Week 2 - Data Science II

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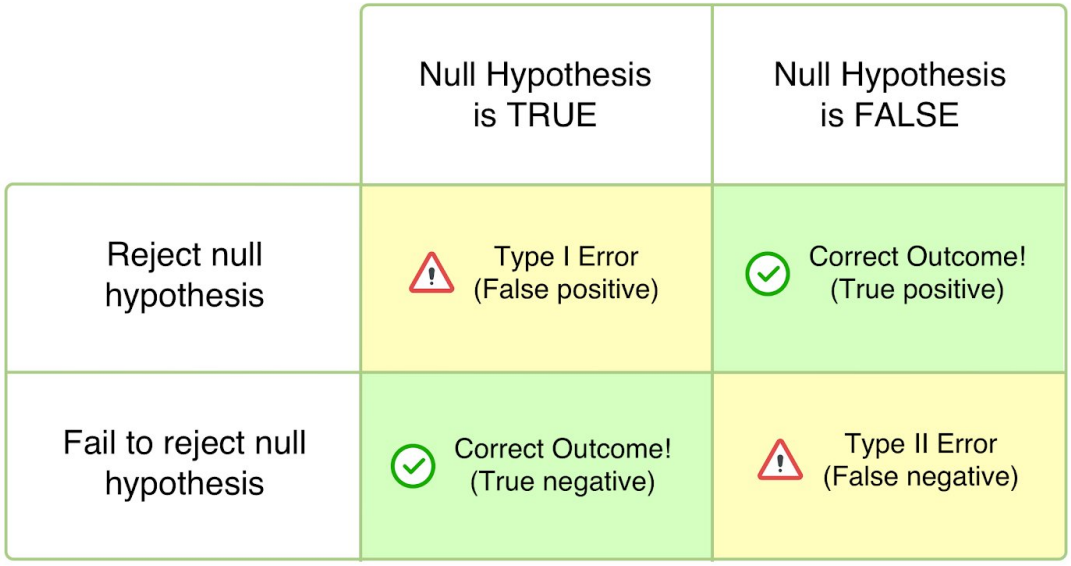
18/01/2022

Today: - Extending linear models beyond just least squares regressions

Let's talk about the three most common methods for feature selection!

Subset Selection: We identify a subset of the p predictors that we believe to be related to the response. We then fit a model using least squares on the reduced set of variables **Shrinkage:** We fit a model involving all p predictors, but the estimated coefficients are shrunken towards zero relative to the least squares estimates. This shrinkage (also known as regularization) has the effect of reducing variance and can also perform variable selection. **Dimension Reduction:** We project the p predictors into a M-dimensional subspace, where M $<$ p. This is achieved by computing M different linear combinations, or projections, of the variables. Then these M projections are used as predictors to fit a linear regression model by least squares. (don't let this sound too scary!)

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# # ------------------------------------------------------------
#
# Best Subset Selection
#
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```r
# # ------------------------------------------------------------

# Best Subset Selection

# Let's take a peek at a new dataset about baseball called Hitters!

data(Hitters)

