data = df_p1)
##
## Coefficients:
##      (Intercept)      Runs_Against      Runs_Scored      Errors
##      81.36756      -0.16765      0.10578      0.13734
##      Strike_Outs      Doubles  Strikeouts_Allowed  Walks_Allowed
##      -0.02958      0.07589      -0.02074      0.02187
##      Home_Run_Allowed
##      0.13804
```

```
fit1 <- lm(Games_Won ~ Runs_Against + Runs_Scored + Errors +
            Strike_Outs + Doubles + Strikeouts_Allowed + Walks_Allowed +
            Home_Run_Allowed, data = df_p1)

summary(fit1)
```

```
##
## Call:
## lm(formula = Games_Won ~ Runs_Against + Runs_Scored + Errors +
##      Strike_Outs + Doubles + Strikeouts_Allowed + Walks_Allowed +
##      Home_Run_Allowed, data = df_p1)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -5.0654 -0.9247 -0.0054  1.7052  4.8746
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   81.367559   14.364171    5.665 4.49e-05 ***
## Runs_Against  -0.167649    0.015890  -10.550 2.46e-08 ***
## Runs_Scored    0.105783    0.010050   10.526 2.54e-08 ***
## Errors         0.137341    0.031883    4.308 0.000622 ***
## Strike_Outs   -0.029577    0.008255   -3.583 0.002720 **
## Doubles        0.075888    0.027427    2.767 0.014389 *
## Strikeouts_Allowed -0.020736    0.009766   -2.123 0.050771 .
## Walks_Allowed  0.021870    0.010144    2.156 0.047728 *
## Home_Run_Allowed 0.138035    0.102079    1.352 0.196334
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
```



```
## Residual standard error: 2.839 on 15 degrees of freedom
## Multiple R-squared:  0.9764, Adjusted R-squared:  0.9638
## F-statistic: 77.55 on 8 and 15 DF,  p-value: 8.327e-11
```

```
# Period 2 - 1920 to 1960
```

```
df_p2 <- drop_na(df_1920_1960[, colSums(is.na(df_1920_1960)) <
                                nrow(df_1920_1960)])[-c(1, 3)]
```

```
## Forward stepwise regression
```

```
null_modelp2 <- lm(Games_Won ~ 1, data = df_p2)
```

```
full_modelp2 <- lm(Games_Won ~ . , data = df_p2)
```

```
step(null_modelp2, direction = "forward", scope = formula(full_modelp2))
```

```
## Start:  AIC=2423.73
```

```
## Games_Won ~ 1
```

```
##
```

|                          | Df | Sum of Sq | RSS   | AIC    |
|--------------------------|----|-----------|-------|--------|
| ## + Runs_Scored         | 1  | 38182     | 54165 | 2182.4 |
| ## + Runs_Against        | 1  | 37767     | 54581 | 2185.9 |
| ## + Earned_Run_Average  | 1  | 36414     | 55933 | 2197.1 |
| ## + Earned_Runs         | 1  | 35788     | 56559 | 2202.2 |
| ## + Shutout             | 1  | 23915     | 68432 | 2289.1 |
| ## + Hits_Allowed        | 1  | 22860     | 69487 | 2296.0 |
| ## + Saves               | 1  | 16685     | 75662 | 2334.9 |
| ## + Hits                | 1  | 14275     | 78072 | 2349.2 |
| ## + Walks               | 1  | 13940     | 78407 | 2351.1 |
| ## + Home_Runs           | 1  | 13124     | 79223 | 2355.8 |
| ## + Errors              | 1  | 10085     | 82263 | 2373.0 |
| ## + Infield_Put_Outs    | 1  | 8894      | 83453 | 2379.6 |
| ## + Fielding_Percentage | 1  | 8757      | 83590 | 2380.3 |
| ## + Complete_Games      | 1  | 8573      | 83775 | 2381.3 |
| ## + Strikeouts_Allowed  | 1  | 7936      | 84411 | 2384.8 |
| ## + Walks_Allowed       | 1  | 5807      | 86540 | 2396.1 |
| ## + Triples             | 1  | 3904      | 88444 | 2406.0 |
| ## + Doubles             | 1  | 3676      | 88672 | 2407.2 |
| ## + At_Bats             | 1  | 2552      | 89795 | 2412.9 |
| ## + Stolen_Bases        | 1  | 2199      | 90149 | 2414.8 |
| ## + Home_Run_Allowed    | 1  | 1474      | 90874 | 2418.4 |
| ## <none>                |    |           | 92347 | 2423.7 |
| ## + Strike_Outs         | 1  | 325       | 92023 | 2424.1 |
| ## + Double_Plays        | 1  | 170       | 92178 | 2424.9 |
| ## + Caught_Stealing     | 1  | 34        | 92314 | 2425.6 |

```
##
```

```
## Step:  AIC=2182.45
```

```
## Games_Won ~ Runs_Scored
```

```
##
```

|                         | Df | Sum of Sq | RSS   | AIC    |
|-------------------------|----|-----------|-------|--------|
| ## + Runs_Against       | 1  | 46327     | 7838  | 1303.0 |
| ## + Earned_Run_Average | 1  | 43522     | 10643 | 1442.5 |
| ## + Earned_Runs        | 1  | 42898     | 11267 | 1468.4 |
| ## + Hits_Allowed       | 1  | 33983     | 20182 | 1734.3 |
| ## + Shutout            | 1  | 24612     | 29553 | 1908.2 |
| ## + Saves              | 1  | 12155     | 42010 | 2068.6 |

```

## + Errors 1 12134 42031 2068.8
## + Fielding_Percentage 1 10885 43280 2082.1
## + Infield_Put_Outs 1 10833 43332 2082.7
## + Strikeouts_Allowed 1 10207 43958 2089.2
## + Doubles 1 7450 46714 2117.0
## + Walks_Allowed 1 5977 48188 2131.1
## + Hits 1 3654 50511 2152.6
## + At_Bats 1 3488 50677 2154.1
## + Home_Runs 1 3182 50983 2156.8
## + Complete_Games 1 1107 53058 2175.0
## + Strike_Outs 1 1057 53108 2175.5
## + Walks 1 903 53262 2176.8
## + Triples 1 595 53570 2179.4
## + Home_Run_Allowed 1 441 53724 2180.7
## + Double_Plays 1 262 53903 2182.2
## <none> 54165 2182.4
## + Stolen_Bases 1 47 54118 2184.1
## + Caught_Stealing 1 18 54147 2184.3
##
## Step: AIC=1302.96
## Games_Won ~ Runs_Scored + Runs_Against
##
## Df Sum of Sq RSS AIC
## + Saves 1 416.16 7421.5 1280.1
## + Infield_Put_Outs 1 383.12 7454.5 1282.1
## + Strikeouts_Allowed 1 73.68 7764.0 1300.7
## <none> 7837.7 1303.0
## + Earned_Run_Average 1 28.38 7809.3 1303.3
## + Double_Plays 1 26.54 7811.1 1303.4
## + Home_Run_Allowed 1 22.04 7815.6 1303.7
## + Fielding_Percentage 1 20.12 7817.5 1303.8
## + Shutout 1 16.51 7821.2 1304.0
## + Walks 1 15.27 7822.4 1304.1
## + Errors 1 11.68 7826.0 1304.3
## + Doubles 1 11.15 7826.5 1304.3
## + Home_Runs 1 10.60 7827.1 1304.3
## + Stolen_Bases 1 9.66 7828.0 1304.4
## + Walks_Allowed 1 2.86 7834.8 1304.8
## + Hits_Allowed 1 2.57 7835.1 1304.8
## + Caught_Stealing 1 1.21 7836.5 1304.9
## + Strike_Outs 1 1.18 7836.5 1304.9
## + Complete_Games 1 0.71 7837.0 1304.9
## + Hits 1 0.16 7837.5 1305.0
## + Triples 1 0.15 7837.5 1305.0
## + Earned_Runs 1 0.15 7837.5 1305.0
## + At_Bats 1 0.11 7837.5 1305.0
##
## Step: AIC=1280.08
## Games_Won ~ Runs_Scored + Runs_Against + Saves
##
## Df Sum of Sq RSS AIC
## + Complete_Games 1 689.30 6732.2 1237.6
## + Infield_Put_Outs 1 304.75 7116.7 1263.0
## + Earned_Run_Average 1 174.20 7247.3 1271.2

```

