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.

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

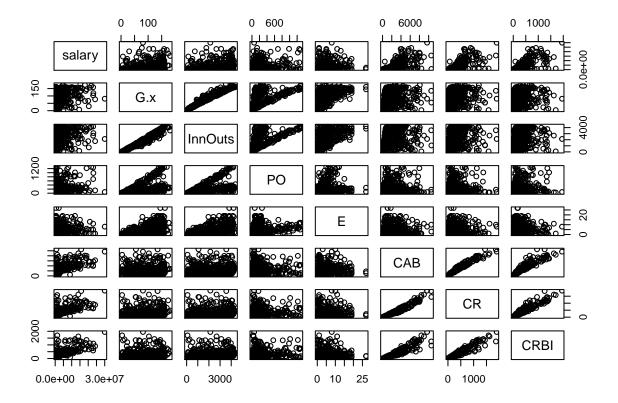
According to Fox's description of his analysis, he mentions **middle infielders** as players who consistently played second base or shortstop so I classified all individuals with either position as such.

```
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 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



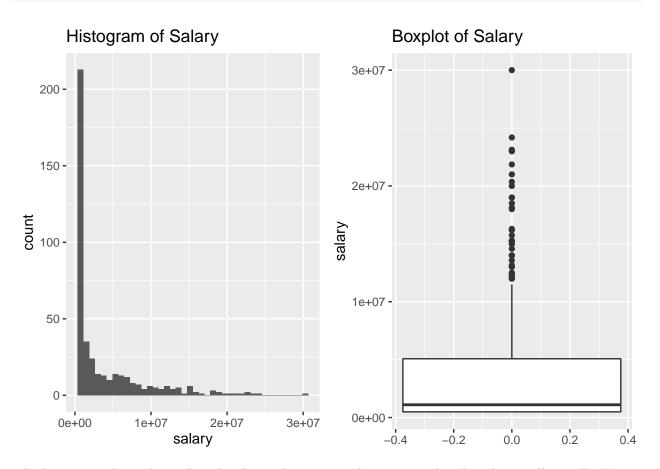
From observing the paired structures of data it is evident that some features are uncorrelated whereas others are strongly correlated. However, this is mostly expected as certain features relate to one another. For example, a player's career at bats would be associated with his career runs or career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

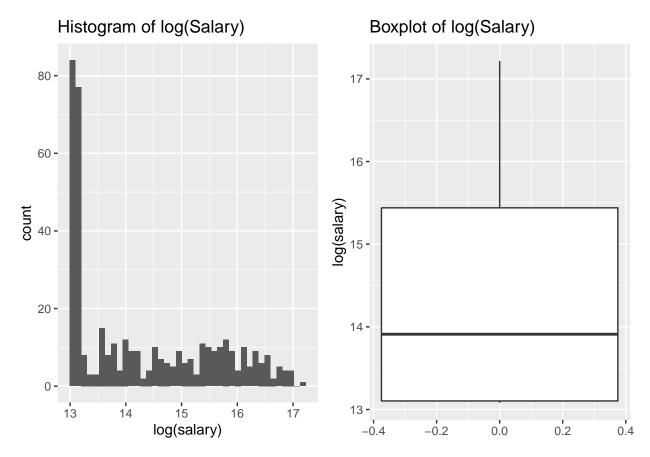
Next, I'd like to look into whether the data is distributed normally as per an assumption of guassian distributed errors in linear modelling.

```
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.