Hitters
```

```
##                   AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun
## -Andy Allanson      293   66     1   30  29    14     1    293    66      1
## -Alan Ashby         315   81     7   24  38    39    14   3449   835     69
## -Alvin Davis        479  130    18   66  72    76     3   1624   457     63
## -Andre Dawson       496  141    20   65  78    37    11   5628  1575    225
## -Andres Galarraga   321   87    10   39  42    30     2    396   101     12
## -Alfredo Griffin    594  169     4   74  51    35    11   4408  1133     19
## -Al Newman          185   37     1   23   8    21     2    214    42      1
## -Argenis Salazar    298   73     0   24  24     7     3    509   108      0
## -Andres Thomas      323   81     6   26  32     8     2    341    86      6
## -Andre Thornton     401   92    17   49  66    65    13   5206  1332    253
## -Alan Trammell      574  159    21  107  75    59    10   4631  1300     90
## -Alex Trevino       202   53     4   31  26    27     9   1876   467     15
## -Andy VanSlyke      418  113    13   48  61    47     4   1512   392     41
## -Alan Wiggins       239   60     0   30  11    22     6   1941   510      4
## -Bill Almon         196   43     7   29  27    30    13   3231   825     36
## -Billy Beane        183   39     3   20  15    11     3    201    42      3
## -Buddy Bell         568  158    20   89  75    73    15   8068  2273    177
## -Buddy Biancalana   190   46     2   24   8    15     5    479   102      5
## -Bruce Bochte       407  104     6   57  43    65    12   5233  1478    100
## -Bruce Bochy        127   32     8   16  22    14     8    727   180     24
## -Barry Bonds        413   92    16   72  48    65     1    413    92     16
## -Bobby Bonilla      426  109     3   55  43    62     1    426   109      3
## -Bob Boone           22   10     1    4   2     1     6     84    26      2
## -Bob Brenly         472  116    16   60  62    74     6   1924   489     67
## -Bill Buckner       629  168    18   73 102    40    18   8424  2464    164
## -Brett Butler       587  163     4   92  51    70     6   2695   747     17
## -Bob Dernier        324   73     4   32  18    22     7   1931   491     13
## -Bo Diaz            474  129    10   50  56    40    10   2331   604     61
## -Bill Doran         550  152     6   92  37    81     5   2308   633     32
## -Brian Downing      513  137    20   90  95    90    14   5201  1382    166
## -Bobby Grich        313   84     9   42  30    39    17   6890  1833    224
## -Billy Hatcher      419  108     6   55  36    22     3    591   149      8
## -Bob Horner         517  141    27   70  87    52     9   3571   994    215
## -Brook Jacoby       583  168    17   83  80    56     5   1646   452     44
## -Bob Kearney        204   49     6   23  25    12     7   1309   308     27
## -Bill Madlock       379  106    10   38  60    30    14   6207  1906    146
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## -Bobby Meacham       161   36     0   19  10    17     4  1053   244      3
## -Bob Melvin          268   60     5   24  25    15     2   350    78      5
## -Ben Oglivie         346   98     5   31  53    30    16  5913  1615    235
## -Bip Roberts         241   61     1   34  12    14     1   241    61      1
## -BillyJo Robidoux    181   41     1   15  21    33     2   232    50      4
## -Bill Russell        216   54     0   21  18    15    18  7318  1926     46
## -Billy Sample        200   57     6   23  14    14     9  2516   684     46
## -Bill Schroeder      217   46     7   32  19     9     4   694   160     32
## -Butch Wynegar       194   40     7   19  29    30    11  4183  1069     64
## -Chris Bando         254   68     2   28  26    22     6   999   236     21
## -Chris Brown         416  132     7   57  49    33     3   932   273     24
## -Carmen Castillo     205   57     8   34  32     9     5   756   192     32
## -Cecil Cooper        542  140    12   46  75    41    16  7099  2130    235
## -Chili Davis         526  146    13   71  70    84     6  2648   715     77
## -Carlton Fisk        457  101    14   42  63    22    17  6521  1767    281
## -Curt Ford           214   53     2   30  29    23     2   226    59      2
## -Cliff Johnson        19    7     0    1   2     1     4    41    13      1
## -Carney Lansford     591  168    19   80  72    39     9  4478  1307    113
## -Chet Lemon          403  101    12   45  53    39    12  5150  1429    166
## -Candy Maldonado     405  102    18   49  85    20     6   950   231     29
## -Carmelo Martinez    244   58     9   28  25    35     4  1335   333     49
## -Charlie Moore       235   61     3   24  39    21    14  3926  1029     35
## -Craig Reynolds      313   78     6   32  41    12    12  3742   968     35
## -Cal Ripken          627  177    25   98  81    70     6  3210   927    133
## -Cory Snyder         416  113    24   58  69    16     1   416   113     24
## -Chris Speier        155   44     6   21  23    15    16  6631  1634     98
## -Curt Wilkerson      236   56     0   27  15    11     4  1115   270      1
## -Dave Anderson       216   53     1   31  15    22     4   926   210      9
## -Doug Baker           24    3     0    1   0     2     3   159    28      0
## -Don Baylor          585  139    31   93  94    62    17  7546  1982    315
## -Dann Bilardello     191   37     4   12  17    14     4   773   163     16
## -Daryl Boston        199   53     5   29  22    21     3   514   120      8
## -Darnell Coles       521  142    20   67  86    45     4   815   205     22
## -Dave Collins        419  113     1   44  27    44    12  4484  1231     32
## -Dave Concepcion     311   81     3   42  30    26    17  8247  2198    100
## -Darren Daulton      138   31     8   18  21    38     3   244    53     12
## -Doug DeCinces       512  131    26   69  96    52    14  5347  1397    221
## -Darrell Evans       507  122    29   78  85    91    18  7761  1947    347
## -Dwight Evans        529  137    26   86  97    97    15  6661  1785    291
## -Damaso Garcia       424  119     6   57  46    13     9  3651  1046     32
## -Dan Gladden         351   97     4   55  29    39     4  1258   353     16
## -Danny Heep          195   55     5   24  33    30     8  1313   338     25
## -Dave Henderson      388  103    15   59  47    39     6  2174   555     80
## -Donnie Hill         339   96     4   37  29    23     4  1064   290     11
## -Dave Kingman        561  118    35   70  94    33    16  6677  1575    442
## -Davey Lopes         255   70     7   49  35    43    15  6311  1661    154
## -Don Mattingly       677  238    31  117 113    53     5  2223   737     93
## -Darryl Motley       227   46     7   23  20    12     5  1325   324     44
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## -Dale Murphy         614  163    29   89  83    75    11   5017  1388    266
## -Dwayne Murphy       329   83     9   50  39    56     9   3828   948    145
## -Dave Parker         637  174    31   89 116    56    14   6727  2024    247
## -Dan Pasqua          280   82    16   44  45    47     2    428   113     25
## -Darrell Porter      155   41    12   21  29    22    16   5409  1338    181
## -Dick Schofield      458  114    13   67  57    48     4   1350   298     28
## -Don Slaught         314   83    13   39  46    16     5   1457   405     28
## -Darryl Strawberry   475  123    27   76  93    72     4   1810   471    108
## -Dale Sveum          317   78     7   35  35    32     1    317    78      7
## -Danny Tartabull     511  138    25   76  96    61     3    592   164     28
## -Dickie Thon         278   69     3   24  21    29     8   2079   565     32
## -Denny Walling       382  119    13   54  58    36    12   2133   594     41
## -Dave Winfield       565  148    24   90 104    77    14   7287  2083    305
## -Enos Cabell         277   71     2   27  29    14    15   5952  1647     60
## -Eric Davis          415  115    27   97  71    68     3    711   184     45
## -Eddie Milner        424  110    15   70  47    36     7   2130   544     38
## -Eddie Murray        495  151    17   61  84    78    10   5624  1679    275
## -Ernest Riles        524  132     9   69  47    54     2    972   260     14
## -Ed Romero           233   49     2   41  23    18     8   1350   336      7
## -Ernie Whitt         395  106    16   48  56    35    10   2303   571     86
## -Fred Lynn           397  114    23   67  67    53    13   5589  1632    241
## -Floyd Rayford       210   37     8   15  19    15     6    994   244     36
## -Franklin Stubbs     420   95    23   55  58    37     3    646   139     31
## -Frank White         566  154    22   76  84    43    14   6100  1583    131
## -George Bell         641  198    31  101 108    41     5   2129   610     92
## -Glenn Braggs        215   51     4   19  18    11     1    215    51      4
## -George Brett        441  128    16   70  73    80    14   6675  2095    209
## -Greg Brock          325   76    16   33  52    37     5   1506   351     71
## -Gary Carter         490  125    24   81 105    62    13   6063  1646    271
## -Glenn Davis         574  152    31   91 101    64     3    985   260     53
## -George Foster       284   64    14   30  42    24    18   7023  1925    348
## -Gary Gaetti         596  171    34   91 108    52     6   2862   728    107
## -Greg Gagne          472  118    12   63  54    30     4    793   187     14
## -George Hendrick     283   77    14   45  47    26    16   6840  1910    259
## -Glenn Hubbard       408   94     4   42  36    66     9   3573   866     59
## -Garth Iorg          327   85     3   30  44    20     8   2140   568     16
## -Gary Matthews       370   96    21   49  46    60    15   6986  1972    231
## -Graig Nettles       354   77    16   36  55    41    20   8716  2172    384
## -Gary Pettis         539  139     5   93  58    69     5   1469   369     12
## -Gary Redus          340   84    11   62  33    47     5   1516   376     42
## -Garry Templeton     510  126     2   42  44    35    11   5562  1578     44
## -Gorman Thomas       315   59    16   45  36    58    13   4677  1051    268
## -Greg Walker         282   78    13   37  51    29     5   1649   453     73
## -Gary Ward           380  120     5   54  51    31     8   3118   900     92
## -Glenn Wilson        584  158    15   70  84    42     5   2358   636     58
## -Harold Baines       570  169    21   72  88    38     7   3754  1077    140
## -Hubie Brooks        306  104    14   50  58    25     7   2954   822     55
## -Howard Johnson      220   54    10   30  39    31     5   1185   299     40
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## -Hal McRae           278   70     7   22  37    18    18   7186  2081    190
## -Harold Reynolds     445   99     1   46  24    29     4    618   129      1
## -Harry Spilman       143   39     5   18  30    15     9    639   151     16
## -Herm Winningham     185   40     4   23  11    18     3    524   125      7
## -Jesse Barfield      589  170    40  107 108    69     6   2325   634    128
## -Juan Beniquez       343  103     6   48  36    40    15   4338  1193     70
## -Juan Bonilla        284   69     1   33  18    25     5   1407   361      6
## -John Cangelosi      438  103     2   65  32    71     2    440   103      2
## -Jose Canseco        600  144    33   85 117    65     2    696   173     38
## -Joe Carter          663  200    29  108 121    32     4   1447   404     57
## -Jack Clark          232   55     9   34  23    45    12   4405  1213    194
## -Jose Cruz           479  133    10   48  72    55    17   7472  2147    153
## -Julio Cruz          209   45     0   38  19    42    10   3859   916     23
## -Jody Davis          528  132    21   61  74    41     6   2641   671     97
## -Jim Dwyer           160   39     8   18  31    22    14   2128   543     56
## -Julio Franco        599  183    10   80  74    32     5   2482   715     27
## -Jim Gantner         497  136     7   58  38    26    11   3871  1066     40
## -Johnny Grubb        210   70    13   32  51    28    15   4040  1130     97
## -Jerry Hairston      225   61     5   32  26    26    11   1568   408     25
## -Jack Howell         151   41     4   26  21    19     2    288    68      9
## -John Kruk           278   86     4   33  38    45     1    278    86      4
## -Jeffrey Leonard     341   95     6   48  42    20    10   2964   808     81
## -Jim Morrison        537  147    23   58  88    47    10   2744   730     97
## -John Moses          399  102     3   56  34    34     5    670   167      4
## -Jerry Mumphrey      309   94     5   37  32    26    13   4618  1330     57
## -Joe Orsulak         401  100     2   60  19    28     4    876   238      2
## -Jorge Orta          336   93     9   35  46    23    15   5779  1610    128
## -Jim Presley         616  163    27   83 107    32     3   1437   377     65
## -Jamie Quirk         219   47     8   24  26    17    12   1188   286     23
## -Johnny Ray          579  174     7   67  78    58     6   3053   880     32
## -Jeff Reed           165   39     2   13   9    16     3    196    44      2
## -Jim Rice            618  200    20   98 110    62    13   7127  2163    351
## -Jerry Royster       257   66     5   31  26    32    14   3910   979     33
## -John Russell        315   76    13   35  60    25     3    630   151     24
## -Juan Samuel         591  157    16   90  78    26     4   2020   541     52
## -John Shelby         404   92    11   54  49    18     6   1354   325     30
## -Joel Skinner        315   73     5   23  37    16     4    450   108      6
## -Jeff Stone          249   69     6   32  19    20     4    702   209     10
## -Jim Sundberg        429   91    12   41  42    57    13   5590  1397     83
## -Jim Traber          212   54    13   28  44    18     2    233    59     13
## -Jose Uribe          453  101     3   46  43    61     3    948   218      6
## -Jerry Willard       161   43     4   17  26    22     3    707   179     21
## -Joel Youngblood     184   47     5   20  28    18    11   3327   890     74
## -Kevin Bass          591  184    20   83  79    38     5   1689   462     40
## -Kal Daniels         181   58     6   34  23    22     1    181    58      6
## -Kirk Gibson         441  118    28   84  86    68     8   2723   750    126
## -Ken Griffey         490  150    21   69  58    35    14   6126  1839    121
## -Keith Hernandez     551  171    13   94  83    94    13   6090  1840    128
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## -Kent Hrbek          550  147    29   85  91    71     6  2816   815    117
## -Ken Landreaux       283   74     4   34  29    22    10  3919  1062     85
## -Kevin McReynolds    560  161    26   89  96    66     4  1789   470     65
## -Kevin Mitchell      328   91    12   51  43    33     2   342    94     12
## -Keith Moreland      586  159    12   72  79    53     9  3082   880     83
## -Ken Oberkfell       503  136     5   62  48    83    10  3423   970     20
## -Ken Phelps          344   85    24   69  64    88     7   911   214     64
## -Kirby Puckett       680  223    31  119  96    34     3  1928   587     35
## -Kurt Stillwell      279   64     0   31  26    30     1   279    64      0
## -Leon Durham         484  127    20   66  65    67     7  3006   844    116
## -Len Dykstra         431  127     8   77  45    58     2   667   187      9
## -Larry Herndon       283   70     8   33  37    27    12  4479  1222     94
## -Lee Lacy            491  141    11   77  47    37    15  4291  1240     84
## -Len Matuszek        199   52     9   26  28    21     6   805   191     30
## -Lloyd Moseby        589  149    21   89  86    64     7  3558   928    102
## -Lance Parrish       327   84    22   53  62    38    10  4273  1123    212
## -Larry Parrish       464  128    28   67  94    52    13  5829  1552    210
## -Luis Rivera         166   34     0   20  13    17     1   166    34      0
## -Larry Sheets        338   92    18   42  60    21     3   682   185     36
## -Lonnie Smith        508  146     8   80  44    46     9  3148   915     41
## -Lou Whitaker        584  157    20   95  73    63    10  4704  1320     93
## -Mike Aldrete        216   54     2   27  25    33     1   216    54      2
## -Marty Barrett       625  179     4   94  60    65     5  1696   476     12
## -Mike Brown          243   53     4   18  26    27     4   853   228     23
## -Mike Davis          489  131    19   77  55    34     7  2051   549     62
## -Mike Diaz           209   56    12   22  36    19     2   216    58     12
## -Mariano Duncan      407   93     8   47  30    30     2   969   230     14
## -Mike Easler         490  148    14   64  78    49    13  3400  1000    113
## -Mike Fitzgerald     209   59     6   20  37    27     4   884   209     14
## -Mel Hall            442  131    18   68  77    33     6  1416   398     47
## -Mickey Hatcher      317   88     3   40  32    19     8  2543   715     28
## -Mike Heath          288   65     8   30  36    27     9  2815   698     55
## -Mike Kingery        209   54     3   25  14    12     1   209    54      3
## -Mike LaValliere     303   71     3   18  30    36     3   344    76      3
## -Mike Marshall       330   77    19   47  53    27     6  1928   516     90
## -Mike Pagliarulo     504  120    28   71  71    54     3  1085   259     54
## -Mark Salas          258   60     8   28  33    18     3   638   170     17
## -Mike Schmidt         20    1     0    0   0     0     2    41     9      2
## -Mike Scioscia       374   94     5   36  26    62     7  1968   519     26
## -Mickey Tettleton    211   43    10   26  35    39     3   498   116     14
## -Milt Thompson       299   75     6   38  23    26     3   580   160      8
## -Mitch Webster       576  167     8   89  49    57     4   822   232     19
## -Mookie Wilson       381  110     9   61  45    32     7  3015   834     40
## -Marvell Wynne       288   76     7   34  37    15     4  1644   408     16
## -Mike Young          369   93     9   43  42    49     5  1258   323     54
## -Nick Esasky         330   76    12   35  41    47     4  1367   326     55
## -Ozzie Guillen       547  137     2   58  47    12     2  1038   271      3
## -Oddibe McDowell     572  152    18  105  49    65     2   978   249     36
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## -Omar Moreno         359   84     4   46  27    21    12   4992  1257     37
## -Ozzie Smith         514  144     0   67  54    79     9   4739  1169     13
## -Ozzie Virgil        359   80    15   45  48    63     7   1493   359     61
## -Phil Bradley        526  163    12   88  50    77     4   1556   470     38
## -Phil Garner         313   83     9   43  41    30    14   5885  1543    104
## -Pete Incaviglia     540  135    30   82  88    55     1    540   135     30
## -Paul Molitor        437  123     9   62  55    40     9   4139  1203     79
## -Pete O'Brien        551  160    23   86  90    87     5   2235   602     75
## -Pete Rose           237   52     0   15  25    30    24  14053  4256    160
## -Pat Sheridan        236   56     6   41  19    21     5   1257   329     24
## -Pat Tabler          473  154     6   61  48    29     6   1966   566     29
## -Rafael Belliard     309   72     0   33  31    26     5    354    82      0
## -Rick Burleson       271   77     5   35  29    33    12   4933  1358     48
## -Randy Bush          357   96     7   50  45    39     5   1394   344     43
## -Rick Cerone         216   56     4   22  18    15    12   2796   665     43
## -Ron Cey             256   70    13   42  36    44    16   7058  1845    312
## -Rob Deer            466  108    33   75  86    72     3    652   142     44
## -Rick Dempsey        327   68    13   42  29    45    18   3949   939     78
## -Rich Gedman         462  119    16   49  65    37     7   2131   583     69
## -Ron Hassey          341  110     9   45  49    46     9   2331   658     50
## -Rickey Henderson    608  160    28  130  74    89     8   4071  1182    103
## -Reggie Jackson      419  101    18   65  58    92    20   9528  2510    548
## -Ricky Jones          33    6     0    2   4     7     1     33     6      0
## -Ron Kittle          376   82    21   42  60    35     5   1770   408    115
## -Ray Knight          486  145    11   51  76    40    11   3967  1102     67
## -Randy Kutcher       186   44     7   28  16    11     1    186    44      7
## -Rudy Law            307   80     1   42  36    29     7   2421   656     18
## -Rick Leach          246   76     5   35  39    13     6    912   234     12
## -Rick Manning        205   52     8   31  27    17    12   5134  1323     56
## -Rance Mulliniks     348   90    11   50  45    43    10   2288   614     43
## -Ron Oester          523  135     8   52  44    52     9   3368   895     39
## -Rey Quinones        312   68     2   32  22    24     1    312    68      2
## -Rafael Ramirez      496  119     8   57  33    21     7   3358   882     36
## -Ronn Reynolds       126   27     3    8  10     5     4    239    49      3
## -Ron Roenicke        275   68     5   42  42    61     6    961   238     16
## -Ryne Sandberg       627  178    14   68  76    46     6   3146   902     74
## -Rafael Santana      394   86     1   38  28    36     4   1089   267      3
## -Rick Schu           208   57     8   32  25    18     3    653   170     17
## -Ruben Sierra        382  101    16   50  55    22     1    382   101     16
## -Roy Smalley         459  113    20   59  57    68    12   5348  1369    155
## -Robby Thompson      549  149     7   73  47    42     1    549   149      7
## -Rob Wilfong         288   63     3   25  33    16    10   2682   667     38
## -Reggie Williams     303   84     4   35  32    23     2    312    87      4
## -Robin Yount         522  163     9   82  46    62    13   7037  2019    153
## -Steve Balboni       512  117    29   54  88    43     6   1750   412    100
## -Scott Bradley       220   66     5   20  28    13     3    290    80      5
## -Sid Bream           522  140    16   73  77    60     4    730   185     22
## -Steve Buechele      461  112    18   54  54    35     2    680   160     24
```

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## -Shawon Dunston      581  145    17   66  68    21     2   831   210     21
## -Scott Fletcher      530  159     3   82  50    47     6  1619   426     11
## -Steve Garvey        557  142    21   58  81    23    18  8759  2583    271
## -Steve Jeltz         439   96     0   44  36    65     4   711   148      1
## -Steve Lombardozzi   453  103     8   53  33    52     2   507   123      8
## -Spike Owen          528  122     1   67  45    51     4  1716   403     12
## -Steve Sax           633  210     6   91  56    59     6  3070   872     19
## -Tony Armas           16    2     0    1   0     0     2    28     4      0
## -Tony Bernazard      562  169    17   88  73    53     8  3181   841     61
## -Tom Brookens        281   76     3   42  25    20     8  2658   657     48
## -Tom Brunansky       593  152    23   69  75    53     6  2765   686    133
## -Tony Fernandez      687  213    10   91  65    27     4  1518   448     15
## -Tim Flannery        368  103     3   48  28    54     8  1897   493      9
## -Tom Foley           263   70     1   26  23    30     4   888   220      9
## -Tony Gwynn          642  211    14  107  59    52     5  2364   770     27
## -Terry Harper        265   68     8   26  30    29     7  1337   339     32
## -Toby Harrah         289   63     7   36  41    44    17  7402  1954    195
## -Tommy Herr          559  141     2   48  61    73     8  3162   874     16
## -Tim Hulett          520  120    17   53  44    21     4   927   227     22
## -Terry Kennedy        19    4     1    2   3     1     1    19     4      1
## -Tito Landrum        205   43     2   24  17    20     7   854   219     12
## -Tim Laudner         193   47    10   21  29    24     6  1136   256     42
## -Tom O'Malley        181   46     1   19  18    17     5   937   238      9
## -Tom Paciorek        213   61     4   17  22     3    17  4061  1145     83
## -Tony Pena           510  147    10   56  52    53     7  2872   821     63
## -Terry Pendleton     578  138     1   56  59    34     3  1399   357      7
## -Tony Perez          200   51     2   14  29    25    23  9778  2732    379
## -Tony Phillips       441  113     5   76  52    76     5  1546   397     17
## -Terry Puhl          172   42     3   17  14    15    10  4086  1150     57
## -Tim Raines          580  194     9   91  62    78     8  3372  1028     48
## -Ted Simmons         127   32     4   14  25    12    19  8396  2402    242
## -Tim Teufel          279   69     4   35  31    32     4  1359   355     31
## -Tim Wallach         480  112    18   50  71    44     7  3031   771    110
## -Vince Coleman       600  139     0   94  29    60     2  1236   309      1
## -Von Hayes           610  186    19  107  98    74     6  2728   753     69
## -Vance Law           360   81     5   37  44    37     7  2268   566     41
## -Wally Backman       387  124     1   67  27    36     7  1775   506      6
## -Wade Boggs          580  207     8  107  71   105     5  2778   978     32
## -Will Clark          408  117    11   66  41    34     1   408   117     11
## -Wally Joyner        593  172    22   82 100    57     1   593   172     22
## -Wayne Krenchicki    221   53     2   21  23    22     8  1063   283     15
## -Willie McGee        497  127     7   65  48    37     5  2703   806     32
## -Willie Randolph     492  136     5   76  50    94    12  5511  1511     39
## -Wayne Tolleson      475  126     3   61  43    52     6  1700   433      7
## -Willie Upshaw       573  144     9   85  60    78     8  3198   857     97
## -Willie Wilson       631  170     9   77  44    31    11  4908  1457     30
##                    CRuns CRBI CWalks League Division PutOuts Assists Errors
## -Andy Allanson        30   29     14      A        E     446      33     20
```