```

## + Strike_Outs      1      158.63 7262.9 1272.2
## + Caught_Stealing  1      124.46 7297.0 1274.4
## + Home_Runs        1       92.34 7329.2 1276.4
## + Walks_Allowed    1       90.19 7331.3 1276.5
## + Hits_Allowed     1       89.29 7332.2 1276.6
## + Triples          1       86.47 7335.0 1276.7
## + Hits             1       76.31 7345.2 1277.4
## + Home_Run_Allowed 1       76.05 7345.5 1277.4
## + Earned_Runs      1       71.64 7349.9 1277.7
## + Errors           1       59.36 7362.1 1278.4
## <none>              7421.5 1280.1
## + Shutout          1       22.78 7398.7 1280.7
## + Stolen_Bases     1       17.76 7403.7 1281.0
## + Strikeouts_Allowed 1      17.57 7403.9 1281.0
## + Fielding_Percentage 1      11.09 7410.4 1281.4
## + Doubles          1        4.77 7416.7 1281.8
## + Walks            1        4.16 7417.3 1281.8
## + At_Bats          1        1.73 7419.8 1282.0
## + Double_Plays     1        0.54 7421.0 1282.0
##
## Step: AIC=1237.63
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games
##
##              Df Sum of Sq    RSS    AIC
## + Infield_Put_Outs      1    292.396 6439.8 1219.4
## + Strikeouts_Allowed    1     42.230 6690.0 1236.8
## + Walks_Allowed         1     32.507 6699.7 1237.4
## <none>                   6732.2 1237.6
## + Fielding_Percentage    1     23.465 6708.7 1238.0
## + Earned_Run_Average     1     22.619 6709.6 1238.1
## + Home_Run_Allowed       1     14.734 6717.5 1238.6
## + Hits_Allowed          1     13.746 6718.5 1238.7
## + Hits                   1     10.734 6721.5 1238.9
## + Caught_Stealing        1     10.447 6721.8 1238.9
## + Shutout                1      6.761 6725.4 1239.2
## + Double_Plays           1      6.421 6725.8 1239.2
## + Triples                1      4.428 6727.8 1239.3
## + Stolen_Bases           1      4.249 6728.0 1239.3
## + At_Bats                1      3.992 6728.2 1239.4
## + Home_Runs              1      2.604 6729.6 1239.5
## + Errors                 1      2.532 6729.7 1239.5
## + Strike_Outs            1      2.510 6729.7 1239.5
## + Doubles                1      2.056 6730.1 1239.5
## + Earned_Runs            1      1.077 6731.1 1239.5
## + Walks                  1      0.058 6732.1 1239.6
##
## Step: AIC=1219.38
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
##           Infield_Put_Outs
##
##              Df Sum of Sq    RSS    AIC
## + At_Bats          1    163.443 6276.4 1209.7
## <none>              6439.8 1219.4
## + Walks_Allowed    1     25.857 6413.9 1219.5

```

```

## + Stolen_Bases      1      18.257 6421.5 1220.1
## + Fielding_Percentage 1      15.845 6424.0 1220.3
## + Home_Run_Allowed   1      12.505 6427.3 1220.5
## + Strikeouts_Allowed 1      10.461 6429.3 1220.6
## + Double_Plays       1       7.795 6432.0 1220.8
## + Strike-Outs        1       6.825 6433.0 1220.9
## + Errors             1       6.116 6433.7 1221.0
## + Earned_Run_Average 1       3.760 6436.0 1221.1
## + Home_Runs          1       3.719 6436.1 1221.1
## + Shutout            1       2.670 6437.1 1221.2
## + Earned_Runs        1       2.253 6437.6 1221.2
## + Doubles            1       1.483 6438.3 1221.3
## + Triples            1       1.281 6438.5 1221.3
## + Hits               1       0.612 6439.2 1221.3
## + Caught_Stealing    1       0.358 6439.4 1221.3
## + Walks              1       0.225 6439.6 1221.4
## + Hits_Allowed       1       0.010 6439.8 1221.4
##
## Step:  AIC=1209.66
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
##      Infield_Put_Outs + At_Bats
##
##              Df Sum of Sq    RSS    AIC
## + Hits              1      43.965 6232.4 1208.5
## + Stolen_Bases      1      39.674 6236.7 1208.8
## <none>                      6276.4 1209.7
## + Walks_Allowed     1      23.665 6252.7 1209.9
## + Double_Plays       1      22.435 6253.9 1210.0
## + Walks              1      20.196 6256.2 1210.2
## + Fielding_Percentage 1      14.585 6261.8 1210.6
## + Strike-Outs        1      13.887 6262.5 1210.7
## + Strikeouts_Allowed 1      10.562 6265.8 1210.9
## + Caught_Stealing    1       8.183 6268.2 1211.1
## + Home_Run_Allowed   1       7.753 6268.6 1211.1
## + Earned_Run_Average 1       7.123 6269.2 1211.1
## + Errors             1       5.493 6270.9 1211.3
## + Triples            1       5.102 6271.3 1211.3
## + Earned_Runs        1       4.823 6271.5 1211.3
## + Doubles            1       3.467 6272.9 1211.4
## + Shutout            1       2.972 6273.4 1211.4
## + Home_Runs          1       1.857 6274.5 1211.5
## + Hits_Allowed       1       0.088 6276.3 1211.7
##
## Step:  AIC=1208.45
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
##      Infield_Put_Outs + At_Bats + Hits
##
##              Df Sum of Sq    RSS    AIC
## + Stolen_Bases      1      96.187 6136.2 1203.4
## + Caught_Stealing    1      77.000 6155.4 1204.8
## + Double_Plays       1      40.656 6191.7 1207.5
## + Strikeouts_Allowed 1      39.860 6192.5 1207.5
## + Home_Run_Allowed   1      38.412 6194.0 1207.6
## + Fielding_Percentage 1      35.425 6197.0 1207.8

```

```

## + Earned_Run_Average 1 34.466 6197.9 1207.9
## + Errors 1 33.051 6199.3 1208.0
## + Home_Runs 1 30.529 6201.9 1208.2
## + Earned_Runs 1 28.335 6204.1 1208.4
## <none> 6232.4 1208.5
## + Hits_Allowed 1 9.797 6222.6 1209.7
## + Shutout 1 5.614 6226.8 1210.0
## + Walks_Allowed 1 5.181 6227.2 1210.1
## + Triples 1 1.181 6231.2 1210.4
## + Walks 1 0.477 6231.9 1210.4
## + Strike_Outs 1 0.014 6232.4 1210.5
## + Doubles 1 0.011 6232.4 1210.5
##
## Step: AIC=1203.36
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
## Infield_Put_Outs + At_Bats + Hits + Stolen_Bases
##
## Df Sum of Sq RSS AIC
## + Double_Plays 1 36.413 6099.8 1202.6
## <none> 6136.2 1203.4
## + Strikeouts_Allowed 1 25.042 6111.2 1203.5
## + Fielding_Percentage 1 21.405 6114.8 1203.8
## + Earned_Run_Average 1 21.178 6115.0 1203.8
## + Home_Run_Allowed 1 21.063 6115.1 1203.8
## + Earned_Runs 1 15.947 6120.3 1204.2
## + Errors 1 12.721 6123.5 1204.4
## + Walks_Allowed 1 12.657 6123.6 1204.4
## + Caught_Stealing 1 11.662 6124.5 1204.5
## + Home_Runs 1 7.135 6129.1 1204.8
## + Hits_Allowed 1 5.776 6130.4 1204.9
## + Walks 1 5.268 6130.9 1205.0
## + Triples 1 3.635 6132.6 1205.1
## + Shutout 1 3.518 6132.7 1205.1
## + Strike_Outs 1 0.913 6135.3 1205.3
## + Doubles 1 0.067 6136.1 1205.3
##
## Step: AIC=1202.64
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
## Infield_Put_Outs + At_Bats + Hits + Stolen_Bases + Double_Plays
##
## Df Sum of Sq RSS AIC
## + Strikeouts_Allowed 1 47.934 6051.9 1201.0
## + Walks_Allowed 1 37.002 6062.8 1201.9
## <none> 6099.8 1202.6
## + Home_Run_Allowed 1 21.410 6078.4 1203.0
## + Walks 1 14.199 6085.6 1203.6
## + Fielding_Percentage 1 12.724 6087.1 1203.7
## + Earned_Run_Average 1 11.701 6088.1 1203.8
## + Caught_Stealing 1 11.586 6088.2 1203.8
## + Home_Runs 1 9.291 6090.5 1204.0
## + Earned_Runs 1 7.827 6092.0 1204.1
## + Errors 1 5.852 6093.9 1204.2
## + Hits_Allowed 1 5.153 6094.6 1204.3
## + Triples 1 4.995 6094.8 1204.3

```

