Project - STAT 151A

Aditya Jhanwar

12/8/2019

```
load(url("http://www.stat.berkeley.edu/users/nolan/data/baseball2012.rda"))
baseball = as_tibble(baseball)
```

Data Exploration and Feature Creation

1)

The first step is to clean the `baseball` data by removing unecessary explanatory variables and entries missing a `salary (observed Yi)` value.

```
baseball = baseball %>% dplyr::select(-c("ID", "yearID", "teamID", "lgID", "nameFirst", "nameLast", "G_
baseball = baseball %>% drop_na(salary) # remove units with no salary values
```

Next, I followed the author's process in creating new features as decribed in the textbook.

```
baseball = baseball %>% mutate(AVG = CH/CAB,
                               OBP = 100*(CH + CBB)/(CAB + CBB),
                               CAB.avg  = CAB/years,
                               CH.avg   = CH/years,
                               CHR.avg  = CHR/years,
                               CR.avg   = CR/years,
                               CRBI.avg = CRBI/years)
```

Finally, I cleaned the `Position` and `Years` explanatory variables through reimpementing them as dummy variables.

According to Fox's description of his analysis, he mentions **middle infielders** as players who consistently played second base or shortstop so I classified all individuals with either position as such.

```
new.pos = c()
MI = c("12", "1S", "23", "2B", "2S", "3S", "O2", "SS")
C  = c("C", "C1", "OC")
CF = c("CF")

# Assign new factor assignment for MI (middle infielders), C (catcher), CF (center field), and O (other
for (i in baseball$POS){
  if      (i %in% MI) { new.pos = c(new.pos, "MI") }
  else if (i %in% C)  { new.pos = c(new.pos, "C")  }
  else if (i %in% CF) { new.pos = c(new.pos, "CF") }
  else                { new.pos = c(new.pos, "O")  }
}

baseball$POS = relevel(factor(new.pos), "O")
```

```r
new.years = c()
neg.cont  = 6
neg.sal   = 3

for (i in baseball$years){
  if      (i >= neg.cont) { new.years = c(new.years, ".cont") }
  else if (i >= neg.sal)  { new.years = c(new.years, ".sal")   }
  else                    { new.years = c(new.years, "other")        }
}

baseball$neg = relevel(factor(new.years), "other")
```

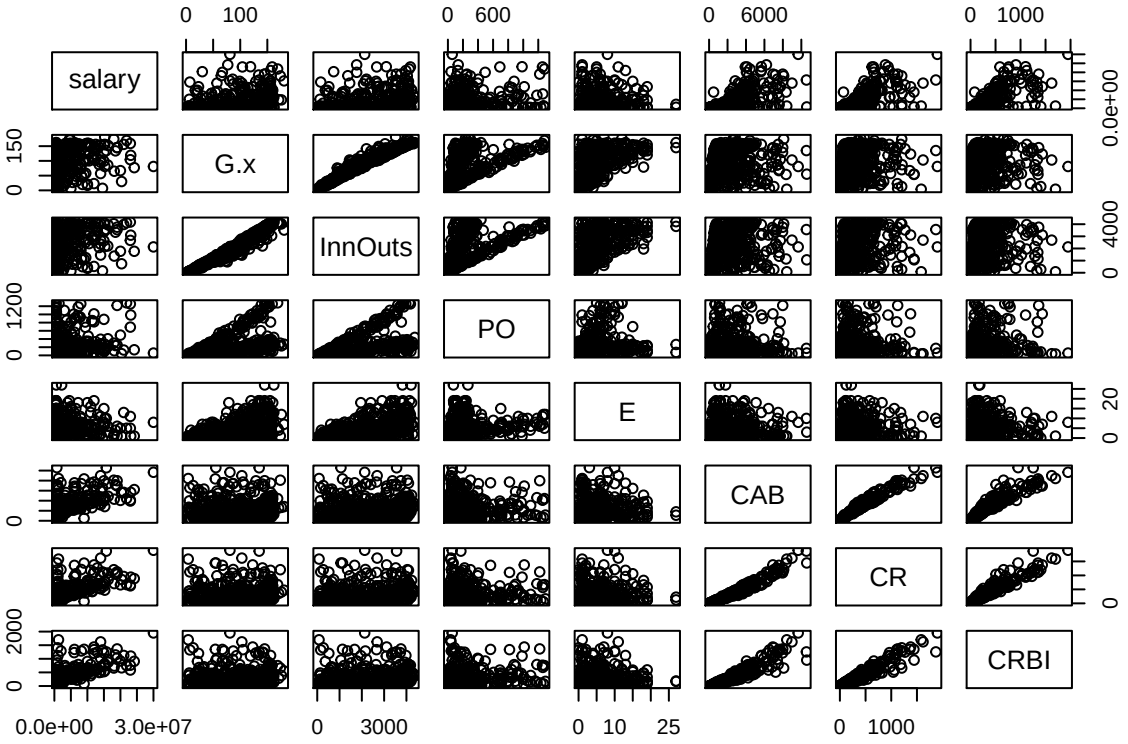
```r
lm.fit = lm(salary ~ ., data = baseball)
new.baseball = as_tibble(model.matrix(lm.fit)[,-1])
new.baseball$salary = baseball$salary
```

Now that we have completed the feature creation process, the next step is to analyze the data itself.

Firstly, I'll look at the the structure of the data itself and how the different variables are associated with each other. Since there are a lot of explanatory variables within the data, I will select a few key variables I believe to be the most influential in the model and investigate the structure.

Note: - `G.x` = Position played at specified position - `InnOut` = Time played in the field expressed as outs - `PO` = Putouts - `E` = Errors - `CAB` = Career at bats - `CR` = Career runs - `CRBI` = Career runs batted in

```
pairs(salary ~ G.x + InnOuts + PO + E + CAB + CR + CRBI, data=new.baseball)
```



From observing the paired structures of data it is evident that some features are uncorrelated whereas others are strongly correlated. However, this is mostly expected as certain features relate to one another. For example, a player's career at bats would be associated with his career runs or career runs batted in since all tie into a players capability of scoring bases.

This indicates a possible issue in inference of coefficients through linear modeling since the standard error calculation will be grossly inflated.

In addition, I noticed some of the variables have a stronger correlation with the salary than that of other variables. For example, `G.x` and `InnOuts` do not seem to have a strong association with `salary` whereas `CAB`, `CR`, and `CRBI` have comparitively stronger correlations with `salary`. This indicates some sort of variable selection and model pruning may be of benefit.