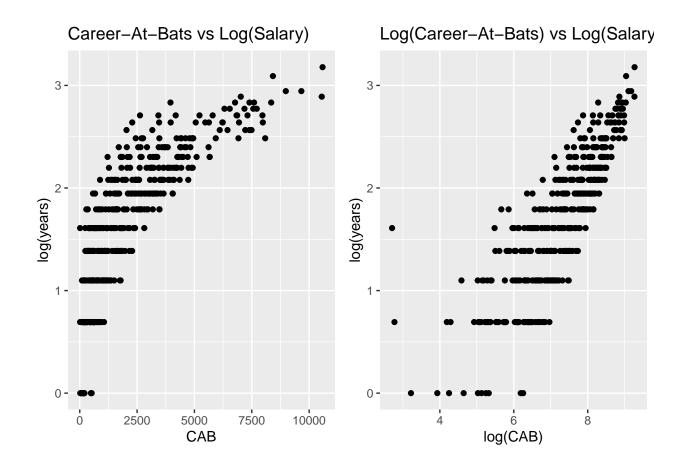
```
log.sal1 = ggplot(data=new.baseball, aes(x=log(salary))) + geom_histogram(bins=40) + ggtitle("Histogram
log.sal2 = ggplot(data=new.baseball, aes(y=log(salary))) + geom_boxplot() + ggtitle("Boxplot of log(Sa
grid.arrange(log.sal1, log.sal2, nrow=1)
```



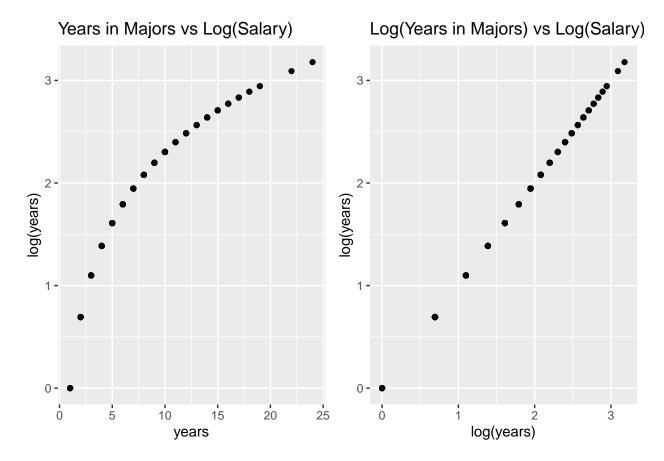
Fox mentions log transforming the salary data in his linear modelling analysis and this is in line with the observed histograms above. The histogram of the original salaries is right skewed whereas the histogram of the log transformed salaries is somewhat more stabilized and appears more so normally 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 = "Years.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
                                            log(1 + CR):neg.sal
            neg.sal log(1 + CR):neg.cont
            -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 evaluation 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	${\tt Studentized.Residuals}$	Cooks.Distance
	<dbl></dbl>	<dbl></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	0.0000807
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
```

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

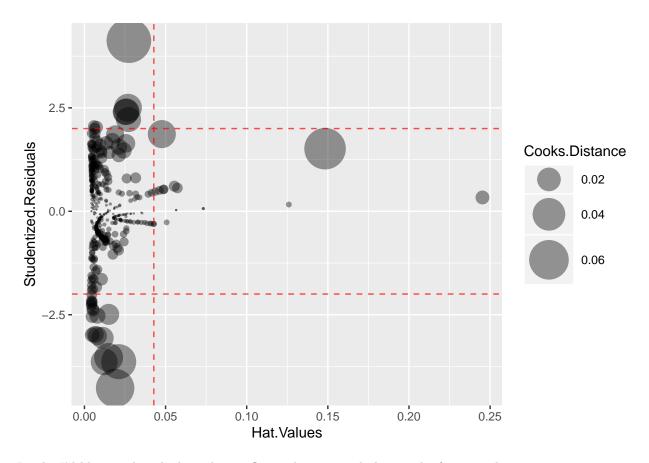
	${\tt Hat.Values}$	${\tt Studentized.Residuals}$	Cooks.Distance
	<dbl></dbl>	<dbl></dbl>	<dbl></dbl>
1	0.0274	4.12	0.0768
2	0.148	1.51	0.0663
3	0.0189	-4.27	0.0563
4	0.0211	-3.63	0.0462
5	0.0149	-3.53	0.0306
6	0.0477	1.87	0.0289
7	0.0268	2.50	0.0285
8	0.0122	-3.64	0.0264
9	0.0258	2.41	0.0254
10	0.0255	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.

CAB.avg

CH.avg

CHR.avg

CR.avg

-0.0042031

-0.0133749

-0.0709547

0.0030973

0.0133111

0.0361205

0.0534385 0.0151076

```
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
                        0.1027617
                                    0.760 0.447882
             0.0780726
G.x
             0.0039647
                        0.0046887
                                    0.846 0.398321
GS
            -0.0062069
                        0.0109901
                                   -0.565 0.572567
                        0.0004900
                                    0.296 0.767175
InnOuts
             0.0001452
PO
             0.0002185
                        0.0003197
                                    0.683 0.494768
Α
             0.0003503
                        0.0008990
                                    0.390 0.697023
Ε
             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
Η
            -0.0065391
                        0.0048988
                                   -1.335 0.182729
X2B
            -0.0063059
                        0.0070018
                                   -0.901 0.368367
ХЗВ
             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
                        0.0058889
                                   -0.223 0.823382
            -0.0013153
CS
            -0.0276728
                        0.0185481
                                   -1.492 0.136549
BB
             0.0056713 0.0039142
                                    1.449 0.148192
                        0.0019363
SO
            -0.0012819
                                   -0.662 0.508337
                        0.0136217
                                    0.688 0.491937
IBB
             0.0093704
                        0.0110282
HBP
             0.0036525
                                    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
                        0.0010424
                                     2.091 0.037157 *
             0.0021802
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
                        0.0005733
                                   -2.065 0.039609 *
            -0.0011839
AVG
             0.5156185
                        3.3598388
                                    0.153 0.878113
OBP
            -0.0025942
                        0.0291738
                                   -0.089 0.929190
```

3.537 0.000455 ***

-1.357 0.175589

-1.005 0.315641

-1.964 0.050219 .