```

## + Shutout          1      2.711 6097.1 1204.4
## + Strike_Outs      1      0.060 6099.7 1204.6
## + Doubles          1      0.009 6099.8 1204.6
##
## Step:  AIC=1201.05
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
##      Infield_Put_Outs + At_Bats + Hits + Stolen_Bases + Double_Plays +
##      Strikeouts_Allowed
##
##              Df Sum of Sq    RSS    AIC
## + Walks_Allowed      1      52.354 5999.5 1199.1
## <none>                      6051.9 1201.0
## + Walks              1      14.216 6037.6 1202.0
## + Triples            1      13.733 6038.1 1202.0
## + Strike_Outs        1       8.187 6043.7 1202.4
## + Fielding_Percentage 1       7.947 6043.9 1202.5
## + Caught_Stealing    1       4.795 6047.1 1202.7
## + Earned_Run_Average 1       4.566 6047.3 1202.7
## + Home_Run_Allowed   1       2.448 6049.4 1202.9
## + Earned_Runs        1       2.197 6049.7 1202.9
## + Shutout            1       1.658 6050.2 1202.9
## + Errors             1       0.736 6051.1 1203.0
## + Doubles            1       0.378 6051.5 1203.0
## + Home_Runs          1       0.279 6051.6 1203.0
## + Hits_Allowed       1       0.009 6051.9 1203.0
##
## Step:  AIC=1199.08
## Games_Won ~ Runs_Scored + Runs_Against + Saves + Complete_Games +
##      Infield_Put_Outs + At_Bats + Hits + Stolen_Bases + Double_Plays +
##      Strikeouts_Allowed + Walks_Allowed
##
##              Df Sum of Sq    RSS    AIC
## <none>                      5999.5 1199.1
## + Hits_Allowed        1      24.2893 5975.2 1199.2
## + Strike_Outs         1      20.3796 5979.1 1199.5
## + Triples             1      13.3995 5986.1 1200.1
## + Fielding_Percentage 1      11.0138 5988.5 1200.2
## + Earned_Run_Average  1       9.8395 5989.7 1200.3
## + Caught_Stealing     1       8.3856 5991.1 1200.5
## + Earned_Runs         1       5.9193 5993.6 1200.6
## + Shutout            1       3.2306 5996.3 1200.8
## + Errors             1       2.1544 5997.4 1200.9
## + Walks              1       2.1237 5997.4 1200.9
## + Home_Runs          1       0.9994 5998.5 1201.0
## + Home_Run_Allowed   1       0.7924 5998.7 1201.0
## + Doubles            1       0.7431 5998.8 1201.0
##
##
## Call:
## lm(formula = Games_Won ~ Runs_Scored + Runs_Against + Saves +
##      Complete_Games + Infield_Put_Outs + At_Bats + Hits + Stolen_Bases +
##      Double_Plays + Strikeouts_Allowed + Walks_Allowed, data = df_p2)
##
## Coefficients:

```

```
##          (Intercept)          Runs_Scored          Runs_Against          Saves
##          0.956490          0.083433          -0.069990          0.317535
##    Complete_Games    Infield_Put_Outs          At_Bats          Hits
##          0.144090          0.029437          -0.017327          0.013152
##          Stolen_Bases    Double_Plays    Strikeouts_Allowed    Walks_Allowed
##          -0.017152          0.028312          0.004682          -0.005361
```

```
fit2 <- lm(Games_Won ~ Runs_Scored + Runs_Against + Saves +
           Complete_Games + Infield_Put_Outs + At_Bats + Hits + Stolen_Bases +
           Double_Plays + Strikeouts_Allowed + Walks_Allowed, data = df_p2)

summary(fit2)
```

```
##
## Call:
## lm(formula = Games_Won ~ Runs_Scored + Runs_Against + Saves +
##     Complete_Games + Infield_Put_Outs + At_Bats + Hits + Stolen_Bases +
##     Double_Plays + Strikeouts_Allowed + Walks_Allowed, data = df_p2)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.9118  -2.5259  -0.0583   2.4852  10.0460
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    0.956490   14.014307   0.068  0.94562
## Runs_Scored     0.083433    0.003461  24.108 < 2e-16 ***
## Runs_Against   -0.069990    0.003111 -22.498 < 2e-16 ***
## Saves          0.317535    0.042249   7.516 3.15e-13 ***
## Complete_Games  0.144090    0.020926   6.886 1.97e-11 ***
## Infield_Put_Outs 0.029437    0.004597   6.404 3.86e-10 ***
## At_Bats        -0.017327    0.003507  -4.941 1.11e-06 ***
## Hits           0.013152    0.004541   2.896  0.00396 **
## Stolen_Bases   -0.017152    0.006934  -2.474  0.01375 *
## Double_Plays    0.028312    0.010543   2.685  0.00751 **
## Strikeouts_Allowed 0.004682    0.002163   2.164  0.03099 *
## Walks_Allowed  -0.005361    0.002723  -1.968  0.04965 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.676 on 444 degrees of freedom
## Multiple R-squared:  0.935, Adjusted R-squared:  0.9334
## F-statistic: 580.9 on 11 and 444 DF, p-value: < 2.2e-16
```

```
# Period 3 - 1960 to 1990
df_p3 <- drop_na(df_1960_1990[, colSums(is.na(df_1960_1990)) <
                                     nrow(df_1960_1990)])[-c(1, 3)]

## Forward stepwise regression
null_modelp3 <- lm(Games_Won ~ 1, data = df_p3)
full_modelp3 <- lm(Games_Won ~ ., data = df_p3)

step(null_modelp3, direction = "forward", scope = formula(full_modelp3))
```

```

## Start:  AIC=3701.27
## Games_Won ~ 1
##
##
##      Df Sum of Sq  RSS    AIC
## + Runs_Scored      1    52361  63546 3264.5
## + Hits              1    38074  77832 3412.6
## + Saves             1    29214  86692 3491.3
## + Earned_Run_Average 1    26316  89590 3515.3
## + Infield_Put_Outs   1    24954  90952 3526.3
## + At_Bats            1    24040  91866 3533.6
## + Shutout           1    23606  92300 3537.0
## + Home_Runs          1    21388  94518 3554.4
## + Doubles            1    19278  96629 3570.5
## + Walks              1    18279  97627 3578.0
## + Strikeouts_Allowed 1    14014 101892 3609.2
## + Complete_Games     1    10428 105478 3634.4
## + Fielding_Percentage 1     7263 108643 3656.0
## + Runs_Against       1     7207 108699 3656.4
## + Earned_Runs        1     5987 109919 3664.6
## + Triples            1     5965 109941 3664.7
## + Stolen_Bases       1     4495 111412 3674.4
## + Walks_Allowed      1     3129 112777 3683.3
## + Double_Plays       1     2898 113008 3684.8
## + Errors             1     2546 113360 3687.1
## + Strike_Outs        1     2096 113810 3689.9
## <none>                115906 3701.3
## + Caught_Stealing    1      171 115736 3702.2
## + Hits_Allowed       1      122 115784 3702.5
## + Home_Run_Allowed   1       16 115890 3703.2
##
## Step:  AIC=3264.52
## Games_Won ~ Runs_Scored
##
##
##      Df Sum of Sq  RSS    AIC
## + Earned_Run_Average 1    50127 13418 2131.3
## + Earned_Runs         1    40039 23507 2540.6
## + Runs_Against        1    40010 23536 2541.5
## + Shutout             1    29204 34341 2817.3
## + Home_Run_Allowed    1    17221 46324 3035.8
## + Hits_Allowed        1    16290 47256 3050.3
## + Walks_Allowed       1    10867 52679 3129.6
## + Saves               1     8309 55236 3164.2
## + Complete_Games      1     6395 57150 3189.1
## + Strikeouts_Allowed  1     4826 58720 3208.9
## + Fielding_Percentage 1     3948 59598 3219.7
## + Errors              1     3590 59956 3224.1
## + Infield_Put_Outs    1     2242 61304 3240.3
## + Doubles             1       781 62765 3257.5
## + Stolen_Bases        1       764 62782 3257.7
## + Double_Plays        1       647 62899 3259.1
## + Home_Runs           1       424 63122 3261.6
## + At_Bats             1       291 63255 3263.2
## + Triples             1       182 63363 3264.4
## <none>                63546 3264.5

```



```

## + Strike_Outs      1      157 63389 3264.7
## + Walks             1       45 63501 3266.0
## + Hits              1        9 63537 3266.4
## + Caught_Stealing   1        8 63538 3266.4
##
## Step:  AIC=2131.26
## Games_Won ~ Runs_Scored + Earned_Run_Average
##
##              Df Sum of Sq  RSS    AIC
## + Saves      1   1510.98 11907 2046.0
## + Fielding_Percentage 1   1081.11 12337 2071.9
## + Errors      1    833.80 12584 2086.4
## + Shutout     1    471.27 12947 2107.2
## + Infield_Put_Outs 1     96.99 13321 2128.0
## + Strikeouts_Allowed 1     86.41 13332 2128.6
## + Earned_Runs   1     70.98 13347 2129.4
## + Runs_Against  1     54.61 13364 2130.3
## + Home_Run_Allowed 1     50.81 13367 2130.5
## + Triples      1     40.84 13377 2131.0
## <none>                13418 2131.3
## + Stolen_Bases  1     27.97 13390 2131.7
## + Walks        1     23.34 13395 2132.0
## + At_Bats      1     20.99 13397 2132.1
## + Double_Plays  1      8.27 13410 2132.8
## + Home_Runs    1      6.37 13412 2132.9
## + Hits         1      6.13 13412 2132.9
## + Strike_Outs  1      4.47 13414 2133.0
## + Doubles      1      3.22 13415 2133.1
## + Hits_Allowed  1      0.84 13417 2133.2
## + Complete_Games 1      0.74 13417 2133.2
## + Caught_Stealing 1      0.23 13418 2133.2
## + Walks_Allowed 1      0.12 13418 2133.3
##
## Step:  AIC=2046.05
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves
##
##              Df Sum of Sq  RSS    AIC
## + Complete_Games  1   1820.91 10086 1926.9
## + Shutout         1    794.62 11112 1997.6
## + Fielding_Percentage 1    751.49 11156 2000.5
## + Errors          1    510.61 11396 2016.1
## + Infield_Put_Outs 1     83.48 11824 2042.9
## + Earned_Runs     1     58.46 11849 2044.5
## + Walks           1     53.30 11854 2044.8
## + Home_Run_Allowed 1     48.16 11859 2045.1
## + Doubles         1     38.05 11869 2045.7
## <none>                11907 2046.0
## + Caught_Stealing  1     29.48 11878 2046.2
## + Strikeouts_Allowed 1     28.94 11878 2046.3
## + Runs_Against    1     28.88 11878 2046.3
## + Triples         1     24.24 11883 2046.6
## + At_Bats         1     20.50 11887 2046.8
## + Double_Plays    1     13.15 11894 2047.2
## + Stolen_Bases    1     12.46 11895 2047.3

```