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## -Alan Ashby          321  414   375  N  W  632  43  10
## -Alvin Davis         224  266   263  A  W  880  82  14
## -Andre Dawson        828  838   354  N  E  200  11   3
## -Andres Galarraga     48   46    33  N  E  805  40   4
## -Alfredo Griffin     501  336   194  A  W  282 421  25
## -Al Newman            30    9    24  N  E   76 127   7
## -Argenis Salazar      41   37    12  A  W  121 283   9
## -Andres Thomas        32   34     8  N  W  143 290  19
## -Andre Thornton      784  890   866  A  E    0   0   0
## -Alan Trammell       702  504   488  A  E  238 445  22
## -Alex Trevino        192  186   161  N  W  304  45  11
## -Andy VanSlyke       205  204   203  N  E  211  11   7
## -Alan Wiggins        309  103   207  A  E  121 151   6
## -Bill Almon          376  290   238  N  E   80  45   8
## -Billy Beane          20   16    11  A  W  118   0   0
## -Buddy Bell         1045  993   732  N  W  105 290  10
## -Buddy Biancalana     65   23    39  A  W  102 177  16
## -Bruce Bochte        643  658   653  A  W  912  88   9
## -Bruce Bochy          67   82    56  N  W  202  22   2
## -Barry Bonds          72   48    65  N  E  280   9   5
## -Bobby Bonilla        55   43    62  A  W  361  22   2
## -Bob Boone             9    9     3  A  W  812  84  11
## -Bob Brenly          242  251   240  N  W  518  55   3
## -Bill Buckner       1008 1072   402  A  E 1067 157  14
## -Brett Butler        442  198   317  A  E  434   9   3
## -Bob Dernier         291  108   180  N  E  222   3   3
## -Bo Diaz             246  327   166  N  W  732  83  13
## -Bill Doran          349  182   308  N  W  262 329  16
## -Brian Downing       763  734   784  A  W  267   5   3
## -Bobby Grich        1033  864  1087  A  W  127 221   7
## -Billy Hatcher        80   46    31  N  W  226   7   4
## -Bob Horner          545  652   337  N  W 1378 102   8
## -Brook Jacoby        219  208   136  A  E  109 292  25
## -Bob Kearney         126  132    66  A  W  419  46   5
## -Bill Madlock        859  803   571  N  W   72 170  24
## -Bobby Meacham       156   86   107  A  E   70 149  12
## -Bob Melvin           34   29    18  N  W  442  59   6
## -Ben Oglivie         784  901   560  A  E    0   0   0
## -Bip Roberts          34   12    14  N  W  166 172  10
## -BillyJo Robidoux     20   29    45  A  E  326  29   5
## -Bill Russell        796  627   483  N  W  103  84   5
## -Billy Sample        371  230   195  N  W   69   1   1
## -Bill Schroeder       86   76    32  A  E  307  25   1
## -Butch Wynegar       486  493   608  A  E  325  22   2
## -Chris Bando         108  117   118  A  E  359  30   4
## -Chris Brown         113  121    80  N  W   73 177  18
## -Carmen Castillo     117  107    51  A  E   58   4   4
## -Cecil Cooper        987 1089   431  A  E  697  61   9
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## -Chili Davis         352  342    289      N        W     303       9      9
## -Carlton Fisk       1003  977    619      A        W     389      39      4
## -Curt Ford            32   32     27      N        E     109       7      3
## -Cliff Johnson         3    4      4      A        E       0       0      0
## -Carney Lansford     634  563    319      A        W      67     147      4
## -Chet Lemon          747  666    526      A        E     316       6      5
## -Candy Maldonado      99  138     64      N        W     161      10      3
## -Carmelo Martinez    164  179    194      N        W     142      14      2
## -Charlie Moore       441  401    333      A        E     425      43      4
## -Craig Reynolds      409  321    170      N        W     106     206      7
## -Cal Ripken          529  472    313      A        E     240     482     13
## -Cory Snyder          58   69     16      A        E     203      70     10
## -Chris Speier        698  661    777      N        E      53      88      3
## -Curt Wilkerson      116   64     57      A        W     125     199     13
## -Dave Anderson       118   69    114      N        W      73     152     11
## -Doug Baker           20   12      9      A        W      80       4      0
## -Don Baylor         1141 1179    727      A        E       0       0      0
## -Dann Bilardello      61   74     52      N        E     391      38      8
## -Daryl Boston         57   40     39      A        W     152       3      5
## -Darnell Coles        99  103     78      A        E     107     242     23
## -Dave Collins        612  344    422      A        E     211       2      1
## -Dave Concepcion     950  909    690      N        W     153     223     10
## -Darren Daulton       33   32     55      N        E     244      21      4
## -Doug DeCinces       712  815    548      A        W     119     216     12
## -Darrell Evans      1175 1152   1380      A        E     808     108      2
## -Dwight Evans       1082  949    989      A        E     280      10      5
## -Damaso Garcia       461  301    112      A        E     224     286      8
## -Dan Gladden         196  110    117      N        W     226       7      3
## -Danny Heep          144  149    153      N        E      83       2      1
## -Dave Henderson      285  274    186      A        W     182       9      4
## -Donnie Hill         123  108     55      A        W     104     213      9
## -Dave Kingman        901 1210    608      A        W     463      32      8
## -Davey Lopes        1019  608    820      N        E      51      54      8
## -Don Mattingly       349  401    171      A        E    1377     100      6
## -Darryl Motley       156  158     67      A        W      92       2      2
## -Dale Murphy         813  822    617      N        W     303       6      6
## -Dwayne Murphy       575  528    635      A        W     276       6      2
## -Dave Parker         978 1093    495      N        W     278       9      9
## -Dan Pasqua           61   70     63      A        E     148       4      2
## -Darrell Porter      746  805    875      A        W     165       9      1
## -Dick Schofield      160  123    122      A        W     246     389     18
## -Don Slaught         156  159     76      A        W     533      40      4
## -Darryl Strawberry   292  343    267      N        E     226      10      6
## -Dale Sveum           35   35     32      A        E      45     122     26
## -Danny Tartabull      87  110     71      A        W     157       7      8
## -Dickie Thon         258  192    162      N        W     142     210     10
## -Denny Walling       287  294    227      N        W      59     156      9
## -Dave Winfield      1135 1234    791      A        E     292       9      5
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## -Enos Cabell          753  596    259      N        W     360       32       5
## -Eric Davis           156  119     99      N        W     274        2       7
## -Eddie Milner         335  174    258      N        W     292        6       3
## -Eddie Murray         884 1015    709      A        E    1045       88      13
## -Ernest Riles         123   92     90      A        E     212      327      20
## -Ed Romero            166  122    106      A        E     102      132      10
## -Ernie Whitt          266  323    248      A        E     709       41       7
## -Fred Lynn            906  926    716      A        E     244        2       4
## -Floyd Rayford        107  114     53      A        E      40      115      15
## -Franklin Stubbs       77   77     61      N        W     206       10       7
## -Frank White          743  693    300      A        W     316      439      10
## -George Bell          297  319    117      A        E     269       17      10
## -Glenn Braggs          19   18     11      A        E     116        5      12
## -George Brett        1072 1050    695      A        W      97      218      16
## -Greg Brock           195  219    214      N        W     726       87       3
## -Gary Carter          847  999    680      N        E     869       62       8
## -Glenn Davis          148  173     95      N        W    1253      111      11
## -George Foster        986 1239    666      N        E      96        4       4
## -Gary Gaetti          361  401    224      A        W     118      334      21
## -Greg Gagne           102   80     50      A        W     228      377      26
## -George Hendrick      915 1067    546      A        W     144        6       5
## -Glenn Hubbard        429  365    410      N        W     282      487      19
## -Garth Iorg           216  208     93      A        E      91      185      12
## -Gary Matthews       1070  955    921      N        E     137        5       9
## -Graig Nettles       1172 1267   1057      N        W      83      174      16
## -Gary Pettis          247  126    198      A        W     462        9       7
## -Gary Redus           284  141    219      N        E     185        8       4
## -Garry Templeton      703  519    256      N        W     207      358      20
## -Gorman Thomas        681  782    697      A        W       0        0       0
## -Greg Walker          211  280    138      A        W     670       57       5
## -Gary Ward            444  419    240      A        W     237        8       1
## -Glenn Wilson         265  316    134      N        E     331       20       4
## -Harold Baines        492  589    263      A        W     295       15       5
## -Hubie Brooks         313  377    187      N        E     116      222      15
## -Howard Johnson       145  154    128      N        E      50      136      20
## -Hal McRae            935 1088    643      A        W       0        0       0
## -Harold Reynolds       72   31     48      A        W     278      415      16
## -Harry Spilman         80   97     61      N        W     138       15       1
## -Herm Winningham       58   37     47      N        E      97        2       2
## -Jesse Barfield       371  376    238      A        E     368       20       3
## -Juan Beniquez        581  421    325      A        E     211       56      13
## -Juan Bonilla         139   98    111      A        E     122      140       5
## -John Cangelosi        67   32     71      A        W     276        7       9
## -Jose Canseco         101  130     69      A        W     319        4      14
## -Joe Carter           210  222     68      A        E     241        8       6
## -Jack Clark           702  705    625      N        E     623       35       3
## -Jose Cruz            980 1032    854      N        W     237        5       4
## -Julio Cruz           557  279    478      A        W     132      205       5
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## -Jody Davis          273  383  226      N       E     885     105      8
## -Jim Dwyer           304  268  298      A       E      33       3      0
## -Julio Franco        330  326  158      A       E     231     374     18
## -Jim Gantner         450  367  241      A       E     304     347     10
## -Johnny Grubb        544  462  551      A       E       0       0      0
## -Jerry Hairston      202  185  257      A       W     132       9      0
## -Jack Howell          45   39   35      A       W      28      56      2
## -John Kruk            33   38   45      N       W     102       4      2
## -Jeffrey Leonard     379  428  221      N       W     158       4      5
## -Jim Morrison        302  351  174      N       E      92     257     20
## -John Moses           89   48   54      A       W     211       9      3
## -Jerry Mumphrey      616  522  436      N       E     161       3      3
## -Joe Orsulak         126   44   55      N       E     193      11      4
## -Jorge Orta          730  741  497      A       W       0       0      0
## -Jim Presley         181  227   82      A       W     110     308     15
## -Jamie Quirk         100  125   63      A       W     260      58      4
## -Johnny Ray          366  337  218      N       E     280     479      5
## -Jeff Reed            18   10   18      A       W     332      19      2
## -Jim Rice           1104 1289  564      A       E     330      16      8
## -Jerry Royster       518  324  382      N       W      87     166     14
## -John Russell         68   94   55      N       E     498      39     13
## -Juan Samuel         310  226   91      N       E     290     440     25
## -John Shelby         188  135   63      A       E     222       5      5
## -Joel Skinner         38   46   28      A       W     227      15      3
## -Jeff Stone           97   48   44      N       E     103       8      2
## -Jim Sundberg        578  579  644      A       W     686      46      4
## -Jim Traber           31   46   20      A       E     243      23      5
## -Jose Uribe           96   72   91      N       W     249     444     16
## -Jerry Willard        77   99   76      A       W     300      12      2
## -Joel Youngblood     419  382  304      N       W      49       2      0
## -Kevin Bass          219  195   82      N       W     303      12      5
## -Kal Daniels          34   23   22      N       W      88       0      3
## -Kirk Gibson         433  420  309      A       E     190       2      2
## -Ken Griffey         983  707  600      A       E      96       5      3
## -Keith Hernandez     969  900  917      N       E    1199     149      5
## -Kent Hrbek          405  474  319      A       W    1218     104     10
## -Ken Landreaux       505  456  283      N       W     145       5      7
## -Kevin McReynolds    233  260  155      N       W     332       9      8
## -Kevin Mitchell       51   44   33      N       E     145      59      8
## -Keith Moreland      363  477  295      N       E     181      13      4
## -Ken Oberkfell       408  303  414      N       W      65     258      8
## -Ken Phelps          150  156  187      A       W       0       0      0
## -Kirby Puckett       262  201   91      A       W     429       8      6
## -Kurt Stillwell       31   26   30      N       W     107     205     16
## -Leon Durham         436  458  377      N       E    1231      80      7
## -Len Dykstra         117   64   88      N       E     283       8      3
## -Larry Herndon       557  483  307      A       E     156       2      2
## -Lee Lacy            615  430  340      A       E     239       8      2
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## -Len Matuszek        113  119   87  N  W  235  22   5
## -Lloyd Moseby        513  471  351  A  E  371   6   6
## -Lance Parrish       577  700  334  A  E  483  48   6
## -Larry Parrish       740  840  452  A  W    0   0   0
## -Luis Rivera          20   13   17  N  E   64 119   9
## -Larry Sheets         88  112   50  A  E    0   0   0
## -Lonnie Smith        571  289  326  A  W  245   5   9
## -Lou Whitaker        724  522  576  A  E  276 421  11
## -Mike Aldrete         27   25   33  N  W  317  36   1
## -Marty Barrett       216  163  166  A  E  303 450  14
## -Mike Brown          101  110   76  N  E  107   3   3
## -Mike Davis          300  263  153  A  W  310   9   9
## -Mike Diaz            24   37   19  N  E  201   6   3
## -Mariano Duncan      121   69   68  N  W  172 317  25
## -Mike Easler         445  491  301  A  E    0   0   0
## -Mike Fitzgerald      66  106   92  N  E  415  35   3
## -Mel Hall            210  203  136  A  E  233   7   7
## -Mickey Hatcher      269  270  118  A  W  220  16   4
## -Mike Heath          315  325  189  N  E  259  30  10
## -Mike Kingery         25   14   12  A  W  102   6   3
## -Mike LaValliere      20   36   45  N  E  468  47   6
## -Mike Marshall       247  288  161  N  W  149   8   6
## -Mike Pagliarulo     150  167  114  A  E  103 283  19
## -Mark Salas           80   75   36  A  W  358  32   8
## -Mike Schmidt          6    7    4  N  E   78 220   6
## -Mike Scioscia       181  199  288  N  W  756  64  15
## -Mickey Tettleton     59   55   78  A  W  463  32   8
## -Milt Thompson        71   33   44  N  E  212   1   2
## -Mitch Webster       132   83   79  N  E  325  12   8
## -Mookie Wilson       451  249  168  N  E  228   7   5
## -Marvell Wynne       198  120  113  N  W  203   3   3
## -Mike Young          181  177  157  A  E  149   1   6
## -Nick Esasky         167  198  167  N  W  512  30   5
## -Ozzie Guillen       129   80   24  A  W  261 459  22
## -Oddibe McDowell     168   91  101  A  W  325  13   3
## -Omar Moreno         699  386  387  N  W  151   8   5
## -Ozzie Smith         583  374  528  N  E  229 453  15
## -Ozzie Virgil        176  202  175  N  W  682  93  13
## -Phil Bradley        245  167  174  A  W  250  11   1
## -Phil Garner         751  714  535  N  W   58 141  23
## -Pete Incaviglia      82   88   55  A  W  157   6  14
## -Paul Molitor        676  390  364  A  E   82 170  15
## -Pete O'Brien        278  328  273  A  W 1224 115  11
## -Pete Rose          2165 1314 1566  N  W  523  43   6
## -Pat Sheridan        166  125  105  A  E  172   1   4
## -Pat Tabler          250  252  178  A  E  846  84   9
## -Rafael Belliard      41   32   26  N  E  117 269  12
## -Rick Burleson       630  435  403  A  W   62  90   3
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## -Randy Bush          178  192    136      A        W     167       2      4
## -Rick Cerone         266  304    198      A        E     391      44      4
## -Ron Cey             965 1128    990      N        E      41     118      8
## -Rob Deer            102  109    102      A        E     286       8      8
## -Rick Dempsey        438  380    466      A        E     659      53      7
## -Rich Gedman         244  288    150      A        E     866      65      6
## -Ron Hassey          249  322    274      A        E     251       9      4
## -Rickey Henderson    862  417    708      A        E     426       4      6
## -Reggie Jackson     1509 1659   1342      A        W       0       0      0
## -Ricky Jones           2    4      7      A        W     205       5      4
## -Ron Kittle          238  299    157      A        W       0       0      0
## -Ray Knight          410  497    284      N        E      88     204     16
## -Randy Kutcher        28   16     11      N        W      99       3      1
## -Rudy Law            379  198    184      A        W     145       2      2
## -Rick Leach          102   96     80      A        E      44       0      1
## -Rick Manning        643  445    459      A        E     155       3      2
## -Rance Mulliniks     295  273    269      A        E      60     176      6
## -Ron Oester          377  284    296      N        W     367     475     19
## -Rey Quinones         32   22     24      A        E      86     150     15
## -Rafael Ramirez      365  280    165      N        W     155     371     29
## -Ronn Reynolds        16   13     14      N        E     190       2      9
## -Ron Roenicke        128  104    172      N        E     181       3      2
## -Ryne Sandberg       494  345    242      N        E     309     492      5
## -Rafael Santana       94   71     76      N        E     203     369     16
## -Rick Schu            98   54     62      N        E      42      94     13
## -Ruben Sierra         50   55     22      A        W     200       7      6
## -Roy Smalley         713  660    735      A        W       0       0      0
## -Robby Thompson       73   47     42      N        W     255     450     17
## -Rob Wilfong         315  259    204      A        W     135     257      7
## -Reggie Williams      39   32     23      N        W     179       5      3
## -Robin Yount        1043  827    535      A        E     352       9      1
## -Steve Balboni       204  276    155      A        W    1236      98     18
## -Scott Bradley        27   31     15      A        W     281      21      3
## -Sid Bream            93  106     86      N        E    1320     166     17
## -Steve Buechele       76   75     49      A        W     111     226     11
## -Shawon Dunston      106   86     40      N        E     320     465     32
## -Scott Fletcher      218  149    163      A        W     196     354     15
## -Steve Garvey       1138 1299    478      N        W    1160      53      7
## -Steve Jeltz          68   56     99      N        E     229     406     22
## -Steve Lombardozzi    63   39     58      A        W     289     407      6
## -Spike Owen          211  146    155      A        W     209     372     17
## -Steve Sax           420  230    274      N        W     367     432     16
## -Tony Armas            1    0      0      A        E     247       4      8
## -Tony Bernazard      450  342    373      A        E     351     442     17
## -Tom Brookens        324  300    179      A        E     106     144      7
## -Tom Brunansky       369  384    321      A        W     315      10      6
## -Tony Fernandez      196  137     89      A        E     294     445     13
## -Tim Flannery        207  162    198      N        W     209     246      3
```