Next, I'd like to look into whether the data is distributed normally as per an assumption of guassian distributed errors in linear modelling.

```
sal1 = ggplot(data=new.baseball, aes(x=salary)) + geom_histogram(bins=40) + ggtitle("Histogram of Salary
sal2 = ggplot(data=new.baseball, aes(y=salary)) + geom_boxplot() + ggtitle("Boxplot of Salary")
grid.arrange(sal1, sal2, nrow=1)
```

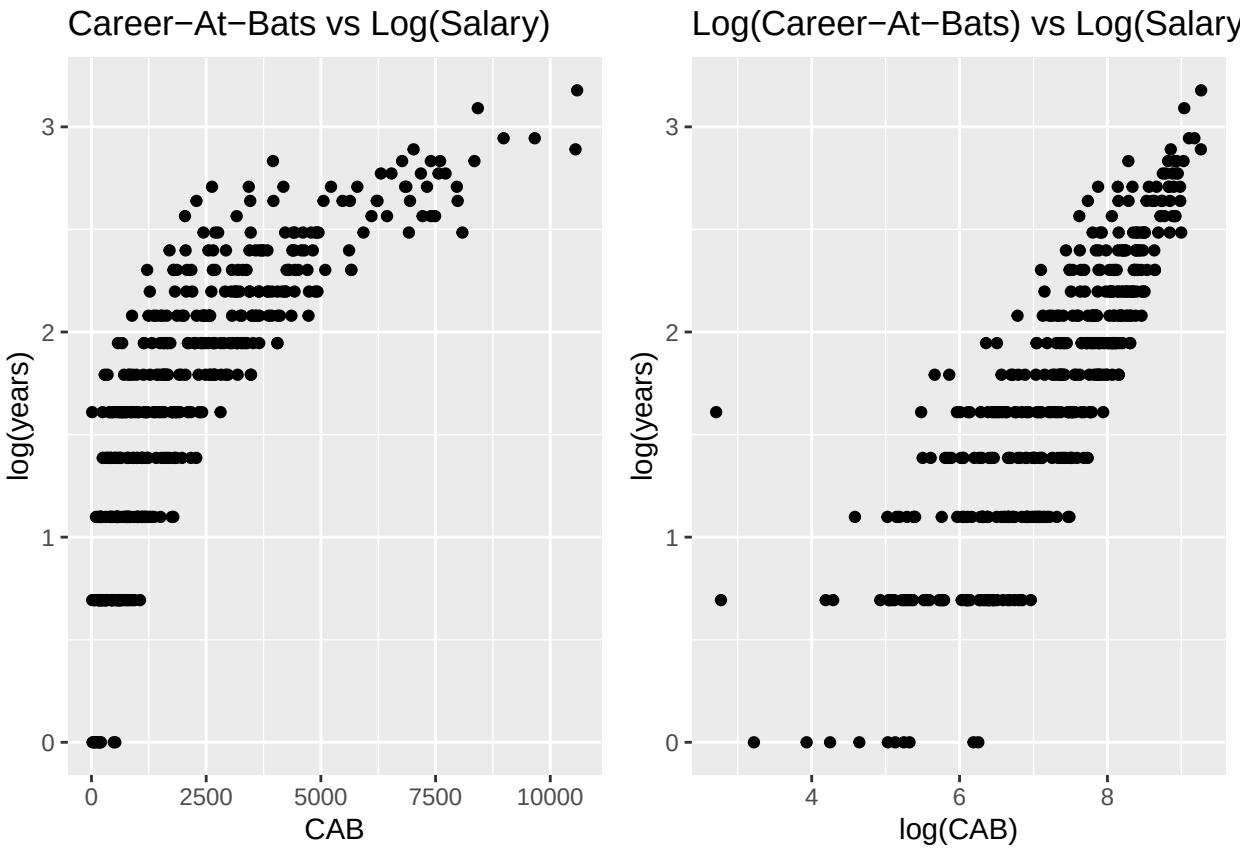
The histogram above shows that the observed outcome values are not distributed normally at all. Hence, some sort of transformation of the data is necessary in order to use linear modelling.

```
log.sal1 = ggplot(data=new.baseball, aes(x=log(salary))) + geom_histogram(bins=40) + ggtitle("Histogram
log.sal2 = ggplot(data=new.baseball, aes(y=log(salary))) + geom_boxplot() +  ggtitle("Boxplot of log(Sa
grid.arrange(log.sal1, log.sal2, nrow=1)
```

Fox mentions log transforming the `salary` data in his linear modelling analysis and this is in line with the observed histograms above. The histogram of the original salaries is right skewed whereas the histogram of the log transformed salaries is somewhat more stabilized and appears more so normally distributed in some sense.

Fox also suggests log transforming some feature variables (years in the majors, career-at-bats) through preliminary examination and so I will do the same to carry forward analysis in a similar manner. An argument for why this may be benefificial is that it might garner a stronger linear relationship between the seemingly most influential explanatory variables and the salary and thus improving the model's predictive capability overall.

```
cab.plot1 = ggplot(data=new.baseball, aes(x=CAB, y=log(years))) + geom_point() + ggtitle(label = "Caree
cab.plot2 = ggplot(data=new.baseball, aes(x=log(CAB), y=log(years))) + geom_point() + ggtitle(label = "
grid.arrange(cab.plot1, cab.plot2, nrow=1)
```




```
yrs.plot1 = ggplot(data=new.baseball, aes(x=years, y=log(years))) + geom_point() + ggtitle(label = "Yea
yrs.plot2 = ggplot(data=new.baseball, aes(x=log(years), y=log(years))) + geom_point() + ggtitle(label =
grid.arrange(yrs.plot1, yrs.plot2, nrow=1)
```


```
new.baseball$log.CAB    = log(new.baseball$CAB)
new.baseball$log.years  = log(new.baseball$years)
new.baseball$log.salary = log(new.baseball$salary)
new.baseball = new.baseball %>% dplyr::select(-c(CAB, years, salary))
```

Data Analysis

1)

For the first of the project, I will be fitting a simple model that predicts `log(salary)` from the **dummy variables** for `years in majors` and `log(career runs)`, allowing for an interactio between the feature variables.

```
dat1 = new.baseball %>% dplyr::select(log.salary, CR, neg.sal, neg.cont)
simple.model = lm(log.salary ~ log(1+CR)*(neg.cont + neg.sal), data=dat1)
simple.model
```

```
Call:
lm(formula = log.salary ~ log(1 + CR) * (neg.cont + neg.sal),
    data = dat1)

Coefficients:
         (Intercept)           log(1 + CR)              neg.cont
            12.88064               0.08743              -3.96431
             neg.sal  log(1 + CR):neg.cont   log(1 + CR):neg.sal
            -1.06871               0.94036               0.24940
```

2)

Although I have fitted the simple model above, I want to check for any outliers, high leverage points, and influential observations for further evaulation of the simple model. All criterions in determining such observations will be in line with what Fox suggests using.

```
hat.vals = hatvalues(simple.model)
stud.res = studres(simple.model)
cook.dis = cooks.distance(simple.model)

measures = tibble(Hat.Values=hat.vals, Studentized.Residuals=stud.res, Cooks.Distance=cook.dis)
```