```

## + Strike_Outs      1      10.87 11896 2047.4
## + Hits             1       8.19 11899 2047.5
## + Home_Runs        1       5.07 11902 2047.7
## + Hits_Allowed     1       2.43 11905 2047.9
## + Walks_Allowed    1       2.00 11905 2047.9
##
## Step:  AIC=1926.89
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games
##
##              Df Sum of Sq    RSS    AIC
## + Fielding_Percentage 1    797.27  9289.0 1868.8
## + Errors              1    672.45  9413.8 1878.5
## + Shutout             1    334.57  9751.7 1904.3
## + Runs_Against        1    131.67  9954.6 1919.3
## + Stolen_Bases        1     48.01 10038.2 1925.4
## + Walks               1     43.44 10042.8 1925.7
## + Triples             1     28.65 10057.6 1926.8
## <none>                1    10086.2 1926.9
## + Strikeouts_Allowed  1     16.96 10069.3 1927.7
## + Hits_Allowed        1     16.73 10069.5 1927.7
## + Strike_Outs         1     13.59 10072.7 1927.9
## + Walks_Allowed       1     12.72 10073.5 1928.0
## + At_Bats             1      8.62 10077.6 1928.3
## + Doubles             1      8.01 10078.2 1928.3
## + Double_Plays        1      7.49 10078.8 1928.3
## + Home_Runs           1      4.10 10082.1 1928.6
## + Hits                1      2.14 10084.1 1928.7
## + Infield_Put_Outs    1      1.32 10084.9 1928.8
## + Home_Run_Allowed    1      0.78 10085.5 1928.8
## + Caught_Stealing     1      0.77 10085.5 1928.8
## + Earned_Runs         1      0.00 10086.2 1928.9
##
## Step:  AIC=1868.78
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##           Fielding_Percentage
##
##              Df Sum of Sq    RSS    AIC
## + Shutout          1   305.360  8983.6 1846.4
## + Errors           1    72.260  9216.7 1865.1
## + Stolen_Bases     1    58.702  9230.3 1866.2
## + Walks            1    49.782  9239.2 1866.9
## + Strikeouts_Allowed 1    40.627  9248.3 1867.6
## <none>              1    9289.0 1868.8
## + Infield_Put_Outs 1    22.913  9266.1 1869.0
## + Home_Runs        1    19.992  9269.0 1869.2
## + Earned_Runs      1    11.482  9277.5 1869.9
## + Runs_Against     1     9.921  9279.1 1870.0
## + Caught_Stealing  1     9.503  9279.5 1870.0
## + Double_Plays     1     8.477  9280.5 1870.1
## + Home_Run_Allowed 1     5.541  9283.4 1870.3
## + Triples          1     4.858  9284.1 1870.4
## + Hits             1     1.393  9287.6 1870.7
## + At_Bats          1     0.821  9288.2 1870.7
## + Hits_Allowed     1     0.588  9288.4 1870.7

```

```

## + Strike_Outs      1      0.420 9288.6 1870.8
## + Walks_Allowed    1      0.388 9288.6 1870.8
## + Doubles          1      0.064 9288.9 1870.8
##
## Step:  AIC=1846.38
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##      Fielding_Percentage + Shutout
##
##              Df Sum of Sq    RSS    AIC
## + Errors      1    87.712 8895.9 1841.2
## + Walks       1    53.755 8929.9 1844.0
## + Stolen_Bases 1    52.846 8930.8 1844.1
## + Runs_Against 1    31.028 8952.6 1845.9
## <none>                8983.6 1846.4
## + Double_Plays  1    17.838 8965.8 1846.9
## + Home_Runs     1    12.574 8971.0 1847.4
## + Strikeouts_Allowed 1    11.862 8971.7 1847.4
## + Strike_Outs   1     8.752 8974.9 1847.7
## + Caught_Stealing 1     7.860 8975.8 1847.7
## + Triples       1     4.858 8978.8 1848.0
## + Home_Run_Allowed 1     4.478 8979.1 1848.0
## + At_Bats       1     4.359 8979.3 1848.0
## + Infield_Put_Outs 1     3.797 8979.8 1848.1
## + Doubles       1     3.022 8980.6 1848.1
## + Hits          1     2.637 8981.0 1848.2
## + Hits_Allowed  1     1.022 8982.6 1848.3
## + Earned_Runs   1     0.421 8983.2 1848.3
## + Walks_Allowed 1     0.194 8983.4 1848.4
##
## Step:  AIC=1841.22
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##      Fielding_Percentage + Shutout + Errors
##
##              Df Sum of Sq    RSS    AIC
## + Infield_Put_Outs 1    75.223 8820.7 1837.0
## + Walks             1    75.009 8820.9 1837.0
## + Stolen_Bases      1    59.342 8836.6 1838.3
## + Earned_Runs       1    50.790 8845.1 1839.0
## + Strikeouts_Allowed 1    28.275 8867.6 1840.9
## + Hits_Allowed      1    26.121 8869.8 1841.1
## <none>                8895.9 1841.2
## + Home_Runs         1    17.129 8878.8 1841.8
## + Caught_Stealing   1    15.455 8880.4 1842.0
## + At_Bats           1    13.824 8882.1 1842.1
## + Double_Plays      1     5.932 8890.0 1842.7
## + Walks_Allowed     1     4.036 8891.9 1842.9
## + Hits              1     3.360 8892.5 1842.9
## + Home_Run_Allowed  1     2.977 8892.9 1843.0
## + Doubles           1     2.706 8893.2 1843.0
## + Triples           1     1.974 8893.9 1843.1
## + Runs_Against      1     1.556 8894.3 1843.1
## + Strike_Outs       1     0.024 8895.9 1843.2
##
## Step:  AIC=1837.02

```

```

## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs
##
##
##      Df Sum of Sq    RSS    AIC
## + At_Bats      1    376.40 8444.3 1807.2
## + Runs_Against  1    323.09 8497.6 1811.8
## + Earned_Runs   1     98.33 8722.3 1830.8
## + Stolen_Bases  1     49.98 8770.7 1834.9
## + Walks         1     48.48 8772.2 1835.0
## <none>                8820.7 1837.0
## + Double_Plays  1     23.10 8797.6 1837.1
## + Home_Run_Allowed  1     21.56 8799.1 1837.2
## + Strike_Outs   1     21.28 8799.4 1837.3
## + Home_Runs     1     14.24 8806.4 1837.8
## + Hits          1     11.64 8809.0 1838.1
## + Doubles       1     11.21 8809.5 1838.1
## + Caught_Stealing  1      8.05 8812.6 1838.3
## + Walks_Allowed  1      4.29 8816.4 1838.7
## + Hits_Allowed   1      3.19 8817.5 1838.8
## + Triples        1      2.61 8818.1 1838.8
## + Strikeouts_Allowed  1      2.02 8818.7 1838.8
##
## Step:  AIC=1807.19
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats
##
##
##      Df Sum of Sq    RSS    AIC
## + Hits      1    397.36 8046.9 1774.0
## + Runs_Against  1    296.50 8147.8 1783.1
## + Earned_Runs   1     82.39 8361.9 1802.0
## + Strike_Outs   1     68.32 8376.0 1803.3
## + Home_Run_Allowed  1     57.68 8386.6 1804.2
## + Walks         1     43.69 8400.6 1805.4
## + Home_Runs     1     40.11 8404.2 1805.7
## <none>                8444.3 1807.2
## + Walks_Allowed  1     23.01 8421.3 1807.2
## + Stolen_Bases  1     10.04 8434.2 1808.3
## + Doubles       1      9.74 8434.5 1808.3
## + Triples       1      7.91 8436.4 1808.5
## + Double_Plays  1      7.91 8436.4 1808.5
## + Caught_Stealing  1      5.14 8439.1 1808.7
## + Hits_Allowed   1      5.01 8439.3 1808.8
## + Strikeouts_Allowed  1      0.00 8444.3 1809.2
##
## Step:  AIC=1774
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats + Hits
##
##
##      Df Sum of Sq    RSS    AIC
## + Runs_Against  1    230.709 7816.2 1754.8
## + Caught_Stealing  1    227.099 7819.8 1755.1
## + Earned_Runs     1     78.961 7968.0 1768.8

```