```
CRBI.avg
             0.0469204
                        0.0166307
                                    2.821 0.005036 **
neg.cont
             1.2416258
                        0.2315305
                                    5.363 1.43e-07 ***
                                    0.356 0.722168
neg.sal
             0.0541843
                        0.1522766
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
                          FALSE
InnOuts
              FALSE
PO
              FALSE
                          FALSE
Α
              FALSE
                          FALSE
Ε
                          FALSE
              FALSE
DP
                          FALSE
              FALSE
                          FALSE
G.y
              FALSE
AB
                          FALSE
              FALSE
                          FALSE
R
              FALSE
Η
                          FALSE
              FALSE
X2B
              FALSE
                          FALSE
ХЗВ
              FALSE
                          FALSE
HR
                          FALSE
              FALSE
RBI
              FALSE
                          FALSE
SB
              FALSE
                          FALSE
CS
              FALSE
                          FALSE
BB
              FALSE
                          FALSE
SO
              FALSE
                          FALSE
                          FALSE
IBB
              FALSE
HBP
              FALSE
                          FALSE
SH
                          FALSE
              FALSE
SF
              FALSE
                          FALSE
GIDP
              FALSE
                          FALSE
                          FALSE
CH
              FALSE
CHR
              FALSE
                          FALSE
CR
              FALSE
                          FALSE
CRBI
                          FALSE
              FALSE
CBB
              FALSE
                          FALSE
AVG
              FALSE
                          FALSE
OBP
              FALSE
                          FALSE
CAB.avg
              FALSE
                          FALSE
                          FALSE
CH.avg
              FALSE
CHR.avg
              FALSE
                          FALSE
CR.avg
                          FALSE
              FALSE
CRBI.avg
              FALSE
                          FALSE
neg.cont
              FALSE
                          FALSE
neg.sal
              FALSE
                          FALSE
                          FALSE
log.CAB
              FALSE
```

log.years FALSE FALSE
10 subsets of each size up to 43
Selection Algorithm: forward
POSC POSCE POSMI G x G

		POSC	P(OSCF	POS	SMI	G.	x	GS	5	In	nOuts	PC)	Α		E		DP	•	G.	у	AB	,	R		Н		Х2	В
1	(1)	" "	"	11	11	11	"	"	"	"	"	11	"	"	"	"	"	"	"	"	"	"	"	"	"	11	"	"	"	"
1	(2)	" "	"	"	"	"	11	"	"	"	11	"	"	"	"	"	"	"	11	"	"	"	"	"	"	"	"	"	"	11
1	(3)	" "	"	11	"	"	11	"	II	"	"	"	"	"	"	"	"	"	11	"	"	"	11	"	"	"	"	"	11	11