First, I'd like to take a look at the **high leverage** points, which are observations with explanatory variables markedly different from that of the average. In terms of numerical cutoffs for diagnostic statistics, *hat values exceeding* ***twice*** *the average hat value* `(k+1)/n` *are noteworthy.*

```
h.3 = 3*length(simple.model$coefficients)/nrow(new.baseball)
high.leverage = measures[hat.vals > h.3,]
high.leverage
```

```
# A tibble: 17 x 3
   Hat.Values Studentized.Residuals Cooks.Distance
        <dbl>                 <dbl>          <dbl>
 1     0.0477                1.87       0.0289
 2     0.0486                0.525      0.00235
 3     0.0565                0.0299     0.00000898
 4     0.0428               -0.305      0.000695
 5     0.0733                0.0664     0.0000582
 6     0.0507               -0.267      0.000637
 7     0.0428               -0.305      0.000694
 8     0.0733                0.0664     0.0000582
 9     0.0437                0.475      0.00172
10     0.0554                0.606      0.00359
11     0.126                 0.163      0.000643
12     0.0565                0.0284     0.00000807
13     0.0489                0.533      0.00244
14     0.0462                0.504      0.00206
15     0.0573                0.564      0.00323
16     0.245                 0.334      0.00606
17     0.148                 1.51       0.0663
```

There appears to be ***17*** data points which have a relatively high leverage.

In addition to high leverage points, I'll analyze discrepant observations to detect outliers within the data through utilizing **studentized residuals** with a numerical cutoff of `|t-test statistic| > 2`

```
outliers = measures[abs(stud.res) > 2,]
outliers %>% head(n=5)
```

```
# A tibble: 5 x 3
  Hat.Values Studentized.Residuals Cooks.Distance
       <dbl>                 <dbl>          <dbl>
1    0.0258                  2.41        0.0254
```

```
2    0.00468                -2.18        0.00370
3    0.0274                  4.12        0.0768
4    0.00804                -3.01        0.0120
5    0.00476                -2.54        0.00510
```

There are ***26*** observations which are determined to be outliers.

Although I have determined observations that have high leverage or are outliers, what I am most conerned about are the subset of these points which have an influence on the determined coefficients of the model. Such points greatly alter the predictive capability of the simple model and thus cannot be overlooked.

Through recommendation by Fox, the criterion I will be using to determine highly influential points is `D_i > 4/(n-k-1)`

```
cook.cutoff = 4/(nrow(new.baseball)-length(simple.model$coefficients))
influential.points = measures[cook.dis > cook.cutoff,]
influential.points %>% arrange(desc(Cooks.Distance))
```

```
# A tibble: 16 x 3
   Hat.Values Studentized.Residuals Cooks.Distance
        <dbl>                 <dbl>          <dbl>
 1    0.0274                  4.12         0.0768
 2    0.148                   1.51         0.0663
 3    0.0189                 -4.27         0.0563
 4    0.0211                 -3.63         0.0462
 5    0.0149                 -3.53         0.0306
 6    0.0477                  1.87         0.0289
 7    0.0268                  2.50         0.0285
 8    0.0122                 -3.64         0.0264
 9    0.0258                  2.41         0.0254
10    0.0255                  2.40         0.0249
11    0.0272                  2.22         0.0227
12    0.0112                 -3.06         0.0173
13    0.0149                 -2.49         0.0155
14    0.00804                -3.01         0.0120
15    0.0256                  1.64         0.0118
16    0.0189                  1.86         0.0111
```

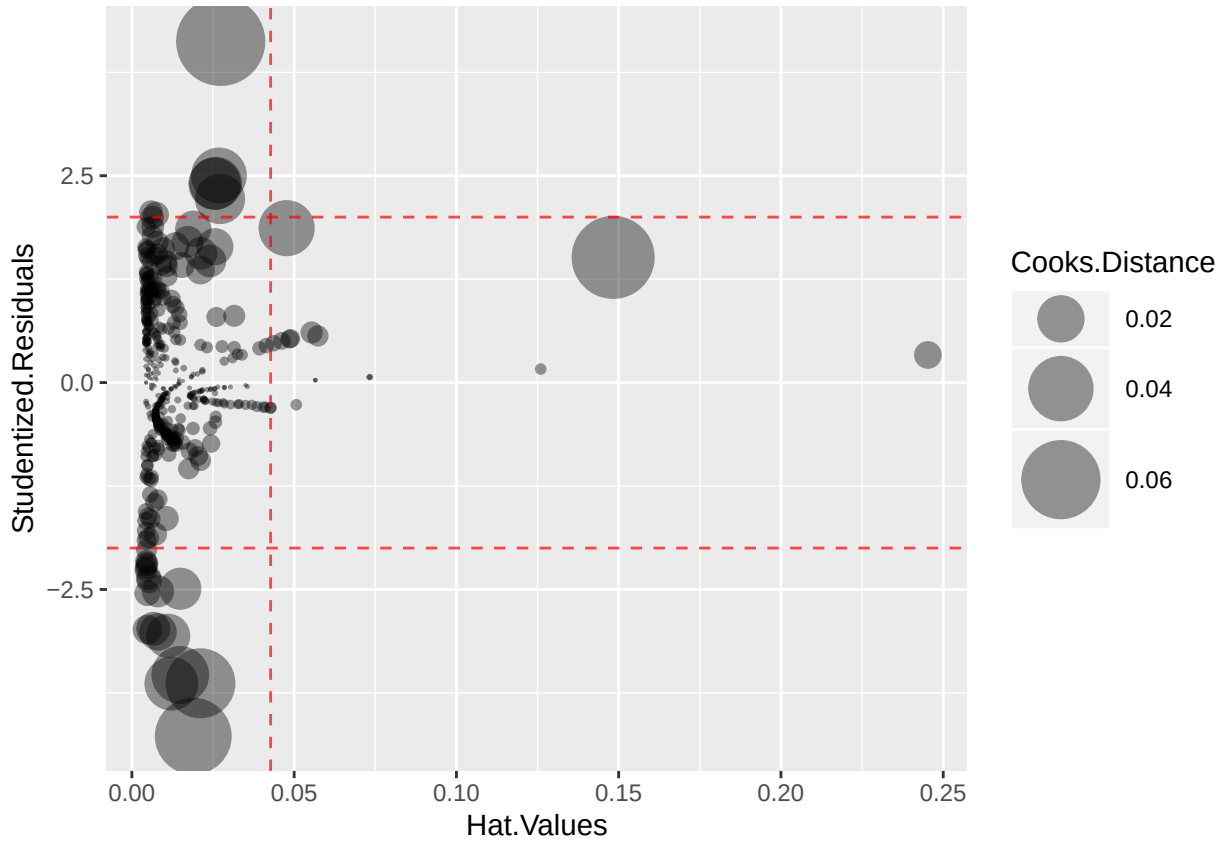
It appears there are ***16*** influential points within the dataset. I'm not very surprised as players' baseball data is incredibly varied and prone to uniquely performing individuals, thus causing there to be influential observations.

To better grasp the idea behind the information produced above, the following is a plot of the `hat` values representing the leverage with relation to the `studentized residuals`. Each circle represents an obervation with it's area proportional to it's calculated `Cook's Distance`.