```

## + Home_Runs          1    40.088 8006.8 1772.3
## + Stolen_Bases       1    23.679 8023.2 1773.8
## + Strikeouts_Allowed 1    23.390 8023.5 1773.9
## <none>                8046.9 1774.0
## + Double_Plays       1    21.172 8025.7 1774.1
## + Walks              1    18.503 8028.4 1774.3
## + Walks_Allowed      1    18.186 8028.7 1774.3
## + Strike-Outs        1    14.113 8032.8 1774.7
## + Hits_Allowed       1     9.383 8037.5 1775.2
## + Doubles            1     6.058 8040.9 1775.5
## + Home_Run_Allowed   1     0.659 8046.3 1775.9
## + Triples            1     0.322 8046.6 1776.0
##
## Step:  AIC=1754.76
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##      Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##      At_Bats + Hits + Runs_Against
##
##              Df Sum of Sq    RSS    AIC
## + Caught_Stealing  1    209.253 7606.9 1737.0
## + Home_Runs        1     42.338 7773.9 1752.8
## + Strikeouts_Allowed 1     29.535 7786.7 1754.0
## + Double_Plays     1     27.375 7788.8 1754.2
## + Stolen_Bases     1     25.918 7790.3 1754.3
## <none>              7816.2 1754.8
## + Earned_Runs      1     17.921 7798.3 1755.1
## + Strike-Outs      1     13.113 7803.1 1755.5
## + Hits_Allowed     1      8.210 7808.0 1756.0
## + Walks            1      8.036 7808.2 1756.0
## + Doubles          1      6.212 7810.0 1756.2
## + Walks_Allowed    1      5.420 7810.8 1756.3
## + Home_Run_Allowed 1      4.546 7811.7 1756.3
## + Triples          1      0.283 7815.9 1756.7
##
## Step:  AIC=1736.95
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##      Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##      At_Bats + Hits + Runs_Against + Caught_Stealing
##
##              Df Sum of Sq    RSS    AIC
## + Double_Plays     1     36.627 7570.3 1735.4
## + Stolen_Bases     1     32.807 7574.1 1735.8
## + Strike-Outs      1     31.258 7575.7 1736.0
## + Walks            1     28.333 7578.6 1736.2
## + Home_Runs        1     21.871 7585.1 1736.8
## <none>              7606.9 1737.0
## + Strikeouts_Allowed 1     18.045 7588.9 1737.2
## + Earned_Runs      1     15.724 7591.2 1737.4
## + Hits_Allowed     1      8.667 7598.3 1738.1
## + Walks_Allowed    1      6.379 7600.6 1738.3
## + Triples          1      2.191 7604.8 1738.7
## + Home_Run_Allowed 1      1.057 7605.9 1738.8
## + Doubles          1      0.138 7606.8 1738.9
##

```

```

## Step: AIC=1735.43
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats + Hits + Runs_Against + Caught_Stealing + Double_Plays
##
##
##      Df Sum of Sq    RSS    AIC
## + Strike_Outs      1  28.6309 7541.7 1734.7
## + Walks            1  25.4813 7544.8 1735.0
## + Stolen_Bases     1  23.1543 7547.2 1735.2
## <none>              7570.3 1735.4
## + Home_Runs        1  19.5777 7550.7 1735.5
## + Earned_Runs       1  16.6367 7553.7 1735.8
## + Strikeouts_Allowed 1   4.6051 7565.7 1737.0
## + Hits_Allowed      1   3.3837 7566.9 1737.1
## + Walks_Allowed     1   2.8961 7567.4 1737.2
## + Triples           1   2.7085 7567.6 1737.2
## + Doubles           1   0.8205 7569.5 1737.3
## + Home_Run_Allowed  1   0.2829 7570.0 1737.4
##
## Step: AIC=1734.66
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats + Hits + Runs_Against + Caught_Stealing + Double_Plays +
##   Strike_Outs
##
##
##      Df Sum of Sq    RSS    AIC
## + Walks            1  24.7409 7517.0 1734.3
## + Stolen_Bases     1  23.6532 7518.0 1734.4
## <none>              7541.7 1734.7
## + Earned_Runs       1  16.8517 7524.8 1735.0
## + Home_Runs         1  12.1437 7529.5 1735.5
## + Walks_Allowed     1   4.4441 7537.2 1736.2
## + Hits_Allowed      1   1.3384 7540.4 1736.5
## + Triples           1   1.2032 7540.5 1736.5
## + Doubles           1   0.5432 7541.1 1736.6
## + Strikeouts_Allowed 1   0.3847 7541.3 1736.6
## + Home_Run_Allowed  1   0.0044 7541.7 1736.7
##
## Step: AIC=1734.27
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats + Hits + Runs_Against + Caught_Stealing + Double_Plays +
##   Strike_Outs + Walks
##
##
##      Df Sum of Sq    RSS    AIC
## + Stolen_Bases     1  29.1793 7487.8 1733.4
## <none>              7517.0 1734.3
## + Earned_Runs       1  14.4245 7502.5 1734.9
## + Home_Runs         1   5.0675 7511.9 1735.8
## + Walks_Allowed     1   2.2676 7514.7 1736.0
## + Hits_Allowed      1   0.9549 7516.0 1736.2
## + Doubles           1   0.8624 7516.1 1736.2
## + Home_Run_Allowed  1   0.8151 7516.1 1736.2
## + Strikeouts_Allowed 1   0.3513 7516.6 1736.2

```

```
## + Triples          1      0.2608 7516.7 1736.2
##
## Step:  AIC=1733.43
## Games_Won ~ Runs_Scored + Earned_Run_Average + Saves + Complete_Games +
##   Fielding_Percentage + Shutout + Errors + Infield_Put_Outs +
##   At_Bats + Hits + Runs_Against + Caught_Stealing + Double_Plays +
##   Strike_Outs + Walks + Stolen_Bases
##
##              Df Sum of Sq    RSS    AIC
## <none>                7487.8 1733.4
## + Home_Runs          1   17.4191 7470.4 1733.7
## + Earned_Runs         1   14.2028 7473.6 1734.0
## + Strikeouts_Allowed  1    2.6140 7485.2 1735.2
## + Walks_Allowed       1    2.0987 7485.7 1735.2
## + Doubles             1    1.8371 7485.9 1735.2
## + Hits_Allowed        1    0.9245 7486.8 1735.3
## + Home_Run_Allowed    1    0.1328 7487.6 1735.4
## + Triples             1    0.0773 7487.7 1735.4

##
## Call:
## lm(formula = Games_Won ~ Runs_Scored + Earned_Run_Average + Saves +
##   Complete_Games + Fielding_Percentage + Shutout + Errors +
##   Infield_Put_Outs + At_Bats + Hits + Runs_Against + Caught_Stealing +
##   Double_Plays + Strike_Outs + Walks + Stolen_Bases, data = df_p3)
##
## Coefficients:
##      (Intercept)      Runs_Scored  Earned_Run_Average
##      -1.001e+02      8.567e-02      -2.275e+00
##           Saves      Complete_Games  Fielding_Percentage
##      2.955e-01      1.406e-01      1.105e+02
##      Shutout      Errors      Infield_Put_Outs
##      1.703e-01     -1.241e-03      5.703e-02
##      At_Bats      Hits      Runs_Against
##     -4.673e-02      3.857e-02     -5.050e-02
##   Caught_Stealing      Double_Plays      Strike_Outs
##     -5.678e-02     -9.962e-03      2.472e-03
##           Walks      Stolen_Bases
##     -4.602e-03      6.869e-03
```

```
fit3 <- lm(Games_Won ~ Runs_Scored + Earned_Run_Average + Saves +
  Complete_Games + Fielding_Percentage + Shutout + Errors +
  Infield_Put_Outs + At_Bats + Hits + Runs_Against + Caught_Stealing +
  Double_Plays + Strike_Outs + Walks + Stolen_Bases, data = df_p3)

summary(fit3)
```

```
##
## Call:
## lm(formula = Games_Won ~ Runs_Scored + Earned_Run_Average + Saves +
##   Complete_Games + Fielding_Percentage + Shutout + Errors +
##   Infield_Put_Outs + At_Bats + Hits + Runs_Against + Caught_Stealing +
##   Double_Plays + Strike_Outs + Walks + Stolen_Bases, data = df_p3)
```

```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -10.0646  -2.1949   0.0916   2.1205  10.3707
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)   -1.001e+02  3.867e+01  -2.588  0.00984 **
## Runs_Scored    8.567e-02  3.893e-03  22.003 < 2e-16 ***
## Earned_Run_Average -2.275e+00  1.982e+00  -1.148  0.25144
## Saves          2.955e-01  2.253e-02  13.117 < 2e-16 ***
## Complete_Games  1.406e-01  1.529e-02   9.193 < 2e-16 ***
## Fielding_Percentage 1.105e+02  3.844e+01   2.874  0.00417 **
## Shutout        1.703e-01  3.950e-02   4.311 1.86e-05 ***
## Errors        -1.241e-03  1.189e-02  -0.104  0.91688
## Infield_Put_Outs  5.703e-02  5.393e-03  10.576 < 2e-16 ***
## At_Bats        -4.673e-02  5.169e-03  -9.040 < 2e-16 ***
## Hits           3.857e-02  5.552e-03   6.947 8.40e-12 ***
## Runs_Against   -5.050e-02  1.196e-02  -4.222 2.74e-05 ***
## Caught_Stealing  -5.678e-02  1.179e-02  -4.814 1.81e-06 ***
## Double_Plays   -9.962e-03  6.995e-03  -1.424  0.15485
## Strike_Outs     2.472e-03  1.504e-03   1.643  0.10076
## Walks          -4.602e-03  2.711e-03  -1.698  0.09001 .
## Stolen_Bases    6.869e-03  4.121e-03   1.667  0.09598 .
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 3.241 on 713 degrees of freedom
## Multiple R-squared:  0.9354, Adjusted R-squared:  0.9339
## F-statistic: 645.2 on 16 and 713 DF,  p-value: < 2.2e-16