1	(4)	11 11	"	"	11 1	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	"	11	"	"	"	"
1	(5)	" "	"	"		"	"	"	"	"	"	"	"	"	"	"	"	"	11	"	"	"	"	"	"	"	"	"	"	"
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)	" "		"		"	"	"	"	"	"	"	"	"	"	"	"	"					•		"		"	"	"	"
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2	(9)	11 11	" "	11 11	11 11	"*"	11 11	11 11	11 11	11 11	11 11
2	(10)	11 11	11 11	11 11	"*"	11 11	11 11	11 11			11 11
3	(1)	11 11	11 11	11 11	II II	11 11	11 11	11 11	"*"	"*"	11 11
3	(2)	11 11	11 11	11 11	II II	11 11	11 11	"*"	II II	"*"	11 11
3	(3)	11 11	11 11	11 11	11 11	11 11	"*"	11 11		"*"	11 11
3	(4)	11 11	11 11	11 11	11 11	11 11	11 11	11 11	11 11	"*"	11 11
3	(5)	11 11	11 11	11 11	11 11	"*"	11 11	11 11	11 11	"*"	11 11
3	(6)	11 11	11 11	11 11	11 11	11 11	11 11	11 11		"*"	11 11
3	(7)	11 11	11 11	11 11	"*"	11 11	11 11	11 11		"*"	11 11
3	(8)	11 11	11 11	11 11	11 11	11 11	11 11	11 11		"*"	11 11
3	(9)	11 11	11 11	11 11	11 11	11 11	11 11	11 11		"*"	11 11
3	(10)	11 11	11 11	11 11	11 11	11 11	11 11	11 11		"*"	11 11
4	(1)	11 11	11 11	11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(2)	11 11	11 11	11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(3)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(4)	11 11		11 11	11 11	11 11	11 11	"*"	"*"	"*"	11 11
4	(5)	11 11	11 11	11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(6)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(7)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(8)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(9)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
4	(10)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(1)	11 11		11 11	11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(2)	11 11			11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(3)	11 11			11 11	11 11	11 11	"*"	"*"	"*"	11 11
5	(4)	"*"			11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(5)				11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(6)	11 11			11 11	11 11	11 11	11 11	"*"	"*"	11 11
5	(7)	11 11	"*"				11 11	11 11	"*"	"*"	11 11
5	(8)	11 11	11 11				11 11	11 11	"*"	"*"	11 11
5	(9)	11 11		"*"			11 11	11 11	"*"	"*"	11 11
5	(10)			т II II			11 11	11 11	"*"	"*"	11 11
6	(10)						11 11	"*"	"*"	"*"	11 11
6	(2)						11 11	т II II	"*"	*" "*"	
6	(3)	"*"			11 11		11 11		"*"	*" "*"	
6	(4)	II II					11 11	11 11	"*"	"*"	11 11
6	(5)				11 11		11 11		"*"	*" "*"	
-	,	11 11	11 11		11 11	11 11	11 11	11 11	"*"	"*"	11 11
6	(6) (7)				11 11	11 11	11 11	11 11	т "*"	*" "*"	11 11
6 6	(8)	11 11	11 11		11 11	11 11	11 11	11 11	"*"	"*"	11 11
6	(9)	11 11	11 11		11 11	11 11	11 11	11 11	"*"	"*"	"*"
		11 11	11 11		11 11	11 11	11 11	11 11	"*"	"*"	II II
6 7	(10)				 II II	" "	 II II	"*"	"*"	"*"	II II
	(1)	11 11	11 11		11 11	" "	 II II	"*"	"*"	"*"	II II
7	(2)				 II II	" "	 II II	"*"	"*"	"*"	II II
7	(3)		11 11		 II II	" "	 II II	"*"	"*"	"*"	II II