Note: The horizontal line represents `3 times the average hat value` and the 2 vertical lines mark `t-test statistics of -2 and 2`.

```
measures = tibble(Hat.Values=hat.vals, Studentized.Residuals=stud.res, Cooks.Distance=cook.dis)

ggplot(aes(x=Hat.Values, y=Studentized.Residuals, size=Cooks.Distance), data=measures) +
  geom_point(alpha=0.4) + scale_size(range=c(0, 15)) +
  geom_vline(xintercept = 3*6/421, color='red', alpha=.7, linetype = "dashed") +
  geom_hline(yintercept = -2, color='red', alpha=.7, linetype = "dashed") +
  geom_hline(yintercept = 2, color='red', alpha=.7, linetype = "dashed")
```



Lastly, I'd like to take a look at these influential points and observe the feature values.

3)

```
all.fit = lm(log.salary ~ ., data = new.baseball)
summary(all.fit)
```

```
Call:
lm(formula = log.salary ~ ., data = new.baseball)

Residuals:
     Min       1Q   Median       3Q      Max
-1.63762 -0.31246  0.06423  0.31947  1.51943

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) 14.2702482  0.5240182  27.232  < 2e-16 ***
POSC        -0.0426637  0.1518434  -0.281 0.778886
POSCF       -0.0268705  0.1494435  -0.180 0.857403
POSMI        0.0780726  0.1027617   0.760 0.447882
G.x          0.0039647  0.0046887   0.846 0.398321
GS          -0.0062069  0.0109901  -0.565 0.572567
InnOuts      0.0001452  0.0004900   0.296 0.767175
PO           0.0002185  0.0003197   0.683 0.494768
A            0.0003503  0.0008990   0.390 0.697023
E            0.0026430  0.0104617   0.253 0.800687
DP          -0.0042697  0.0029331  -1.456 0.146306
G.y         -0.0118007  0.0033350  -3.538 0.000453 ***
AB           0.0065267  0.0016068   4.062 5.92e-05 ***
R           -0.0093742  0.0063621  -1.473 0.141465
H           -0.0065391  0.0048988  -1.335 0.182729
X2B         -0.0063059  0.0070018  -0.901 0.368367
X3B          0.0006723  0.0184037   0.037 0.970877
HR          -0.0102874  0.0121474  -0.847 0.397599
RBI          0.0039993  0.0057956   0.690 0.490580
SB          -0.0013153  0.0058889  -0.223 0.823382
CS          -0.0276728  0.0185481  -1.492 0.136549
BB           0.0056713  0.0039142   1.449 0.148192
SO          -0.0012819  0.0019363  -0.662 0.508337
IBB          0.0093704  0.0136217   0.688 0.491937
HBP          0.0036525  0.0110282   0.331 0.740680
SH           0.0093553  0.0161609   0.579 0.563012
SF           0.0014463  0.0204969   0.071 0.943783
GIDP        -0.0086423  0.0093884  -0.921 0.357889
CH           0.0021802  0.0010424   2.091 0.037157 *
CHR          0.0076434  0.0038205   2.001 0.046147 *
CR          -0.0022325  0.0016753  -1.333 0.183480
CRBI        -0.0026771  0.0018308  -1.462 0.144502
CBB         -0.0011839  0.0005733  -2.065 0.039609 *
AVG          0.5156185  3.3598388   0.153 0.878113
OBP         -0.0025942  0.0291738  -0.089 0.929190
CAB.avg     -0.0042031  0.0030973  -1.357 0.175589
CH.avg      -0.0133749  0.0133111  -1.005 0.315641
CHR.avg     -0.0709547  0.0361205  -1.964 0.050219 .
CR.avg       0.0534385  0.0151076   3.537 0.000455 ***
```

```
CRBI.avg     0.0469204  0.0166307   2.821 0.005036 **
neg.cont     1.2416258  0.2315305   5.363 1.43e-07 ***
neg.sal      0.0541843  0.1522766   0.356 0.722168
log.CAB     -0.3434284  0.1713702  -2.004 0.045783 *
log.years    0.2802810  0.2404271   1.166 0.244447
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.5807 on 377 degrees of freedom
Multiple R-squared:  0.8082,    Adjusted R-squared:  0.7863
F-statistic: 36.95 on 43 and 377 DF,  p-value: < 2.2e-16
```

From former analysis I am aware of collinearity within the explanatory variables and hence inflated standard errors. However, it appears several of the coefficients are statistically significant and that the omnibus F-statistic for all explanatory variables in the model having coefficients of 0 is also statistically significant. In addition, the adjusted R-squared value is significantly lower than R-squared. This all leans toward the argument of possible variable selection that may improve the model's regression ability.

4)