# Period 4 - 1990 to 2010
df_p4 <- drop_na(df_1990_2010[, colSums(is.na(df_1990_2010)) <
                                     nrow(df_1990_2010)))[-c(1, 3)]

## Forward stepwise regression
null_modelp4 <- lm(Games_Won ~ 1, data = df_p4)
full_modelp4 <- lm(Games_Won ~ ., data = df_p4)

step(null_modelp4, direction = "forward", scope = formula(full_modelp4))

## Start:  AIC=1619.18
## Games_Won ~ 1
##
##              Df Sum of Sq  RSS    AIC
## + Saves          1    19728.7 24611 1426.9
## + Runs_Against    1    19487.7 24852 1430.1
## + Earned_Run_Average 1    19333.2 25006 1432.2
## + Earned_Runs      1    18422.0 25917 1444.0
## + Runs_Scored      1    15400.5 28939 1480.4
## + Hits_Allowed     1    12364.0 31975 1513.3
## + Infield_Put_Outs 1    11292.4 33047 1524.2
## + Walks_Allowed    1    10037.6 34302 1536.5
## + Shutout          1    10004.9 34335 1536.8
```



```
## + Walks          1      8519.6 35820 1550.8
## + Home_Runs       1      7574.2 36765 1559.4
## + Fielding_Percentage 1      7284.2 37055 1562.0
## + Hits            1      7265.3 37074 1562.1
## + Errors           1      6992.7 37347 1564.5
## + Home_Run_Allowed 1      6720.4 37619 1566.9
## + Strikeouts_Allowed 1      6566.2 37773 1568.3
## + Sacrifice_Fly    1      4757.9 39581 1583.7
## + Doubles          1      2831.5 41508 1599.4
## + At_Bats          1      1825.3 42514 1607.3
## + Double_Plays     1      1533.7 42806 1609.6
## + Strike-Outs      1      1076.9 43263 1613.1
## + Complete_Games   1        935.7 43404 1614.1
## + Hit_By_Pitch     1        556.5 43783 1617.0
## + Stolen_Bases     1        422.2 43917 1618.0
## + Caught_Stealing  1        415.4 43924 1618.1
## <none>              44339 1619.2
## + Triples          1        213.0 44126 1619.6
```

```
##
## Step: AIC=1426.91
## Games_Won ~ Saves
```

```
##
##              Df Sum of Sq  RSS    AIC
## + Runs_Scored      1    10503.0 14108 1245.3
## + Runs_Against     1     6196.4 18414 1333.2
## + Earned_Run_Average 1     6116.7 18494 1334.6
## + Walks             1     5848.4 18762 1339.4
## + Earned_Runs       1     5689.8 18921 1342.2
## + Hits              1     5440.4 19170 1346.5
## + Home_Runs         1     4096.4 20514 1368.8
## + Hits_Allowed      1     3614.4 20996 1376.5
## + Infield_Put_Outs  1     3421.0 21190 1379.5
## + Doubles           1     3072.1 21539 1384.9
## + Fielding_Percentage 1     3040.5 21570 1385.4
## + Shutout           1     2952.3 21658 1386.7
## + Errors            1     2913.8 21697 1387.3
## + Walks_Allowed     1     2676.2 21935 1390.9
## + Sacrifice_Fly     1     2653.1 21958 1391.3
## + Strikeouts_Allowed 1     2367.0 22244 1395.5
## + At_Bats           1     2306.3 22304 1396.4
## + Home_Run_Allowed  1     1890.2 22720 1402.5
## + Complete_Games    1     1465.0 23146 1408.7
## + Caught_Stealing   1       527.7 24083 1421.8
## + Strike-Outs       1       291.6 24319 1425.0
## + Hit_By_Pitch      1       156.2 24455 1426.8
## <none>              24611 1426.9
## + Double_Plays      1        57.0 24554 1428.1
## + Triples           1         50.7 24560 1428.2
## + Stolen_Bases      1         18.6 24592 1428.7
```

```
##
## Step: AIC=1245.28
## Games_Won ~ Saves + Runs_Scored
```

```
##
##              Df Sum of Sq    RSS    AIC
```

```

## + Runs_Against      1  10964.5  3143.2  751.79
## + Earned_Run_Average 1  10697.1  3410.6  778.73
## + Earned_Runs        1  10630.2  3477.5  785.14
## + Hits_Allowed       1   7150.6  6957.1 1013.98
## + Shutout            1   4757.4  9350.3 1111.54
## + Home_Run_Allowed   1   4455.9  9651.8 1122.02
## + Strikeouts_Allowed 1   2774.8 11332.9 1175.00
## + Walks_Allowed      1   2398.4 11709.4 1185.79
## + Fielding_Percentage 1   2047.2 12060.5 1195.54
## + Infield_Put_Outs   1   2011.4 12096.3 1196.52
## + Errors              1   1977.6 12130.2 1197.44
## + Complete_Games     1    940.8 13166.9 1224.50
## + Walks               1    584.9 13522.8 1233.30
## + At_Bats             1    474.9 13632.8 1235.98
## + Triples             1    267.0 13840.7 1240.97
## + Double_Plays        1    228.4 13879.3 1241.89
## + Caught_Stealing     1    118.3 13989.4 1244.50
## + Hits                1    113.4 13994.4 1244.61
## + Home_Runs           1     90.4 14017.3 1245.15
## <none>                1         14107.7 1245.28
## + Strike_Outs         1     67.4 14040.3 1245.70
## + Sacrifice_Fly       1     55.2 14052.5 1245.98
## + Hit_By_Pitch        1     47.6 14060.1 1246.16
## + Stolen_Bases        1     10.9 14096.8 1247.02
## + Doubles             1      0.0 14107.7 1247.28
##
## Step:  AIC=751.79
## Games_Won ~ Saves + Runs_Scored + Runs_Against
##
##              Df Sum of Sq  RSS  AIC
## + Triples      1  108.610 3034.6 742.19
## + Shutout      1   80.243 3063.0 745.26
## + Complete_Games 1   69.088 3074.1 746.46
## + Strikeouts_Allowed 1  50.722 3092.5 748.42
## + At_Bats      1  43.552 3099.7 749.19
## + Infield_Put_Outs 1  38.822 3104.4 749.69
## + Walks_Allowed 1  37.723 3105.5 749.81
## + Walks        1  28.756 3114.5 750.76
## <none>          1         3143.2 751.79
## + Doubles      1  15.641 3127.6 752.14
## + Errors       1  14.349 3128.9 752.28
## + Earned_Run_Average 1  13.680 3129.5 752.35
## + Double_Plays  1  12.308 3130.9 752.50
## + Home_Runs     1  12.001 3131.2 752.53
## + Caught_Stealing 1  11.012 3132.2 752.63
## + Stolen_Bases  1  10.353 3132.9 752.70
## + Fielding_Percentage 1   6.357 3136.9 753.12
## + Hits_Allowed  1   5.309 3137.9 753.23
## + Strike_Outs   1   3.728 3139.5 753.40
## + Home_Run_Allowed 1   3.635 3139.6 753.41
## + Hits          1   2.012 3141.2 753.58
## + Sacrifice_Fly  1   1.674 3141.5 753.61
## + Earned_Runs   1   1.338 3141.9 753.65
## + Hit_By_Pitch  1   0.192 3143.0 753.77

```

```

##
## Step:  AIC=742.19
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples
##
##           Df Sum of Sq    RSS    AIC
## + Shutout      1      84.912 2949.7 734.82
## + Complete_Games 1      68.793 2965.8 736.62
## + Strikeouts_Allowed 1     51.894 2982.7 738.49
## + At_Bats       1     40.310 2994.3 739.77
## + Infield_Put_Outs 1     36.848 2997.8 740.15
## + Walks_Allowed 1     29.993 3004.6 740.91
## + Caught_Stealing 1     25.656 3008.9 741.38
## + Stolen_Bases   1     25.525 3009.1 741.40
## <none>                3034.6 742.19
## + Errors          1     18.320 3016.3 742.19
## + Walks           1     16.655 3017.9 742.37
## + Doubles         1     14.305 3020.3 742.63
## + Sacrifice_Fly   1     11.243 3023.4 742.96
## + Fielding_Percentage 1      9.092 3025.5 743.20
## + Double_Plays     1      9.035 3025.6 743.20
## + Earned_Run_Average 1      8.004 3026.6 743.31
## + Strike_Outs      1      4.795 3029.8 743.66
## + Home_Run_Allowed 1      4.456 3030.2 743.70
## + Hits_Allowed     1      3.545 3031.1 743.80
## + Hit_By_Pitch     1      3.264 3031.3 743.83
## + Earned_Runs      1      0.112 3034.5 744.17
## + Home_Runs        1      0.025 3034.6 744.18
## + Hits             1      0.005 3034.6 744.19
##
## Step:  AIC=734.82
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout
##
##           Df Sum of Sq    RSS    AIC
## + Complete_Games 1     49.822 2899.9 731.20
## + Strikeouts_Allowed 1    43.834 2905.9 731.88
## + At_Bats         1    40.493 2909.2 732.26
## + Infield_Put_Outs 1    38.349 2911.3 732.50
## + Caught_Stealing 1    33.506 2916.2 733.05
## + Walks_Allowed   1    32.613 2917.1 733.15
## + Stolen_Bases     1    25.893 2923.8 733.91
## + Walks            1    19.016 2930.7 734.69
## <none>                2949.7 734.82
## + Doubles         1    16.524 2933.2 734.97
## + Errors          1    14.190 2935.5 735.23
## + Double_Plays     1    11.628 2938.1 735.52
## + Sacrifice_Fly   1    10.258 2939.4 735.67
## + Earned_Run_Average 1      6.440 2943.3 736.10
## + Fielding_Percentage 1      6.357 2943.3 736.11
## + Hits_Allowed     1      4.853 2944.8 736.28
## + Strike_Outs      1      4.388 2945.3 736.33
## + Hit_By_Pitch     1      2.584 2947.1 736.53
## + Home_Runs        1      1.224 2948.5 736.68
## + Home_Run_Allowed 1      0.568 2949.1 736.76
## + Hits             1      0.004 2949.7 736.82

```