```
## -Tom Foley            83   82     86      N        E      81     147      4
## -Tony Gwynn          352  230    193      N        W     337      19      4
## -Terry Harper        135  163    128      N        W      92       5      3
## -Toby Harrah        1115  919   1153      A        W     166     211      7
## -Tommy Herr          421  349    359      N        E     352     414      9
## -Tim Hulett          106   80     52      A        W      70     144     11
## -Terry Kennedy         2    3      1      N        W     692      70      8
## -Tito Landrum        105   99     71      N        E     131       6      1
## -Tim Laudner         129  139    106      A        W     299      13      5
## -Tom O'Malley         88   95    104      A        E      37      98      9
## -Tom Paciorek        488  491    244      A        W     178      45      4
## -Tony Pena           307  340    174      N        E     810      99     18
## -Terry Pendleton     149  161     87      N        E     133     371     20
## -Tony Perez         1272 1652    925      N        W     398      29      7
## -Tony Phillips       226  149    191      A        W     160     290     11
## -Terry Puhl          579  363    406      N        W      65       0      0
## -Tim Raines          604  314    469      N        E     270      13      6
## -Ted Simmons        1048 1348    819      N        W     167      18      6
## -Tim Teufel          180  148    158      N        E     133     173      9
## -Tim Wallach         338  406    239      N        E      94     270     16
## -Vince Coleman       201   69    110      N        E     300      12      9
## -Von Hayes           399  366    286      N        E    1182      96     13
## -Vance Law           279  257    246      N        E     170     284      3
## -Wally Backman       272  125    194      N        E     186     290     17
## -Wade Boggs          474  322    417      A        E     121     267     19
## -Will Clark           66   41     34      N        W     942      72     11
## -Wally Joyner         82  100     57      A        W    1222     139     15
## -Wayne Krenchicki    107  124    106      N        E     325      58      6
## -Willie McGee        379  311    138      N        E     325       9      3
## -Willie Randolph     897  451    875      A        E     313     381     20
## -Wayne Tolleson      217   93    146      A        W      37     113      7
## -Willie Upshaw       470  420    332      A        E    1314     131     12
## -Willie Wilson       775  357    249      A        W     408       4      3
##                     Salary NewLeague
## -Andy Allanson          NA         A
## -Alan Ashby         475.000         N
## -Alvin Davis        480.000         A
## -Andre Dawson       500.000         N
## -Andres Galarraga    91.500         N
## -Alfredo Griffin    750.000         A
## -Al Newman           70.000         A
## -Argenis Salazar    100.000         A
## -Andres Thomas       75.000         N
## -Andre Thornton    1100.000         A
## -Alan Trammell      517.143         A
## -Alex Trevino       512.500         N
## -Andy VanSlyke      550.000         N
## -Alan Wiggins       700.000         A
```