Next, I'll be finding the best **10** models for each model size using forward selection.

```
best10 = regsubsets(log.salary ~ ., data=new.baseball, nvmax=43, nbest=10, method="forward")
summary(best10)
```

```
Subset selection object
Call: regsubsets.formula(log.salary ~ ., data = new.baseball, nvmax = 43,
    nbest = 10, method = "forward")
43 Variables  (and intercept)
          Forced in Forced out
POSC          FALSE      FALSE
POSCF         FALSE      FALSE
POSMI         FALSE      FALSE
G.x           FALSE      FALSE
GS            FALSE      FALSE
InnOuts       FALSE      FALSE
PO            FALSE      FALSE
A             FALSE      FALSE
E             FALSE      FALSE
DP            FALSE      FALSE
G.y           FALSE      FALSE
AB            FALSE      FALSE
R             FALSE      FALSE
H             FALSE      FALSE
X2B           FALSE      FALSE
X3B           FALSE      FALSE
HR            FALSE      FALSE
RBI           FALSE      FALSE
SB            FALSE      FALSE
CS            FALSE      FALSE
BB            FALSE      FALSE
SO            FALSE      FALSE
IBB           FALSE      FALSE
HBP           FALSE      FALSE
SH            FALSE      FALSE
SF            FALSE      FALSE
GIDP          FALSE      FALSE
CH            FALSE      FALSE
CHR           FALSE      FALSE
CR            FALSE      FALSE
CRBI          FALSE      FALSE
CBB           FALSE      FALSE
AVG           FALSE      FALSE
OBP           FALSE      FALSE
CAB.avg       FALSE      FALSE
CH.avg        FALSE      FALSE
CHR.avg       FALSE      FALSE
CR.avg        FALSE      FALSE
CRBI.avg      FALSE      FALSE
neg.cont      FALSE      FALSE
neg.sal       FALSE      FALSE
log.CAB       FALSE      FALSE
```

```
log.years     FALSE      FALSE
10 subsets of each size up to 43
Selection Algorithm: forward
          POSC POSCF POSMI G.x GS  InnOuts PO  A   E   DP  G.y AB  R   H   X2B
1  ( 1 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 2 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 3 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 4 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 5 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 6 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 7 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 8 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 9 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
1  ( 10 ) " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 1 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 2 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 3 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 4 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 5 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 6 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 7 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 8 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " "*" " " " "
2  ( 9 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
2  ( 10 ) " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 1 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 2 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 3 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 4 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 5 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 6 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " "*" " " " "
3  ( 7 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 8 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 9 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
3  ( 10 ) " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " "*" " " " " "
4  ( 1 )  " "  " "   " "   " " " " " " " "     " " " " " " " " " " " " " " " " " " " "*" " " " "
4  ( 2 )  " "  " "   " "   " " "*" " " "     " " " " " " " " " " " " " " " " " " " " " " " " " "
4  ( 3 )  " "  " "   " "   " " " " " " "*"     " " " " " " " " " " " " " " " " " " " " " " " " " "
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43  ( 1 )  "*" "*" "*" "*" "*" "*" "*" "*" "*" "*" "*" "*"  "*" "*" "*" "*"
           CBB AVG OBP CAB.avg CH.avg CHR.avg CR.avg CRBI.avg neg.cont neg.sal
1   ( 1 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
1   ( 2 )  " " " " " " " "      " "    " "     " "    "*"      " "      " "
1   ( 3 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
1   ( 4 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
1   ( 5 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
1   ( 6 )  " " " " " " " "      " "    " "     "*"    " "      " "      " "
1   ( 7 )  " " " " " " " "      " "    " "     " "    " "      "*"      " "
1   ( 8 )  " " " " " " " "      "*"    " "     " "    " "      " "      " "
1   ( 9 )  " " " " " " "*"      " "    " "     " "    " "      " "      " "
1   ( 10 ) " " " " " " " "      " "    " "     " "    " "      " "      " "
2   ( 1 )  " " " " " " " "      " "    " "     " "    " "      "*"      " "
2   ( 2 )  " " " " " " " "      " "    " "     " "    "*"      " "      " "
2   ( 3 )  " " " " " " " "      " "    "*"     " "    " "      " "      " "
2   ( 4 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
2   ( 5 )  " " " " " " " "      " "    " "     "*"    " "      " "      " "
2   ( 6 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
2   ( 7 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
2   ( 8 )  " " " " " " " "      " "    " "     " "    " "      " "      " "
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2  ( 9 )   " " " " " " " " "     "*"    " "    " "    " "     " "     " "
2  ( 10 )  " " " " " " " "*"     " "    " "    " "    " "     " "     " "
3  ( 1 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
3  ( 2 )   " " " " " " " " "     " "    " "    "*"    " "     "*"     " "
3  ( 3 )   " " " " " " " " "     " "    "*"    " "    " "     "*"     " "
3  ( 4 )   " " " " " " " " "     " "    " "    " "    " "     "*"     " "
3  ( 5 )   " " " " " " " " "     "*"    " "    " "    " "     "*"     " "
3  ( 6 )   " " " " " " " " "     " "    " "    " "    " "     "*"     " "
3  ( 7 )   " " " " " " " "*"     " "    " "    " "    " "     "*"     " "
3  ( 8 )   " " " " " " " " "     " "    " "    " "    " "     "*"     " "
3  ( 9 )   " " " " " " " " "     " "    " "    " "    " "     "*"     " "
3  ( 10 )  " " " " " " " " "     " "    " "    " "    " "     "*"     " "
4  ( 1 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 2 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 3 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 4 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
4  ( 5 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 6 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 7 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 8 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 9 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
4  ( 10 )  " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 1 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 2 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 3 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
5  ( 4 )   "*" " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 5 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 6 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 7 )   " " "*" " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 8 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
5  ( 9 )   " " " " "*" " " "     " "    " "    " "    "*"     "*"     " "
5  ( 10 )  " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 1 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
6  ( 2 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 3 )   "*" " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 4 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 5 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 6 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 7 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 8 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
6  ( 9 )   " " " " " " " " "     " "    " "    " "    "*"     "*"     "*"
6  ( 10 )  " " " " " " " " "     " "    " "    " "    "*"     "*"     " "
7  ( 1 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 2 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 3 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 4 )   "*" " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 5 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 6 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     "*"
7  ( 7 )   " " " " " " "*"       " "    " "    "*"    "*"     "*"     " "
7  ( 8 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 9 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
7  ( 10 )  " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
8  ( 1 )   "*" " " " " " " "     " "    " "    "*"    "*"     "*"     " "
8  ( 2 )   " " " " " " " " "     " "    " "    "*"    "*"     "*"     " "
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8  ( 3 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 4 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 5 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 6 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 7 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 8 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 9 )   " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
8  ( 10 )  " " " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 1 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 2 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 3 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 4 )   "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
9  ( 5 )   "*" " " " " " " "     "*"    " "     "*"    "*"      "*"      " "
9  ( 6 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 7 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 8 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 9 )   "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
9  ( 10 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
10  ( 2 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 3 )  "*" " " " " " " "     "*"    " "     "*"    "*"      "*"      " "
10  ( 4 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 5 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 6 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 7 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 8 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 9 )  "*" " " " " " " "     " "    " "     "*"    "*"      "*"      " "
10  ( 10 ) "*" " " "*" " " "     " "    " "     "*"    "*"      "*"      " "
11  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
11  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
11  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
12  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
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```
13  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
13  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
14  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
15  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 6 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
16  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
16  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 2 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
17  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
17  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
18  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
18  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
```

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19  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
19  ( 10 ) "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
20  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
20  ( 9 )  "*" " " " " " "*"     "*"    " "     "*"    "*"      "*"      " "
20  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
21  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
21  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 8 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
22  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
22  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 1 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
23  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
23  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 1 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
24  ( 2 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 3 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 4 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
```

```
24  ( 5 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 6 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 7 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 8 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 9 )  "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
24  ( 10 ) "*" " " " " " "*"     " "    " "     "*"    "*"      "*"      " "
25  ( 1 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 2 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 5 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 6 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 7 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 8 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
25  ( 10 ) "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 1 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 2 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 5 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
26  ( 6 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 7 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 8 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
26  ( 10 ) "*" "*" " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 1 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 2 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 5 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
27  ( 6 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 7 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 8 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
27  ( 10 ) "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 1 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 2 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
28  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 5 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 6 )  "*" "*" " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 7 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 8 )  "*" " " "*" "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 9 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
28  ( 10 ) "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 1 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
29  ( 2 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 3 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 4 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 5 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 6 )  "*" "*" " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 7 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 8 )  "*" " " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
```

```
29  ( 9 )  "*" " " "*" "*"     " "    "*"     "*"    "*"      "*"      " "
29  ( 10 ) "*" " " " " "*"     " "    "*"     "*"    "*"      "*"      " "
30  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 3 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 4 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 5 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 6 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 7 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
30  ( 8 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 9 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
30  ( 10 ) "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 3 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 4 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 5 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 6 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
31  ( 7 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 8 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 9 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      " "
31  ( 10 ) "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 3 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 4 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 5 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
32  ( 6 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 7 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 8 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 9 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
32  ( 10 ) "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 3 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
33  ( 4 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 5 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 6 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 7 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 8 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 9 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      " "
33  ( 10 ) "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
34  ( 3 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 4 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 5 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 6 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 7 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 8 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 9 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
34  ( 10 ) "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 1 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
35  ( 2 )  "*" " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
```