```

## + Earned_Runs          1      0.003 2949.7 736.82
##
## Step:  AIC=731.2
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games
##
##              Df Sum of Sq    RSS    AIC
## + Strikeouts_Allowed  1      60.323 2839.6 726.26
## + Infield_Put_Outs    1      43.118 2856.8 728.26
## + At_Bats              1      30.644 2869.2 729.69
## + Caught_Stealing      1      22.961 2876.9 730.58
## + Stolen_Bases         1      21.182 2878.7 730.78
## + Walks                1      21.073 2878.8 730.79
## + Walks_Allowed        1      19.839 2880.0 730.93
## + Errors               1      19.414 2880.5 730.98
## <none>                  2899.9 731.20
## + Double_Plays         1      14.723 2885.2 731.52
## + Doubles              1      13.999 2885.9 731.60
## + Fielding_Percentage  1       9.625 2890.2 732.10
## + Earned_Run_Average   1       6.688 2893.2 732.44
## + Sacrifice_Fly        1       6.646 2893.2 732.44
## + Hits_Allowed         1       4.008 2895.9 732.74
## + Home_Run_Allowed     1       3.591 2896.3 732.79
## + Hit_By_Pitch         1       3.577 2896.3 732.79
## + Home_Runs            1       0.640 2899.2 733.13
## + Strike_Outs          1       0.527 2899.3 733.14
## + Hits                 1       0.492 2899.4 733.14
## + Earned_Runs          1       0.026 2899.8 733.20
##
## Step:  AIC=726.26
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games + Strikeouts_Allowed
##
##              Df Sum of Sq    RSS    AIC
## + Walks_Allowed        1      39.735 2799.8 723.61
## + At_Bats              1      30.781 2808.8 724.67
## + Hits_Allowed         1      29.447 2810.1 724.82
## + Infield_Put_Outs     1      28.259 2811.3 724.96
## + Caught_Stealing      1      23.682 2815.9 725.50
## + Stolen_Bases         1      18.905 2820.7 726.06
## + Errors               1      18.525 2821.0 726.10
## <none>                  2839.6 726.26
## + Doubles              1      14.008 2825.5 726.63
## + Walks                1      12.474 2827.1 726.81
## + Fielding_Percentage  1      11.469 2828.1 726.93
## + Sacrifice_Fly        1      11.293 2828.3 726.95
## + Strike_Outs          1       5.777 2833.8 727.59
## + Home_Run_Allowed     1       4.218 2835.3 727.77
## + Earned_Run_Average   1       2.890 2836.7 727.93
## + Hit_By_Pitch         1       2.259 2837.3 728.00
## + Hits                 1       1.483 2838.1 728.09
## + Home_Runs            1       0.281 2839.3 728.23
## + Earned_Runs          1       0.253 2839.3 728.23
## + Double_Plays         1       0.236 2839.3 728.23

```

```

##
## Step: AIC=723.61
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
## Complete_Games + Strikeouts_Allowed + Walks_Allowed
##
##
##      Df Sum of Sq  RSS   AIC
## + At_Bats      1    35.503 2764.3 721.40
## + Infield_Put_Outs 1    28.237 2771.6 722.27
## + Caught_Stealing 1    21.623 2778.2 723.05
## + Stolen_Bases    1    18.734 2781.1 723.40
## + Errors          1    17.912 2781.9 723.49
## <none>                      2799.8 723.61
## + Walks          1    16.696 2783.1 723.64
## + Doubles         1    15.934 2783.9 723.73
## + Fielding_Percentage 1    11.278 2788.5 724.28
## + Home_Run_Allowed 1    10.880 2788.9 724.33
## + Sacrifice_Fly   1     9.893 2789.9 724.44
## + Hits_Allowed    1     6.735 2793.1 724.82
## + Strike_Outs     1     5.739 2794.1 724.93
## + Hit_By_Pitch    1     3.640 2796.2 725.18
## + Earned_Run_Average 1     2.055 2797.8 725.37
## + Double_Plays    1     0.915 2798.9 725.50
## + Earned_Runs     1     0.612 2799.2 725.54
## + Hits            1     0.545 2799.3 725.55
## + Home_Runs       1     0.020 2799.8 725.61
##
##
## Step: AIC=721.4
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
## Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats
##
##
##      Df Sum of Sq  RSS   AIC
## + Infield_Put_Outs 1   106.920 2657.4 710.38
## + Hits              1    57.794 2706.5 716.43
## + Errors            1    27.453 2736.9 720.11
## + Fielding_Percentage 1    20.259 2744.1 720.97
## + Stolen_Bases      1    17.451 2746.9 721.31
## + Strike_Outs       1    17.446 2746.9 721.31
## <none>                      2764.3 721.40
## + Caught_Stealing   1    13.038 2751.3 721.84
## + Hits_Allowed      1    12.179 2752.1 721.94
## + Home_Run_Allowed  1    11.624 2752.7 722.01
## + Sacrifice_Fly     1     8.966 2755.3 722.33
## + Hit_By_Pitch      1     6.409 2757.9 722.63
## + Doubles           1     6.395 2757.9 722.64
## + Earned_Run_Average 1     5.064 2759.2 722.79
## + Walks             1     3.623 2760.7 722.97
## + Double_Plays      1     2.472 2761.8 723.10
## + Home_Runs         1     1.928 2762.4 723.17
## + Earned_Runs       1     1.741 2762.6 723.19
##
##
## Step: AIC=710.38
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
## Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
## Infield_Put_Outs

```

```

##
##           Df Sum of Sq    RSS    AIC
## + Hits           1    200.511 2456.9 686.49
## + Strike_Outs     1     41.722 2615.7 707.16
## + Errors          1     31.683 2625.7 708.42
## + Home_Run_Allowed 1     21.921 2635.5 709.65
## + Fielding_Percentage 1    19.352 2638.0 709.97
## <none>                2657.4 710.38
## + Hit_By_Pitch     1     13.975 2643.4 710.64
## + Stolen_Bases     1     13.302 2644.1 710.73
## + Home_Runs        1     12.010 2645.4 710.89
## + Sacrifice_Fly    1      6.396 2651.0 711.59
## + Caught_Stealing  1      5.000 2652.4 711.76
## + Walks            1      4.957 2652.4 711.77
## + Earned_Runs      1      2.946 2654.4 712.02
## + Earned_Run_Average 1      2.924 2654.5 712.02
## + Doubles          1      2.669 2654.7 712.05
## + Hits_Allowed     1      2.360 2655.0 712.09
## + Double_Plays     1      0.182 2657.2 712.36
##
## Step:  AIC=686.49
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
##      Infield_Put_Outs + Hits
##
##           Df Sum of Sq    RSS    AIC
## + Home_Run_Allowed  1    22.8573 2434.0 685.41
## + Caught_Stealing   1    16.8543 2440.0 686.22
## + Errors            1    16.8218 2440.1 686.23
## <none>                2456.9 686.49
## + Home_Runs         1     9.8217 2447.1 687.17
## + Fielding_Percentage 1     9.3939 2447.5 687.23
## + Hit_By_Pitch      1     4.1908 2452.7 687.93
## + Sacrifice_Fly     1     3.8513 2453.0 687.98
## + Doubles           1     2.9928 2453.9 688.09
## + Stolen_Bases      1     1.0873 2455.8 688.35
## + Strike_Outs       1     0.8376 2456.1 688.38
## + Walks             1     0.4023 2456.5 688.44
## + Double_Plays      1     0.2216 2456.7 688.46
## + Hits_Allowed      1     0.2181 2456.7 688.46
## + Earned_Runs       1     0.1040 2456.8 688.48
## + Earned_Run_Average 1     0.0783 2456.8 688.48
##
## Step:  AIC=685.41
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
##      Infield_Put_Outs + Hits + Home_Run_Allowed
##
##           Df Sum of Sq    RSS    AIC
## + Errors           1    25.6830 2408.3 683.91
## + Fielding_Percentage 1    15.0219 2419.0 685.37
## <none>                2434.0 685.41
## + Caught_Stealing   1    12.2845 2421.7 685.74
## + Home_Runs         1    11.9366 2422.1 685.79

```