```
## -Bill Almon         240.000        N
## -Billy Beane             NA        A
## -Buddy Bell         775.000        N
## -Buddy Biancalana   175.000        A
## -Bruce Bochte            NA        A
## -Bruce Bochy        135.000        N
## -Barry Bonds        100.000        N
## -Bobby Bonilla      115.000        N
## -Bob Boone               NA        A
## -Bob Brenly         600.000        N
## -Bill Buckner       776.667        A
## -Brett Butler       765.000        A
## -Bob Dernier        708.333        N
## -Bo Diaz            750.000        N
## -Bill Doran         625.000        N
## -Brian Downing      900.000        A
## -Bobby Grich             NA        A
## -Billy Hatcher      110.000        N
## -Bob Horner              NA        N
## -Brook Jacoby       612.500        A
## -Bob Kearney        300.000        A
## -Bill Madlock       850.000        N
## -Bobby Meacham           NA        A
## -Bob Melvin          90.000        N
## -Ben Oglivie             NA        A
## -Bip Roberts             NA        N
## -BillyJo Robidoux    67.500        A
## -Bill Russell            NA        N
## -Billy Sample            NA        N
## -Bill Schroeder     180.000        A
## -Butch Wynegar           NA        A
## -Chris Bando        305.000        A
## -Chris Brown        215.000        N
## -Carmen Castillo    247.500        A
## -Cecil Cooper            NA        A
## -Chili Davis        815.000        N
## -Carlton Fisk       875.000        A
## -Curt Ford           70.000        N
## -Cliff Johnson           NA        A
## -Carney Lansford   1200.000        A
## -Chet Lemon         675.000        A
## -Candy Maldonado    415.000        N
## -Carmelo Martinez   340.000        N
## -Charlie Moore           NA        A
## -Craig Reynolds     416.667        N
## -Cal Ripken        1350.000        A
## -Cory Snyder         90.000        A
## -Chris Speier       275.000        N
```