```
35  ( 3 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 4 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 5 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 6 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 7 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 8 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 9 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      " "
35  ( 10 ) "*" "*" "*" "*"     " "    " "     " "    " "      " "      " "
36  ( 1 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 2 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 3 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 4 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 5 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 6 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 7 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 8 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
36  ( 9 )  "*" "*" "*" "*"     "*"    " "     " "    " "      " "      " "
37  ( 1 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 2 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 3 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 4 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 5 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 6 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 7 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
37  ( 8 )  "*" "*" "*" "*"     "*"    "*"     " "    " "      " "      " "
38  ( 1 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 2 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 3 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 4 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 5 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 6 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
38  ( 7 )  "*" "*" "*" "*"     "*"    "*"     "*"    " "      " "      " "
39  ( 1 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
39  ( 2 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
39  ( 3 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
39  ( 4 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
39  ( 5 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
39  ( 6 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      " "      " "
40  ( 1 )  "*" "*" " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
40  ( 2 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
40  ( 3 )  "*" " " "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
40  ( 4 )  "*" " " " " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
40  ( 5 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      " "
41  ( 1 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
41  ( 2 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
41  ( 3 )  "*" "*" " " "*"     "*"    "*"     "*"    "*"      "*"      "*"
41  ( 4 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
42  ( 1 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
42  ( 2 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
42  ( 3 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
43  ( 1 )  "*" "*" "*" "*"     "*"    "*"     "*"    "*"      "*"      "*"
           log.CAB log.years
1   ( 1 )  " "     " "
1   ( 2 )  " "     " "
```

```
1  ( 3 )   " "     " "
1  ( 4 )   "*"     " "
1  ( 5 )   " "     " "
1  ( 6 )   " "     " "
1  ( 7 )   " "     " "
1  ( 8 )   " "     " "
1  ( 9 )   " "     " "
1  ( 10 )  " "     " "
2  ( 1 )   " "     " "
2  ( 2 )   " "     " "
2  ( 3 )   " "     " "
2  ( 4 )   " "     " "
2  ( 5 )   " "     " "
2  ( 6 )   " "     " "
2  ( 7 )   " "     " "
2  ( 8 )   " "     " "
2  ( 9 )   " "     " "
2  ( 10 )  " "     " "
3  ( 1 )   " "     " "
3  ( 2 )   " "     " "
3  ( 3 )   " "     " "
3  ( 4 )   " "     " "
3  ( 5 )   " "     " "
3  ( 6 )   " "     " "
3  ( 7 )   " "     " "
3  ( 8 )   " "     " "
3  ( 9 )   " "     " "
3  ( 10 )  " "     " "
4  ( 1 )   " "     " "
4  ( 2 )   " "     " "
4  ( 3 )   " "     " "
4  ( 4 )   " "     " "
4  ( 5 )   " "     " "
4  ( 6 )   " "     " "
4  ( 7 )   " "     " "
4  ( 8 )   " "     " "
4  ( 9 )   " "     " "
4  ( 10 )  " "     " "
5  ( 1 )   "*"     " "
5  ( 2 )   " "     " "
5  ( 3 )   " "     " "
5  ( 4 )   " "     " "
5  ( 5 )   " "     " "
5  ( 6 )   " "     "*"
5  ( 7 )   " "     " "
5  ( 8 )   " "     " "
5  ( 9 )   " "     " "
5  ( 10 )  " "     " "
6  ( 1 )   "*"     " "
6  ( 2 )   "*"     " "
6  ( 3 )   "*"     " "
6  ( 4 )   "*"     " "
6  ( 5 )   "*"     " "
6  ( 6 )   "*"     " "
```

```
6  ( 7 )   "*"     " "
6  ( 8 )   "*"     " "
6  ( 9 )   "*"     " "
6  ( 10 )  "*"     " "
7  ( 1 )   "*"     "*"
7  ( 2 )   "*"     " "
7  ( 3 )   "*"     " "
7  ( 4 )   "*"     " "
7  ( 5 )   "*"     " "
7  ( 6 )   "*"     " "
7  ( 7 )   "*"     " "
7  ( 8 )   "*"     " "
7  ( 9 )   "*"     " "
7  ( 10 )  "*"     " "
8  ( 1 )   "*"     "*"
8  ( 2 )   "*"     "*"
8  ( 3 )   "*"     "*"
8  ( 4 )   "*"     "*"
8  ( 5 )   "*"     "*"
8  ( 6 )   "*"     "*"
8  ( 7 )   "*"     "*"
8  ( 8 )   "*"     "*"
8  ( 9 )   "*"     "*"
8  ( 10 )  "*"     "*"
9  ( 1 )   "*"     "*"
9  ( 2 )   "*"     "*"
9  ( 3 )   "*"     "*"
9  ( 4 )   "*"     "*"
9  ( 5 )   "*"     "*"
9  ( 6 )   "*"     "*"
9  ( 7 )   "*"     "*"
9  ( 8 )   "*"     "*"
9  ( 9 )   "*"     "*"
9  ( 10 )  "*"     "*"
10  ( 1 )  "*"     "*"
10  ( 2 )  "*"     "*"
10  ( 3 )  "*"     "*"
10  ( 4 )  "*"     "*"
10  ( 5 )  "*"     "*"
10  ( 6 )  "*"     "*"
10  ( 7 )  "*"     "*"
10  ( 8 )  "*"     "*"
10  ( 9 )  "*"     "*"
10  ( 10 ) "*"     "*"
11  ( 1 )  "*"     "*"
11  ( 2 )  "*"     "*"
11  ( 3 )  "*"     "*"
11  ( 4 )  "*"     "*"
11  ( 5 )  "*"     "*"
11  ( 6 )  "*"     "*"
11  ( 7 )  "*"     "*"
11  ( 8 )  "*"     "*"
11  ( 9 )  "*"     "*"
11  ( 10 ) "*"     "*"
```