```

## + Doubles          1      6.5224 2427.5 686.52
## + Hit_By_Pitch     1      3.8344 2430.2 686.89
## + Sacrifice_Fly    1      3.6330 2430.4 686.92
## + Stolen_Bases     1      3.0271 2431.0 687.00
## + Earned_Runs      1      1.9343 2432.1 687.15
## + Earned_Run_Average 1      1.7188 2432.3 687.18
## + Strike-Outs      1      0.5507 2433.5 687.33
## + Hits_Allowed     1      0.5220 2433.5 687.34
## + Double_Plays     1      0.1635 2433.9 687.39
## + Walks            1      0.0450 2434.0 687.40
##
## Step:  AIC=683.91
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
##      Infield_Put_Outs + Hits + Home_Run_Allowed + Errors
##
##              Df Sum of Sq    RSS    AIC
## + Fielding_Percentage  1      49.031 2359.3 679.12
## <none>                    2408.3 683.91
## + Home_Runs            1      12.929 2395.4 684.13
## + Earned_Run_Average   1       7.385 2401.0 684.89
## + Doubles              1       7.181 2401.2 684.92
## + Earned_Runs          1       6.893 2401.4 684.96
## + Caught_Stealing      1       6.482 2401.9 685.02
## + Sacrifice_Fly        1       4.233 2404.1 685.33
## + Hit_By_Pitch         1       3.941 2404.4 685.37
## + Stolen_Bases         1       3.416 2404.9 685.44
## + Hits_Allowed         1       2.994 2405.3 685.50
## + Strike-Outs          1       1.249 2407.1 685.74
## + Double_Plays         1       0.741 2407.6 685.81
## + Walks                1       0.012 2408.3 685.91
##
## Step:  AIC=679.12
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +
##      Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
##      Infield_Put_Outs + Hits + Home_Run_Allowed + Errors + Fielding_Percentage
##
##              Df Sum of Sq    RSS    AIC
## + Home_Runs            1      17.2765 2342.0 678.70
## <none>                    2359.3 679.12
## + Earned_Run_Average   1       9.1798 2350.1 679.83
## + Earned_Runs          1       8.9818 2350.3 679.86
## + Caught_Stealing      1       6.8546 2352.5 680.16
## + Sacrifice_Fly        1       6.5983 2352.7 680.20
## + Hit_By_Pitch         1       4.7356 2354.6 680.46
## + Doubles              1       3.8322 2355.5 680.58
## + Double_Plays         1       2.0118 2357.3 680.84
## + Stolen_Bases         1       1.2769 2358.0 680.94
## + Hits_Allowed         1       1.0301 2358.3 680.98
## + Strike-Outs          1       0.4132 2358.9 681.06
## + Walks                1       0.0176 2359.3 681.12
##
## Step:  AIC=678.7
## Games_Won ~ Saves + Runs_Scored + Runs_Against + Triples + Shutout +

```

```
## Complete_Games + Strikeouts_Allowed + Walks_Allowed + At_Bats +
## Infield_Put_Outs + Hits + Home_Run_Allowed + Errors + Fielding_Percentage +
## Home_Runs
##
##           Df Sum of Sq    RSS    AIC
## <none>                2342.0 678.70
## + Earned_Run_Average  1     9.3615 2332.7 679.37
## + Earned_Runs         1     9.1813 2332.8 679.40
## + Caught_Stealing     1     5.9140 2336.1 679.86
## + Hit_By_Pitch        1     5.1676 2336.9 679.97
## + Stolen_Bases        1     2.9138 2339.1 680.28
## + Sacrifice_Fly       1     2.5188 2339.5 680.34
## + Doubles             1     2.4708 2339.6 680.35
## + Double_Plays        1     1.6169 2340.4 680.47
## + Walks               1     1.3406 2340.7 680.51
## + Hits_Allowed        1     0.7988 2341.2 680.58
## + Strike_Outs         1     0.0200 2342.0 680.69

##
## Call:
## lm(formula = Games_Won ~ Saves + Runs_Scored + Runs_Against +
##     Triples + Shutout + Complete_Games + Strikeouts_Allowed +
##     Walks_Allowed + At_Bats + Infield_Put_Outs + Hits + Home_Run_Allowed +
##     Errors + Fielding_Percentage + Home_Runs, data = df_p4)
##
## Coefficients:
##           (Intercept)              Saves          Runs_Scored
##           1.108e+03          3.678e-01          7.879e-02
##           Runs_Against            Triples              Shutout
##           -5.653e-02          -6.822e-02          1.519e-01
##           Complete_Games  Strikeouts_Allowed      Walks_Allowed
##           1.239e-01          2.328e-03          -8.176e-03
##           At_Bats      Infield_Put_Outs              Hits
##           -3.440e-02          4.363e-02          3.042e-02
##           Home_Run_Allowed            Errors  Fielding_Percentage
##           -2.304e-02          -1.949e-01          -1.096e+03
##           Home_Runs
##           1.234e-02
```

```
fit4 <- lm(Games_Won ~ Saves + Runs_Scored + Runs_Against +
  Triples + Shutout + Complete_Games + Strikeouts_Allowed +
  Walks_Allowed + At_Bats + Infield_Put_Outs + Hits +
  Home_Run_Allowed + Errors + Fielding_Percentage + Home_Runs,
  data = df_p4)

summary(fit4)
```

```
##
## Call:
## lm(formula = Games_Won ~ Saves + Runs_Scored + Runs_Against +
##     Triples + Shutout + Complete_Games + Strikeouts_Allowed +
##     Walks_Allowed + At_Bats + Infield_Put_Outs + Hits + Home_Run_Allowed +
##     Errors + Fielding_Percentage + Home_Runs, data = df_p4)
```



```
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -7.7050 -1.8150 -0.1751  1.7257  8.6409
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept)    1.108e+03  4.040e+02   2.741 0.006467 **
## Saves          3.678e-01  2.754e-02  13.352 < 2e-16 ***
## Runs_Scored    7.879e-02  4.912e-03  16.038 < 2e-16 ***
## Runs_Against  -5.653e-02  4.187e-03 -13.499 < 2e-16 ***
## Triples        -6.821e-02  1.833e-02  -3.721 0.000235 ***
## Shutout        1.519e-01  5.713e-02   2.659 0.008239 **
## Complete_Games 1.239e-01  4.906e-02   2.526 0.012041 *
## Strikeouts_Allowed 2.328e-03  1.840e-03   1.265 0.206668
## Walks_Allowed  -8.176e-03  2.859e-03  -2.859 0.004532 **
## At_Bats        -3.440e-02  5.145e-03  -6.685 1.06e-10 ***
## Infield_Put_Outs 4.363e-02  6.758e-03   6.456 4.09e-10 ***
## Hits           3.042e-02  6.185e-03   4.918 1.41e-06 ***
## Home_Run_Allowed -2.304e-02  9.143e-03  -2.520 0.012244 *
## Errors         -1.949e-01  6.621e-02  -2.944 0.003484 **
## Fielding_Percentage -1.096e+03  4.096e+02  -2.675 0.007860 **
## Home_Runs       1.234e-02  8.107e-03   1.522 0.129031
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 2.731 on 314 degrees of freedom
## Multiple R-squared:  0.9472, Adjusted R-squared:  0.9447
## F-statistic: 375.4 on 15 and 314 DF,  p-value: < 2.2e-16
```

```
# Use the 4th regression model from 1990 to 2010 and forecast the number of games
# won for the New York Yankees and the Toronto Blue Jays using values for the
# independent variables for 2012 and 2015.
```

```
# New York Yankees
```

```
df_yk <- data %>%
  filter(Team_Name == 'New York Yankees', Year %in% c(2012, 2015))
```

```
df_yk2 <- df_yk %>%
  select(Saves, Runs_Scored, Runs_Against, Triples, Shutout, Complete_Games,
         Strikeouts_Allowed, Walks_Allowed, At_Bats, Infield_Put_Outs, Hits,
         Home_Run_Allowed, Errors, Fielding_Percentage, Home_Runs)
```

```
pred_yk <- predict(fit4, df_yk2)
```

```
cor(pred_yk, df_yk$Games_Won)
```

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

```
rmse(as.double(df_yk$Games_Won), as.double(pred_yk))
```

```
## [1] 2.779608
```

```

# Game won 2012 Toronto Blue Jays
df_bj <- data %>%
  filter(Team_Name == 'Toronto Blue Jays', Year %in% c(2012, 2015))

df_bj2 <- df_bj %>%
  select(Saves, Runs_Scored, Runs_Against, Triples, Shutout, Complete_Games,
         Strikeouts_Allowed, Walks_Allowed, At_Bats, Infield_Put_Outs, Hits,
         Home_Run_Allowed, Errors, Fielding_Percentage, Home_Runs)

pred_bj <- predict(fit4, df_bj2)

cor(pred_bj, df_bj$Games_Won)

## [1] 1

rmse(as.double(df_bj$Games_Won), as.double(pred_bj))

## [1] 5.060376

```