7	(4)	"*"			" "	" "	" "				
7	(5)			" "	" "	" "	" "	"*" "*"	"*"	"*"	
7	(6)	" "	" "	" "	"*"	" "	" "		"*"	"*"	"*" " "
7	(7)		" "	" "	"*"	" "	" "	"*"	"*"	"*"	" "
7	(8)	" "			" "		" "	"*"	"*"	"*"	" "
7	(9)	" "	" "	" "	" "	" "	" "	"*"	"*"	"*"	" "
7	(10)					" "	" "	"*"	"*"	"*"	" "
8	(1)	•						"*"	"*"	"*"	
8	(2)	" "	" "	" "	" "	" "	" "	"*"	"*"	"*"	" "

8	(3)	11 11	"	"	"	"	" "	"	"	"	11	"*"	"*"	"*"	"	"
8	(4)	11 11	"	"	"	"	" "	"	"	"	11	"*"	"*"	"*"	"	"
8	(5)	11 11	11	"	"	"	" "	"	"	11	"	"*"	"*"	"*"	11	"
8	(6)	" "	"	"	"	"	" "	"	"	"	"	"*"	"*"	"*"	"	"
8	(7)	11 11	"	"	"	"	11 11	"	"	"	"	"*"	"*"	"*"	"	"
8	(8)	11 11	11	11	"	"	II II	"	11	11	11	"*"	"*"	"*"	11	"
8	(9)	11 11	11	"	11	"	11 11	"	11	"	"	"*"	"*"	"*"	11	"
8	(10)	11 11	11	"	"	"	II II	"	"	"	"	"*"	"*"	"*"	11	"
9	(1)	"*"	11	"	11	"	11 11	"	"	11	"	"*"	"*"	"*"	11	"
9	(2)	"*"	11	11	11	11	11 11	"	11	11	"	"*"	"*"	"*"	11	11
9	(3)	"*"	11	11	11	"		"	11	11	"	"*"	"*"	"*"	11	"
9	(4)	"*"		11	"	"	"*"	"	"	11	"	"*"	"*"	"*"	11	"
9	(5)	"*"		"		"	т II II		k "	"	"	"*"	"*"	"*"	"	"
				"		"	" "	1 	"	11	11			"*"	11	11
9	(6)	"*"							"		"	"*"	"*"			"
9	(7)	"*"		"		"		"		"		"*"	"*"	"*"		
9	(8)	"*"		"		"	" "	"	"	"	"	"*"	"*"	"*"	"	"
9	(9)	"*"	"	"		"	" "	"	"	"	"	"*"	"*"	"*"	"	"
9	(10)	"*"	"	"	"	"	" "	"	"	"	"	"*"	"*"	"*"	"	"
10	(1)	"*"	"	"	"	"	"*"	"	"	11	"	"*"	"*"	"*"	"	"
10	(2)	"*"	11	"	"	"	11 11	"	11	11	"	"*"	"*"	"*"	11	"
10	(3)	"*"	11	"	"	"	" "	" *	k "	11	"	"*"	"*"	"*"	11	"
10	(4)	"*"	11	"	"	"	11 11	"	11	11	"	"*"	"*"	"*"	11	"
10	(5)	"*"	11	"	11	"	11 11	"	11	"	"	"*"	"*"	"*"	11	"
10	(6)	"*"	11	11	11	11	11 11	"	11	11	"	"*"	"*"	"*"	11	11
10	(7)	"*"	11	11	11	"	" "	"	11	11	"	"*"	"*"	"*"	11	"
10	(8)	"*"		11	"	"	" "	"	"	11	"	"*"	"*"	"*"	11	"
10	(9)	"*"		"	"	"	" "	"	"	11	"	"*"	"*"	"*"	"	"
		"*"			"*			"	"	"	11	"*"	"*"	"*"	"	"
10	(10)			11	II		"*"	"	"	11	11				"	11
11	(1)	"*"										"*"	"*"	"*"		"
11	(2)	"*"		"		"	"*"	"	"	"	"	"*"	"*"	"*"	"	
11	(3)	"*"		"		"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
11	(4)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
11	(5)	"*"	"	"	"	"	"*"	"	11	"	"	"*"	"*"	"*"	"	"
11	(6)	"*"	11	"	"	"	"*"	"	11	11	"	"*"	"*"	"*"	11	"
11	(7)	"*"	11	"	"	"	"*"	"	11	11	"	"*"	"*"	"*"	11	"
11	(8)	"*"	11	"	"	"	"*"	"	11	11	"	"*"	"*"	"*"	11	"
11	(9)	"*"	11	11	"	"	"*"	"	11	"*	۱۱ ۽	"*"	"*"	"*"	11	"
11	(10)	"*"	11	11	11	"	"*"	"	11	11	"	"*"	"*"	"*"	11	11
12	(1)	"*"	11	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	11	"
12	(2)	"*"	"	"	11	"	"*"	"	11	"	11	"*"	"*"	"*"	11	"
12	(3)	"*"						"	11	"	"	"*"	"*"	"*"	11	"
12	(4)	"*"							"	"		"*"	"*"	"*"	"	"
		т "*"							"	"		* "*"	"*"	"*"		"
12	(5)	"*"							11	11		"*"				11
12	(6)								"	"			"*"	"*"		
12	(7)	"*"										"*"	"*"	"*"		
12	(8)	"*"							"	"		"*"	"*"	"*"		"
12	(9)	"*"							"	"		"*"	"*"	"*"		"
12	(10)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
13	(1)	"*"	"	"	"	"	"*"	"	"	"	11	"*"	"*"	"*"	"	"
13	(2)	"*"	"	"	"	"	"*"	"	"	"	11	"*"	"*"	"*"	"	"