```
12  ( 1 )  "*"     "*"
12  ( 2 )  "*"     "*"
12  ( 3 )  "*"     "*"
12  ( 4 )  "*"     "*"
12  ( 5 )  "*"     "*"
12  ( 6 )  "*"     "*"
12  ( 7 )  "*"     "*"
12  ( 8 )  "*"     "*"
12  ( 9 )  "*"     "*"
12  ( 10 ) "*"     "*"
13  ( 1 )  "*"     "*"
13  ( 2 )  "*"     "*"
13  ( 3 )  "*"     "*"
13  ( 4 )  "*"     "*"
13  ( 5 )  "*"     "*"
13  ( 6 )  "*"     "*"
13  ( 7 )  "*"     "*"
13  ( 8 )  "*"     "*"
13  ( 9 )  "*"     "*"
13  ( 10 ) "*"     "*"
14  ( 1 )  "*"     "*"
14  ( 2 )  "*"     "*"
14  ( 3 )  "*"     "*"
14  ( 4 )  "*"     "*"
14  ( 5 )  "*"     "*"
14  ( 6 )  "*"     "*"
14  ( 7 )  "*"     "*"
14  ( 8 )  "*"     "*"
14  ( 9 )  "*"     "*"
14  ( 10 ) "*"     "*"
15  ( 1 )  "*"     "*"
15  ( 2 )  "*"     "*"
15  ( 3 )  "*"     "*"
15  ( 4 )  "*"     "*"
15  ( 5 )  "*"     "*"
15  ( 6 )  "*"     "*"
15  ( 7 )  "*"     "*"
15  ( 8 )  "*"     "*"
15  ( 9 )  "*"     "*"
15  ( 10 ) "*"     "*"
16  ( 1 )  "*"     "*"
16  ( 2 )  "*"     "*"
16  ( 3 )  "*"     "*"
16  ( 4 )  "*"     "*"
16  ( 5 )  "*"     "*"
16  ( 6 )  "*"     "*"
16  ( 7 )  "*"     "*"
16  ( 8 )  "*"     "*"
16  ( 9 )  "*"     "*"
16  ( 10 ) "*"     "*"
17  ( 1 )  "*"     "*"
17  ( 2 )  "*"     "*"
17  ( 3 )  "*"     "*"
17  ( 4 )  "*"     "*"
```

```
17  ( 5 )  "*"     "*"
17  ( 6 )  "*"     "*"
17  ( 7 )  "*"     "*"
17  ( 8 )  "*"     "*"
17  ( 9 )  "*"     "*"
17  ( 10 ) "*"     "*"
18  ( 1 )  "*"     "*"
18  ( 2 )  "*"     "*"
18  ( 3 )  "*"     "*"
18  ( 4 )  "*"     "*"
18  ( 5 )  "*"     "*"
18  ( 6 )  "*"     "*"
18  ( 7 )  "*"     "*"
18  ( 8 )  "*"     "*"
18  ( 9 )  "*"     "*"
18  ( 10 ) "*"     "*"
19  ( 1 )  "*"     "*"
19  ( 2 )  "*"     "*"
19  ( 3 )  "*"     "*"
19  ( 4 )  "*"     "*"
19  ( 5 )  "*"     "*"
19  ( 6 )  "*"     "*"
19  ( 7 )  "*"     "*"
19  ( 8 )  "*"     "*"
19  ( 9 )  "*"     "*"
19  ( 10 ) "*"     "*"
20  ( 1 )  "*"     "*"
20  ( 2 )  "*"     "*"
20  ( 3 )  "*"     "*"
20  ( 4 )  "*"     "*"
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```

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33  ( 7 )  "*"     "*"
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36  ( 9 )  " "     " "
37  ( 1 )  "*"     "*"
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38  ( 7 )  " "     " "
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39  ( 4 )  "*"     "*"
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```

```
40  ( 1 )  "*"     "*"
40  ( 2 )  "*"     "*"
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40  ( 4 )  "*"     "*"
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41  ( 3 )  "*"     "*"
41  ( 4 )  " "     " "
42  ( 1 )  "*"     "*"
42  ( 2 )  "*"     "*"
42  ( 3 )  "*"     " "
43  ( 1 )  "*"     "*"
```

5)

```
lowest5.bic  = sort(summary(best10)$bic)[1:5]
top5.bic.loc = order(summary(best10)$bic)[1:5]
top5.models  = summary(best10)$which[top5.bic.loc,]
models = c()

for(i in 1:nrow(top5.models)){
  cat(sprintf("Model %d:", i))
  cat(sprintf("\nBIC: %f", lowest5.bic[i]))

  models = c(models, list(names(which(top5.models[i,]))[-1]))
  cat(sprintf("\nFeature: %s", models[[i]]))
  cat("\n\n")
}
```

```
Model 1:
BIC: -586.225215
Feature: GS
Feature: G.y
Feature: AB
Feature: R
Feature: BB
Feature: CH
Feature: CBB
Feature: CAB.avg
Feature: CR.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB
Feature: log.years

Model 2:
BIC: -583.405937
Feature: GS
Feature: R
Feature: CH
Feature: CBB
Feature: CAB.avg
Feature: CR.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB
Feature: log.years

Model 3:
BIC: -582.502074
Feature: G.x
Feature: GS
Feature: G.y
Feature: AB
Feature: R
Feature: BB
```

```
Feature: CH
Feature: CBB
Feature: CAB.avg
Feature: CR.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB
Feature: log.years

Model 4:
BIC: -582.402615
Feature: GS
Feature: G.y
Feature: AB
Feature: R
Feature: X2B
Feature: BB
Feature: CH
Feature: CBB
Feature: CAB.avg
Feature: CR.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB
Feature: log.years

Model 5:
BIC: -582.248168
Feature: GS
Feature: G.y
Feature: AB
Feature: R
Feature: H
Feature: BB
Feature: CH
Feature: CBB
Feature: CAB.avg
Feature: CR.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB
Feature: log.years
```

6)

Using `BIC` as a criterion may not be sufficient and hence I will use 10-fold cross validation to re-rank the 5 models determined above.

```
paste(models[[1]], collapse=" + ")
```

```
[1] "GS + G.y + AB + R + BB + CH + CBB + CAB.avg + CR.avg + CRBI.avg + neg.cont + log.CAB + log.years"
```

7)

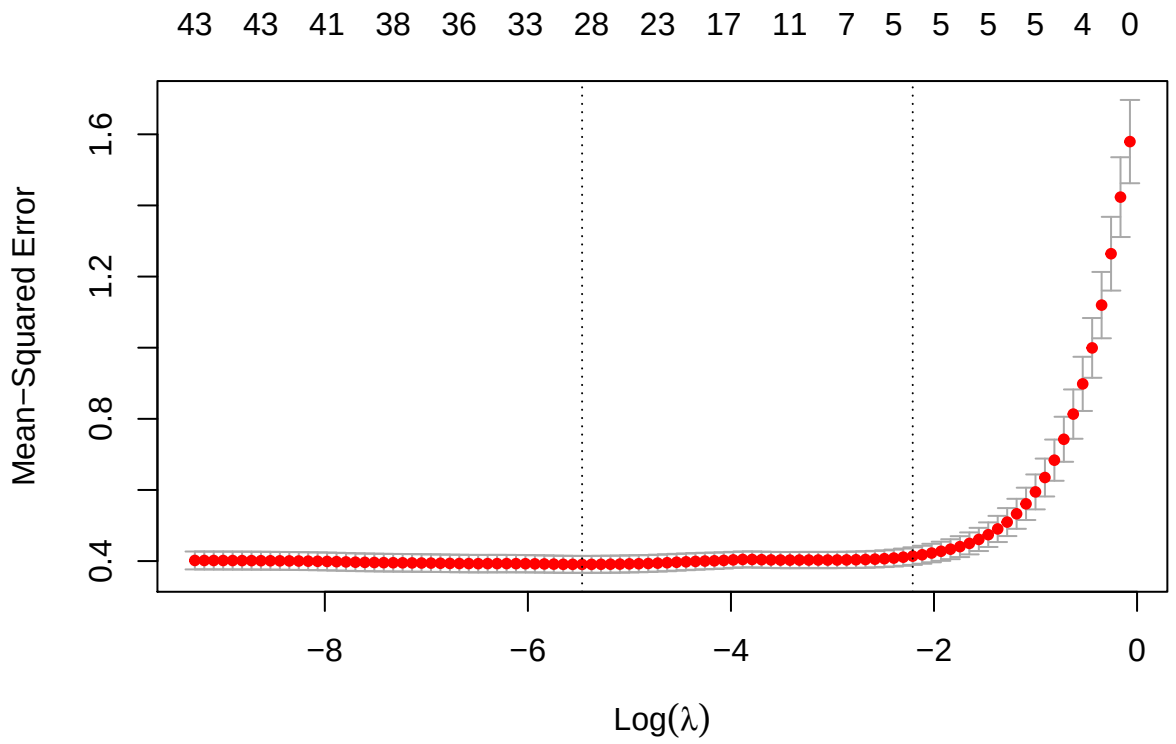
In determining the value of the hyperparameter `lambda` to use for the LASSO model (original feature variables), I will be using 10-fold cross validation with an average MSE for the criterion.

```
X = new.baseball %>% dplyr::select(-c(log.salary)) %>% as.matrix()
y = new.baseball$log.salary

lasso.model    = glmnet(x = X, y = y, alpha = 1)
cv.lasso.model = cv.glmnet(x = X, y = y, alpha = 1, nfolds = 10)
```