```
## -Curt Wilkerson     230.000         A
## -Dave Anderson      225.000         N
## -Doug Baker              NA         A
## -Don Baylor         950.000         A
## -Dann Bilardello         NA         N
## -Daryl Boston         75.000         A
## -Darnell Coles      105.000         A
## -Dave Collins            NA         A
## -Dave Concepcion    320.000         N
## -Darren Daulton          NA         N
## -Doug DeCinces      850.000         A
## -Darrell Evans      535.000         A
## -Dwight Evans       933.333         A
## -Damaso Garcia      850.000         N
## -Dan Gladden        210.000         A
## -Danny Heep              NA         N
## -Dave Henderson     325.000         A
## -Donnie Hill        275.000         A
## -Dave Kingman            NA         A
## -Davey Lopes        450.000         N
## -Don Mattingly     1975.000         A
## -Darryl Motley           NA         A
## -Dale Murphy       1900.000         N
## -Dwayne Murphy      600.000         A
## -Dave Parker       1041.667         N
## -Dan Pasqua         110.000         A
## -Darrell Porter     260.000         A
## -Dick Schofield     475.000         A
## -Don Slaught        431.500         A
## -Darryl Strawberry 1220.000         N
## -Dale Sveum          70.000         A
## -Danny Tartabull    145.000         A
## -Dickie Thon             NA         N
## -Denny Walling      595.000         N
## -Dave Winfield     1861.460         A
## -Enos Cabell             NA         N
## -Eric Davis         300.000         N
## -Eddie Milner       490.000         N
## -Eddie Murray      2460.000         A
## -Ernest Riles            NA         A
## -Ed Romero          375.000         A
## -Ernie Whitt             NA         A
## -Fred Lynn               NA         A
## -Floyd Rayford           NA         A
## -Franklin Stubbs         NA         N
## -Frank White        750.000         A
## -George Bell       1175.000         A
## -Glenn Braggs         70.000         A
```