13	(3)	"*"	"	"	"	"	"*"	"	"	"	11	"*"	"*"	"*"	"	11
13	(4)	"*"	11	"	"	"	"*"	"	"	11	11	"*"	"*"	"*"	11	"
13	(5)	"*"	"	"	"	"	"*"	"	"	11	11	"*"	"*"	"*"	"	11
13	(6)	"*"	"	"	"	"	"*"	"	"	"	11	"*"	"*"	"*"	"	11
	/															

13	(7)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
13	(8)	"*"	11	"	11	11	"*"	"	"	"	"	"*"	"*"	"*"	"	"
13	(9)	"*"	11	"	11	11	"*"	"	11	11	II .	"*"	"*"	"*"	11	"
13	(10)	"*"	11	"	11	11	"*"	"	"	"	"	"*"	"*"	"*"	"	"
14	(1)	"*"	11	"	"	11	"*"	"	"	"	11	"*"	"*"	"*"	"	"
14	(2)	"*"	11	11	11	"	"*"	"	11	11	"	"*"	"*"	"*"	11	"
14	(3)	"*"	11	11	11	"	"*"	"	11	11	"	"*"	"*"	"*"	11	"
14	(4)	"*"	11	11	11	11	"*"	"	11	11	"	"*"	"*"	"*"	11	"
14	(5)	"*"	11	11	11	11	"*"	"	11	11	"	"*"	"*"	"*"	11	"
14	(6)	"*"	11	"	"	11	"*"	"	"	11	II .	"*"	"*"	"*"	11	"
14	(7)	"*"	11	11	11	11	"*"	"	11	11	"	"*"	"*"	"*"	11	"
14	(8)	"*"	11	"	11	11	"*"	"	11	11	11	"*"	"*"	"*"	11	"
14	(9)	"*"	11	"	11	11	"*"	"	11	11	11	"*"	"*"	"*"	11	"
14	(10)	"*"	11	11	11	11	"*"	"	11	11	"	"*"	"*"	"*"	11	11
15	(1)	"*"	11	11	11	11	"*"	"	11	11	11	"*"	"*"	"*"	11	"
15	(2)	"*"	11	"	"	11	"*"	"	"	"	11	"*"	"*"	"*"	11	11
15	(3)	"*"	11	"	"	11	"*"	"	"	"	11	"*"	"*"	"*"	11	11
15	(4)	"*"		11	11	11	"*"	"	11	11	11	"*"	"*"	"*"	11	"
15	(5)	"*"		"	"	11	"*"	"	11	11	11	"*"	"*"	"*"	11	11
15	(6)	"*"		"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
15	(7)	"*"		"	"	"	"*"	"	"	11	"	"*"	"*"	"*"	11	"
15	(8)	"*"		"		"	"*"	"	"	"	"	"*"	"*"	"*"	"	
15	(9)	"*"		"		"	"*"	"	"		"	"*"	"*"	"*"	"	"
15	(10)			"		"	т "*"	"	"		"	*"	*"*"	*"	"	"
		"*"		"		"	"*"	"	"		"	*"	"*"	*"	"	"
16	(1)	"*"		11		11	"*"	"	"		"	"*"	"*"	"*"	11	11
16	`	"*"			"	"	"*"	"	"		"	"*"	"*"	"*"	"	"
16	(3)			11		11	"*"	"	"		"				"	11
16	(4)	"*"		"		"		"	"			"*"	"*"	"*"	"	"
16	(5)	"*"		"		"	"*"	"	"			"*"	"*"	"*"	"	"
16	(6)	"*"					"*"	"	"	"* "		"*"	"*"	"*"	"	"
16	(7)	"*"		"		"	"*"		"			"*"	"*"	"*"	"	"
16	(8)	"*"		"		"	"*"	"				"*"	"*"	"*"		
16	(9)	"*"		"		"	"*"	"	"			"*"	"*"	"*"	"	"
16	(10)	"*"		"		"	"*"	"	"	"		"*"	"*"	"*"	"	"
17	(1)	"*"		"	"	"	"*"	"	"	"		"*"	"*"	"*"	"	"
17	(2)	"*"		"	"	"	"*"	"	"	"*		"*"	"*"	"*"	"	"
17	(3)	"*"						"	"	"		"*"	"*"	"*"	"	
17	(4)	"*"					"*"	"	"		"	"*"	"*"	"*"	"	"
17	(5)						"*"	"	"		"	"*"	"*"	"*"		11
17	(6)	"*"							"	"		"*"	"*"	"*"		11
17	(7)	"*"							"	"		"*"	"*"	"*"		"
17	(8)	"*"						"	"	"	"	"*"	"*"	"*"	"	"
17	(9)	"*"	"	"	"	"	"*"	"	"	"		"*"	"*"	"*"	"	"
17	(10)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(1)	"*"	11	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(2)	"*"	11	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(3)	"*"	11	"	"	"	"*"	"	11	"*	"	"*"	"*"	"*"	11	"
18	(4)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(5)	"*"	"	"	"	"	"*"	"	11	11	"	"*"	"*"	"*"	"	"
18	(6)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(7)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	11
18	(8)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	"