The following is the plot of the `log of the hyperparameter lambda` with respect to the resulting `average MSE`.

```
plot(cv.lasso.model)
```



The left-most dashed vertical line in the plot represents the lambda corresponding to the minimum MSE whereas the right-most dashed vertical line represents the lambda 1 standard error away from the min lambda.

I believe the data intrinsically contains a lot of collinear explanatory variables and would like to reduce the number of features used in model prediction. I believe the lambda corresponding to the minimum MSE would be suitable as it not only performs variable selection through utilizing just 28 feature variables for regression rather than all 43, it also has the lowest MSE out of all other possible lambda hyperparameter values and thus seems to be the best choice in prediction.

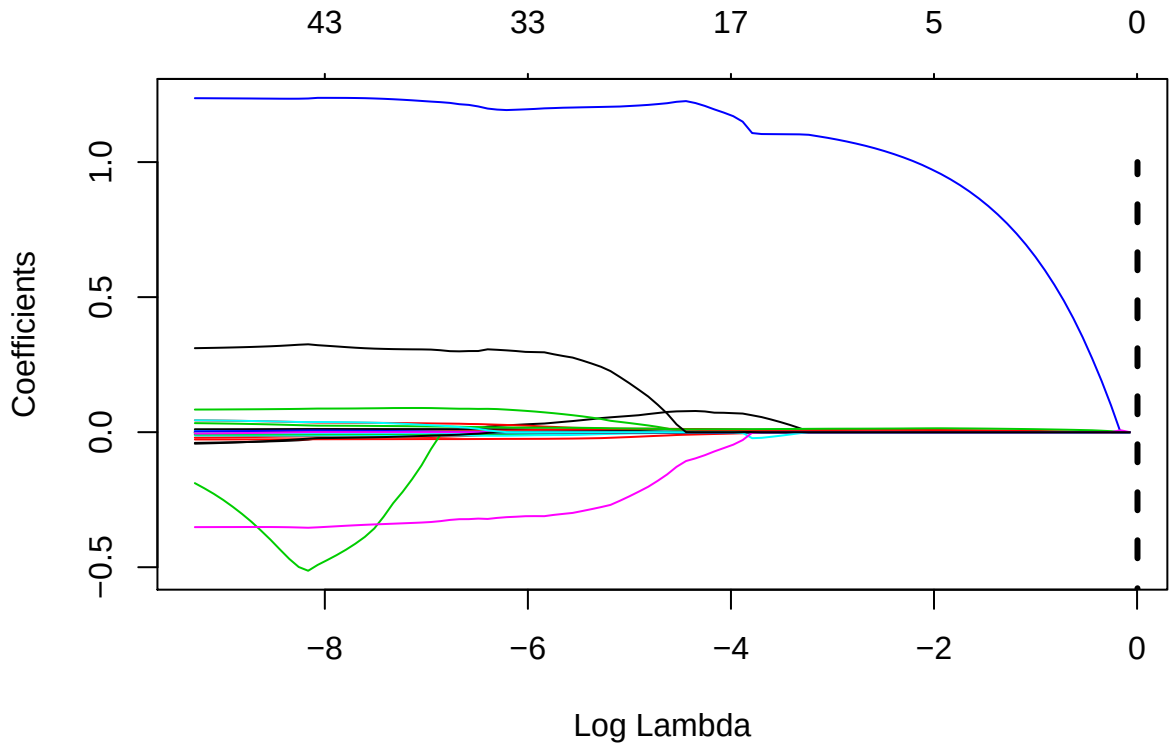
The value of `lambda` I will use for the LASSO model is the following:

```
best.lasso.lambda = cv.lasso.model$lambda.min
best.lasso.lambda
```

```
[1] 0.004228187
```

The following is a visualization of how different values of lambda influence the coefficient values of the regression model:

```
plot(lasso.model, xvar = "lambda", )
lines(c(best.lasso.lambda, best.lasso.lambda), c(-1, 1), lty = "dashed", lwd = 3)
```



Lastly, using the hyperparameter value of lambda specified above, I'd like to analyze which coefficients are retained through implicit variable selection of LASSO.

```
best.lasso.coefs = predict(lasso.model, type = 'coefficients', s = best.lasso.lambda)
best.lasso.coefs
```

```
44 x 1 sparse Matrix of class "dgCMatrix"
                         1
(Intercept)  1.395376e+01
POSC         4.464352e-02
POSCF        .
POSMI        5.860071e-02
G.x          9.792966e-04
```

```
GS            .
InnOuts       7.228064e-05
PO            3.176194e-05
A             .
E             .
DP           -1.580214e-03
G.y          -6.484793e-03
AB            1.509140e-03
R             .
H             .
X2B          -3.628000e-03
X3B           .
HR           -9.471769e-03
RBI           1.628877e-03
SB           -4.844934e-04
CS           -2.316805e-02
BB            4.166142e-03
SO            .
IBB           8.517895e-03
HBP           1.603347e-03
SH            7.769733e-03
SF            1.004775e-02
GIDP          .
CH            2.917989e-05
CHR           9.569908e-04
CR            8.298561e-04
CRBI          .
CBB          -1.065447e-03
AVG           .
OBP           .
CAB.avg      -5.338189e-04
CH.avg        .
CHR.avg       .
CR.avg        1.543482e-02
CRBI.avg      1.603380e-02
neg.cont      1.202804e+00
neg.sal       .
log.CAB      -2.921016e-01
log.years     2.656102e-01
```