```
## -George Brett      1500.000        A
## -Greg Brock         385.000        A
## -Gary Carter       1925.571        N
## -Glenn Davis        215.000        N
## -George Foster           NA        N
## -Gary Gaetti        900.000        A
## -Greg Gagne         155.000        A
## -George Hendrick    700.000        A
## -Glenn Hubbard      535.000        N
## -Garth Iorg         362.500        A
## -Gary Matthews      733.333        N
## -Graig Nettles      200.000        N
## -Gary Pettis        400.000        A
## -Gary Redus         400.000        A
## -Garry Templeton    737.500        N
## -Gorman Thomas           NA        A
## -Greg Walker        500.000        A
## -Gary Ward          600.000        A
## -Glenn Wilson       662.500        N
## -Harold Baines      950.000        A
## -Hubie Brooks       750.000        N
## -Howard Johnson     297.500        N
## -Hal McRae          325.000        A
## -Harold Reynolds     87.500        A
## -Harry Spilman      175.000        N
## -Herm Winningham     90.000        N
## -Jesse Barfield    1237.500        A
## -Juan Beniquez      430.000        A
## -Juan Bonilla            NA        N
## -John Cangelosi     100.000        N
## -Jose Canseco       165.000        A
## -Joe Carter         250.000        A
## -Jack Clark        1300.000        N
## -Jose Cruz          773.333        N
## -Julio Cruz              NA        A
## -Jody Davis        1008.333        N
## -Jim Dwyer          275.000        A
## -Julio Franco       775.000        A
## -Jim Gantner        850.000        A
## -Johnny Grubb       365.000        A
## -Jerry Hairston          NA        A
## -Jack Howell         95.000        A
## -John Kruk          110.000        N
## -Jeffrey Leonard    100.000        N
## -Jim Morrison       277.500        N
## -John Moses          80.000        A
## -Jerry Mumphrey     600.000        N
## -Joe Orsulak             NA        N
```

```
## -Jorge Orta              NA         A
## -Jim Presley         200.000        A
## -Jamie Quirk             NA         A
## -Johnny Ray          657.000        N
## -Jeff Reed            75.000        N
## -Jim Rice           2412.500        A
## -Jerry Royster       250.000        A
## -John Russell        155.000        N
## -Juan Samuel         640.000        N
## -John Shelby         300.000        A
## -Joel Skinner        110.000        A
## -Jeff Stone              NA         N
## -Jim Sundberg        825.000        N
## -Jim Traber              NA         A
## -Jose Uribe          195.000        N
## -Jerry Willard           NA         A
## -Joel Youngblood     450.000        N
## -Kevin Bass          630.000        N
## -Kal Daniels          86.500        N
## -Kirk Gibson        1300.000        A
## -Ken Griffey        1000.000        N
## -Keith Hernandez    1800.000        N
## -Kent Hrbek         1310.000        A
## -Ken Landreaux       737.500        N
## -Kevin McReynolds    625.000        N
## -Kevin Mitchell      125.000        N
## -Keith Moreland     1043.333        N
## -Ken Oberkfell       725.000        N
## -Ken Phelps          300.000        A
## -Kirby Puckett       365.000        A
## -Kurt Stillwell       75.000        N
## -Leon Durham        1183.333        N
## -Len Dykstra         202.500        N
## -Larry Herndon       225.000        A
## -Lee Lacy            525.000        A
## -Len Matuszek        265.000        N
## -Lloyd Moseby        787.500        A
## -Lance Parrish       800.000        N
## -Larry Parrish       587.500        A
## -Luis Rivera             NA         N
## -Larry Sheets        145.000        A
## -Lonnie Smith            NA         A
## -Lou Whitaker        420.000        A
## -Mike Aldrete         75.000        N
## -Marty Barrett       575.000        A
## -Mike Brown              NA         N
## -Mike Davis          780.000        A
## -Mike Diaz            90.000        N
```

```
## -Mariano Duncan     150.000         N
## -Mike Easler        700.000         N
## -Mike Fitzgerald         NA         N
## -Mel Hall           550.000         A
## -Mickey Hatcher          NA         A
## -Mike Heath         650.000         A
## -Mike Kingery        68.000         A
## -Mike LaValliere    100.000         N
## -Mike Marshall      670.000         N
## -Mike Pagliarulo    175.000         A
## -Mark Salas         137.000         A
## -Mike Schmidt      2127.333         N
## -Mike Scioscia      875.000         N
## -Mickey Tettleton   120.000         A
## -Milt Thompson      140.000         N
## -Mitch Webster      210.000         N
## -Mookie Wilson      800.000         N
## -Marvell Wynne      240.000         N
## -Mike Young         350.000         A
## -Nick Esasky             NA         N
## -Ozzie Guillen      175.000         A
## -Oddibe McDowell    200.000         A
## -Omar Moreno             NA         N
## -Ozzie Smith       1940.000         N
## -Ozzie Virgil       700.000         N
## -Phil Bradley       750.000         A
## -Phil Garner        450.000         N
## -Pete Incaviglia    172.000         A
## -Paul Molitor      1260.000         A
## -Pete O'Brien            NA         A
## -Pete Rose          750.000         N
## -Pat Sheridan       190.000         A
## -Pat Tabler         580.000         A
## -Rafael Belliard    130.000         N
## -Rick Burleson      450.000         A
## -Randy Bush         300.000         A
## -Rick Cerone        250.000         A
## -Ron Cey           1050.000         A
## -Rob Deer           215.000         A
## -Rick Dempsey       400.000         A
## -Rich Gedman             NA         A
## -Ron Hassey         560.000         A
## -Rickey Henderson  1670.000         A
## -Reggie Jackson     487.500         A
## -Ricky Jones             NA         A
## -Ron Kittle         425.000         A
## -Ray Knight         500.000         A
## -Randy Kutcher           NA         N
```

```
## -Rudy Law                NA         A
## -Rick Leach          250.000         A
## -Rick Manning        400.000         A
## -Rance Mulliniks     450.000         A
## -Ron Oester          750.000         N
## -Rey Quinones         70.000         A
## -Rafael Ramirez      875.000         N
## -Ronn Reynolds       190.000         N
## -Ron Roenicke        191.000         N
## -Ryne Sandberg       740.000         N
## -Rafael Santana      250.000         N
## -Rick Schu           140.000         N
## -Ruben Sierra         97.500         A
## -Roy Smalley         740.000         A
## -Robby Thompson      140.000         N
## -Rob Wilfong         341.667         A
## -Reggie Williams          NA         N
## -Robin Yount        1000.000         A
## -Steve Balboni       100.000         A
## -Scott Bradley        90.000         A
## -Sid Bream           200.000         N
## -Steve Buechele      135.000         A
## -Shawon Dunston      155.000         N
## -Scott Fletcher      475.000         A
## -Steve Garvey       1450.000         N
## -Steve Jeltz         150.000         N
## -Steve Lombardozzi   105.000         A
## -Spike Owen          350.000         A
## -Steve Sax            90.000         N
## -Tony Armas               NA         A
## -Tony Bernazard      530.000         A
## -Tom Brookens        341.667         A
## -Tom Brunansky       940.000         A
## -Tony Fernandez      350.000         A
## -Tim Flannery        326.667         N
## -Tom Foley           250.000         N
## -Tony Gwynn          740.000         N
## -Terry Harper        425.000         A
## -Toby Harrah              NA         A
## -Tommy Herr          925.000         N
## -Tim Hulett          185.000         A
## -Terry Kennedy       920.000         A
## -Tito Landrum        286.667         N
## -Tim Laudner         245.000         A
## -Tom O'Malley             NA         A
## -Tom Paciorek        235.000         A
## -Tony Pena          1150.000         N
## -Terry Pendleton     160.000         N
```

```
## -Tony Perez              NA         N
## -Tony Phillips      425.000         A
## -Terry Puhl         900.000         N
## -Tim Raines              NA         N
## -Ted Simmons        500.000         N
## -Tim Teufel         277.500         N
## -Tim Wallach        750.000         N
## -Vince Coleman      160.000         N
## -Von Hayes         1300.000         N
## -Vance Law          525.000         N
## -Wally Backman      550.000         N
## -Wade Boggs        1600.000         A
## -Will Clark         120.000         N
## -Wally Joyner       165.000         A
## -Wayne Krenchicki        NA         N
## -Willie McGee       700.000         N
## -Willie Randolph    875.000         A
## -Wayne Tolleson     385.000         A
## -Willie Upshaw      960.000         A
## -Willie Wilson     1000.000         A
```

```
names(Hitters)
```

```
##  [1] "AtBat"     "Hits"      "HmRun"     "Runs"      "RBI"       "Walks"
##  [7] "Years"     "CAtBat"    "CHits"     "CHmRun"    "CRuns"     "CRBI"
## [13] "CWalks"    "League"    "Division"  "PutOuts"   "Assists"   "Errors"
## [19] "Salary"    "NewLeague"
```

```
dim(Hitters)
```

```
## [1] 322  20
```

```
sum(is.na(Hitters$Salary))
```

```
## [1] 59
```

```
# NAs can be bad for modeling purposes, so let's drop all the rows that contain NAs!