18	(9)	"*"	"	"	"	"	"*"	"	"	"	"	"*"	"*"	"*"	"	11
18	(10)	"*"	"	"	"	"	"*"	"	"	11	"	"*"	"*"	"*"	"	"

19	(1)	"*"	11	"	11	11	"*"	"	1	1	"	II .	"*"	"*"	"*"	"	"
19	(2)	"*"	11	"	11	11	"*"	"	1	1	"	II .	"*"	"*"	"*"	"	"
19	(3)	"*"	"	"	"	11	"*"	"	1	1	"	11	"*"	"*"	"*"	"	11
19	(4)	"*"	11	11	11	11	"*"	"	1	1	"	"	"*"	"*"	"*"	11	"
19	(5)	"*"	11	"	11	11	"*"	"		1	"	11	"*"	"*"	"*"	11	11
19	(6)	"*"	11	11	11	11	"*"	"		1	11	11	"*"	"*"	"*"	11	"
19	(7)	"*"	11	11	11	"	"*"	"		1	11	11	"*"	"*"	"*"	11	11
19	(8)	"*"	"	"	"	"	"*"	"		1	"	11	"*"	"*"	"*"	"	"
19	(9)	"*"	"	11	11	"	"*"	"		1	"		"*"	"*"	"*"	"	"
19	(10)	"*"	11	11	11	"	"*"	"			11,	*"	"*"	"*"	"*"	"	"
20	(10)	"*"	11	"	11	"	"*"	"			"	"	"*"	"*"	"*"	"	"
			"	"	"	"	* "*"	"			"	11	т "*"	"*"	"*"	"	"
20			"	"	"	"		"			"					"	"
20	(3)	"*"					"*"						"*"	"*"	"*"		
20	(4)	"*"	"	"	"	"	"*"	"			"	"	"*"	"*"	"*"	"	"
20	(5)	"*"	"	"	"	"	"*"	"		"	"	"	"*"	"*"	"*"	"	"
20	(6)	"*"	"	"	"	"	"*"	"	1	"	"	"	"*"	"*"	"*"	"	"
20	(7)	"*"	11	"	11	"	"*"	"	1	1	"	"	"*"	"*"	"*"	"	"
20	(8)	"*"	11	"	11	"	"*"	"	1	1	"	11	"*"	"*"	"*"	"	"
20	(9)	"*"	11	11	11	11	"*"	" :	*	1	"	"	"*"	"*"	"*"	11	"
20	(10)	"*"	11	11	11	11	"*"	"	1	1	"	"	"*"	"*"	"*"	11	"
21	(1)	"*"	11	11	11	11	"*"	"	1	1	11	11	"*"	"*"	"*"	11	"
21	(2)	"*"	11	11	11	11	"*"	"		1	11	11	"*"	"*"	"*"	11	11
21	(3)	"*"	11	11	11	11	"*"	"		1	11	11	"*"	"*"	"*"	11	11
21	(4)	"*"	11	11	11	"	"*"	"		1	ш,	*"	"*"	"*"	"*"	11	11
21	(5)	"*"	"	11	11	"	"*"	"		1			"*"	"*"	"*"	"	"
21	(6)	"*"	"	"	11	"	"*"	"			"	11	"*"	"*"	"*"	"	"
21	(7)	"*"	"	"	"	"	*"	"			"	11	"*"	"*"	"*"	"	"
			11	"	11	11	"*"	11			"	11				"	
21	(8)	"*"											"*"	"*"	"*"	"	"
21	(9)	"*"	"	"	"	"	"*"	"			"	"	"*"	"*"	"*"		
21	(10)	"*"	"	"	"	"	"*"	"		"	"	"	"*"	"*"	"*"	"	"
22	(1)	"*"	"	"	"	"	"*"	"		"	"	"	"*"	"*"	"*"	"	"
22	(2)	"*"	"	"	"	"	"*"	"	1	"	"	"	"*"	"*"	"*"	"	"
22	(3)	"*"	11	"	11	"	"*"	"	1	1	"	"	"*"	"*"	"*"	"	"
22	(4)	"*"	11	11	11	11	"*"	"	1	1	"	"	"*"	"*"	"*"	11	"
22	(5)	"*"	11	"	11	11	"*"	"	1	"	"	II .	"*"	"*"	"*"	11	"
22	(6)	"*"	11	"	11	11	"*"	"	1	"	"	II .	"*"	"*"	"*"	11	"
22	(7)	"*"	11	11	11	"	"*"	"	1	1	"	11	"*"	"*"	"*"	11	"
22	(8)	"*"	11	11	11	11	"*"	"		1	ш,	*"	"*"	"*"	"*"	11	11
22	(9)	"*"	"	"	"	11	"*"	"		1	"	11	"*"	"*"	"*"	"	"
22	(10)	"*"	11	11	11	11	"*"	"		1	11	11	"*"	"*"	"*"	11	"
23	(1)	"*"					"*"	"		1	"	11	"*"	"*"	"*"	"	11
23	(2)	"*"					"*"	"			"		"*"	"*"	"*"	"	"
23	(3)	"*"		"			"*"	"		1	"	11	"*"	"*"	"*"	"	11
23	(4)	"*"		"			*"	"				11	"*"	"*"	"*"		11
							"*"	11				11					11
23	(5)	"*"						"				"	"*"	"*"	"*"		"
23	(6)	"*"					"*"						"*"	"*"	"*"		
23	(7)	"*"					"*"	"				"	"*"	"*"	"*"		"
23	(8)	"*"					"*"	"				"	"*"	"*"	"*"		"
23	(9)	•		"	"	"	"*"	"	1	"	",	* ^{!!}	"*"	"*"	"*"	"	"
23	(10)	"*"		"	"		"*"	"	1	11	"	11	"*"	"*"	"*"	"	"
24	(1)	"*"	"	"	"	"	"*"	11	١	1	",	*"	"*"	"*"	"*"	"	"
24	(2)	"*"	"	"	"	"	"*"	"	1	"	"	11	"*"	"*"	"*"	"	"
24	(3)	"*"	"	"	"	"	"*"	"		1	"	11	"*"	"*"	"*"	"	"
24	(4)	"*"	"	"	"	"	"*"	"	1	1	"	11	"*"	"*"	"*"	"	"

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24	(6)	"*"	11 11	11 1	"*"	" "	11 11	"*"	"*"	"*"	11	11
24	(7)	"*"	11 11		"*"	11 11	11 11	"*"	"*"	"*"	11	11
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25	(4)	"*"	" "		" "*"	" "	"*"	"*"	"*"	"*"	"	"
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25	(7)	"*"	" "	" "	"*"	" "	"*"	"*"	"*"	"*"	"	"
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25	(10)	"*"	11 11		"*"	11 11	"*"	"*"	"*"	"*"	11	11
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26	(2)	"*"			"*"	11 11	"*"	"*"	"*"	"*"	"	"
26	(3)	"*"	11 11		" "*"	11 11	"*"	"*"	"*"	"*"	11	11
26	(4)	"*"			"*"	" "	"*"	"*"	"*"	"*"	11	11
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31	(10)	"*"	11 11	11 11	"*"	"*"	"*"	"*"	"*"	"*"	11 11
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32	(10)	"*"	11 11	"*"	"*"	"*"	"*"	"*"	"*"	"*"	11 11
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33	(2)	"*"	11 11	11 11	"*"	"*"	"*"	"*"	"*"	"*"	11 11
33	(3)	"*"	11 11	11 11	"*"	"*"	"*"	"*"	"*"	"*"	"*"
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38	(1)	"*" " "	" " "*"	"*"	"*"	"*"	"*"	"*"	"*"
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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: CRB.avg
Feature: CRBI.avg
Feature: CRBI.avg
Feature: neg.cont
Feature: log.CAB

Model 5:

BIC: -582.248168

Feature: log.years

Feature: GS
Feature: G.y
Feature: AB
Feature: R
Feature: H
Feature: BB
Feature: CH
Feature: CBB
Feature: CRB.avg
Feature: CRBI.avg
Feature: CRBI.avg
Feature: log.CAB
Feature: log.CAB

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=" + ")
```

7)

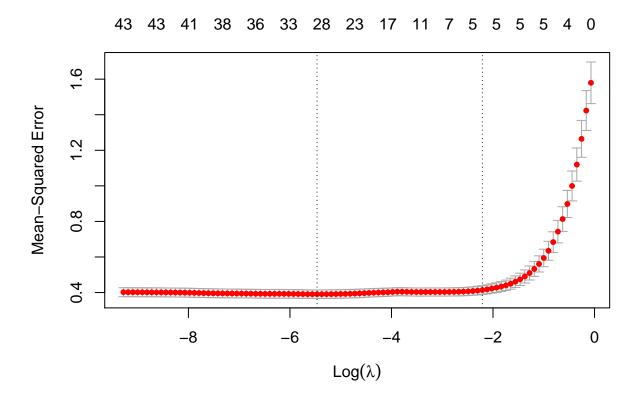
In determining the value of the hyperparameter lambda to use for the LASSO model (original feature variables), I will be using 10-fold cross validation with an average MSE for the criterion.

```
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.

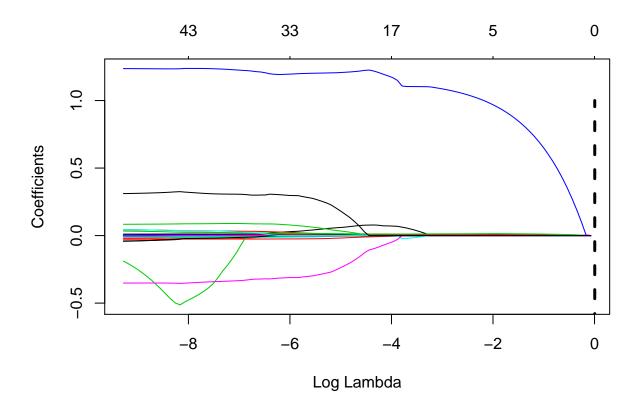
The value of lambda I will use for the LASSO model is the following:

```
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
Α
Е
           -1.580214e-03
DP
           -6.484793e-03
G.y
AB
            1.509140e-03
R
Η
X2B
           -3.628000e-03
ХЗВ
HR
           -9.471769e-03
RBI
            1.628877e-03
SB
           -4.844934e-04
CS
            -2.316805e-02
BB
            4.166142e-03
SO
IBB
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HBP
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            7.769733e-03
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SF
            1.004775e-02
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CHR
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CR
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CRBI
CBB
            -1.065447e-03
AVG
OBP
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CAB.avg
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
```