Hitters_dropNA <- na.omit(Hitters)

dim(Hitters_dropNA)
```

```
## [1] 263  20
```

```r
sum(is.na(Hitters_dropNA))
```

```
## [1] 0
```

```r
# Let's perform a regular subsets regression using the
# regsubsets() function.
# When in doubt, remember: ??regsubsets

regfit.full <- regsubsets(Salary ~ ., Hitters_dropNA)
?regsubsets # a function for linear model selection (stepwise or sequential)

summary(regfit.full) # for each iteration of the search (shows you the top 8), which variables
```

```
## Subset selection object
## Call: regsubsets.formula(Salary ~ ., Hitters_dropNA)
## 19 Variables  (and intercept)
##             Forced in Forced out
## AtBat           FALSE      FALSE
## Hits            FALSE      FALSE
## HmRun           FALSE      FALSE
## Runs            FALSE      FALSE
## RBI             FALSE      FALSE
## Walks           FALSE      FALSE
## Years           FALSE      FALSE
## CAtBat          FALSE      FALSE
## CHits           FALSE      FALSE
## CHmRun          FALSE      FALSE
## CRuns           FALSE      FALSE
## CRBI            FALSE      FALSE
## CWalks          FALSE      FALSE
## LeagueN         FALSE      FALSE
## DivisionW       FALSE      FALSE
## PutOuts         FALSE      FALSE
## Assists         FALSE      FALSE
## Errors          FALSE      FALSE
## NewLeagueN      FALSE      FALSE
## 1 subsets of each size up to 8
## Selection Algorithm: exhaustive
##          AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun CRuns CRBI
## 1  ( 1 ) " "   " "  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 2  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 3  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 4  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 5  ( 1 ) "*"   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 6  ( 1 ) "*"   "*"  " "   " "  " " " "*" " "   " "    " "   " "    " "   "*"
## 7  ( 1 ) " "   "*"  " "   " "  " " " "*" " "   "*"    "*"   "*"    " "   " "
```

```
## 8  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   " "    " "   "*"    "*"   " "
##           CWalks LeagueN DivisionW PutOuts Assists Errors NewLeagueN
## 1  ( 1 ) " "    " "     " "       " "     " "     " "    " "
## 2  ( 1 ) " "    " "     " "       " "     " "     " "    " "
## 3  ( 1 ) " "    " "     " "       "*"     " "     " "    " "
## 4  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 5  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 6  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 7  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 8  ( 1 ) "*"    " "     "*"       "*"     " "     " "    " "
```

```
# Note that since we didn't select a value for the method parameter, it defaulted
# to exhaustive (i.e., full best subsets selection) vs. forward or backwards.
# An asterisk indicates that a given variable is included in the corresponding
# model. For instance, this output indicates that the best two-variable model
# contains only Hits and CRBI. By default, regsubsets() only reports results
# up to the best eight-variable model. But the nvmax option can be used
# in order to return as many variables as are desired.

# Now let's fit a full 19-variable model.

regfit.full <- regsubsets(Salary ~ ., data = Hitters_dropNA,
                          nvmax = 19)

reg.summary <- summary(regfit.full)
reg.summary
```

```
## Subset selection object
## Call: regsubsets.formula(Salary ~ ., data = Hitters_dropNA, nvmax = 19)
## 19 Variables  (and intercept)
##            Forced in Forced out
## AtBat          FALSE      FALSE
## Hits           FALSE      FALSE
## HmRun          FALSE      FALSE
## Runs           FALSE      FALSE
## RBI            FALSE      FALSE
## Walks          FALSE      FALSE
## Years          FALSE      FALSE
## CAtBat         FALSE      FALSE
## CHits          FALSE      FALSE
## CHmRun         FALSE      FALSE
## CRuns          FALSE      FALSE
## CRBI           FALSE      FALSE
## CWalks         FALSE      FALSE
## LeagueN        FALSE      FALSE
## DivisionW      FALSE      FALSE
## PutOuts        FALSE      FALSE
```

```
## Assists        FALSE      FALSE
## Errors         FALSE      FALSE
## NewLeagueN     FALSE      FALSE
## 1 subsets of each size up to 19
## Selection Algorithm: exhaustive
##           AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun CRuns CRBI
## 1  ( 1 )  " "   " "  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 2  ( 1 )  " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 3  ( 1 )  " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 4  ( 1 )  " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 5  ( 1 )  "*"   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 6  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    " "   "*"
## 7  ( 1 )  " "   "*"  " "   " "  " " "*"   " "   "*"    "*"   "*"    " "   " "
## 8  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   " "    " "   "*"    "*"   " "
## 9  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 10  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 11  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 12  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 13  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 14  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 15  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    "*"   " "    "*"   "*"
## 16  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 17  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 18  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   " "    "*"   "*"
## 19  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   "*"    "*"   "*"
##           CWalks LeagueN DivisionW PutOuts Assists Errors NewLeagueN
## 1  ( 1 )  " "    " "     " "       " "     " "     " "    " "
## 2  ( 1 )  " "    " "     " "       " "     " "     " "    " "
## 3  ( 1 )  " "    " "     " "       "*"     " "     " "    " "
## 4  ( 1 )  " "    " "     "*"       "*"     " "     " "    " "
## 5  ( 1 )  " "    " "     "*"       "*"     " "     " "    " "
## 6  ( 1 )  " "    " "     "*"       "*"     " "     " "    " "
## 7  ( 1 )  " "    " "     "*"       "*"     " "     " "    " "
## 8  ( 1 )  "*"    " "     "*"       "*"     " "     " "    " "
## 9  ( 1 )  "*"    " "     "*"       "*"     " "     " "    " "
## 10  ( 1 ) "*"    " "     "*"       "*"     "*"     " "    " "
## 11  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 12  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 13  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 14  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 15  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 16  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 17  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 18  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 19  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
```

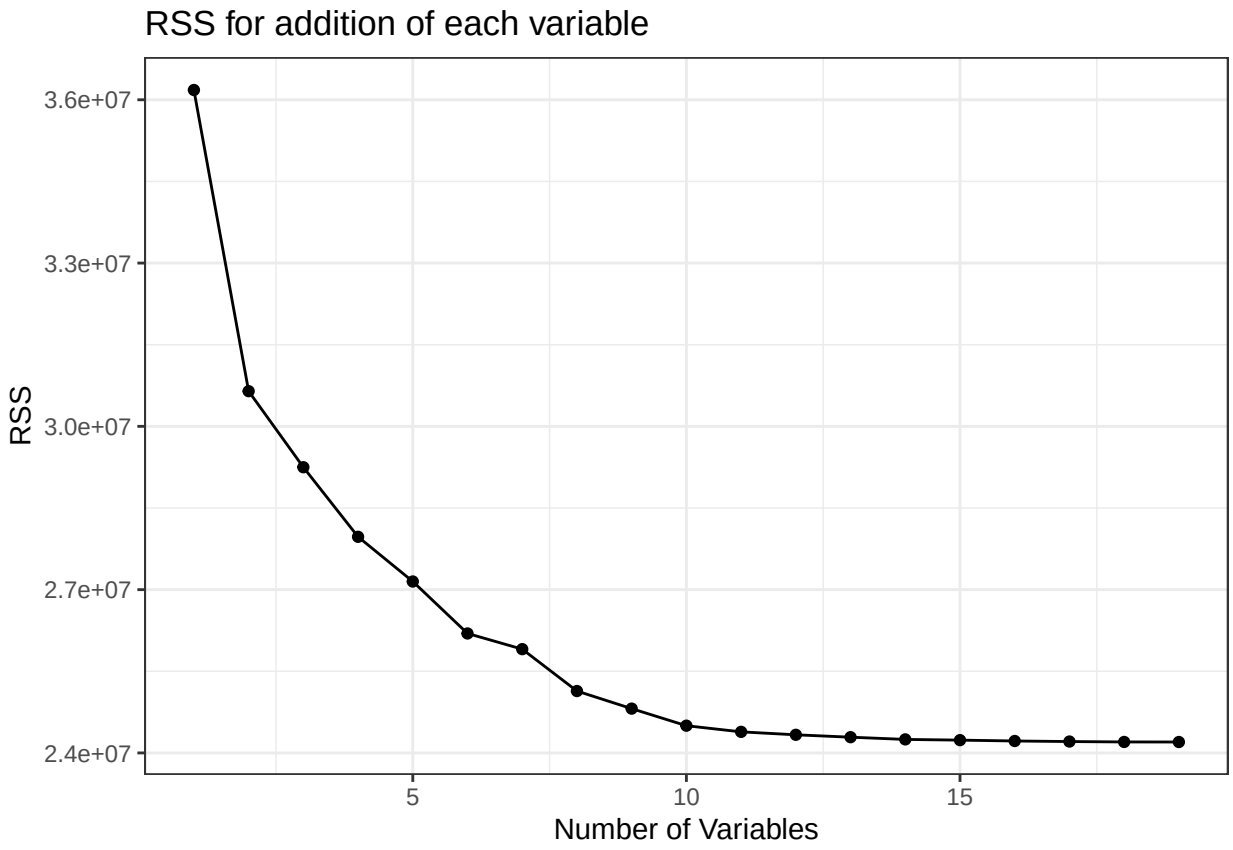
```r
# The summary() function also returns R2, RSS, adjusted R2, Cp, and BIC.
# We can examine these to try to select the best overall model.

names(reg.summary)
```

```
## [1] "which"  "rsq"    "rss"    "adjr2"  "cp"     "bic"    "outmat" "obj"
```

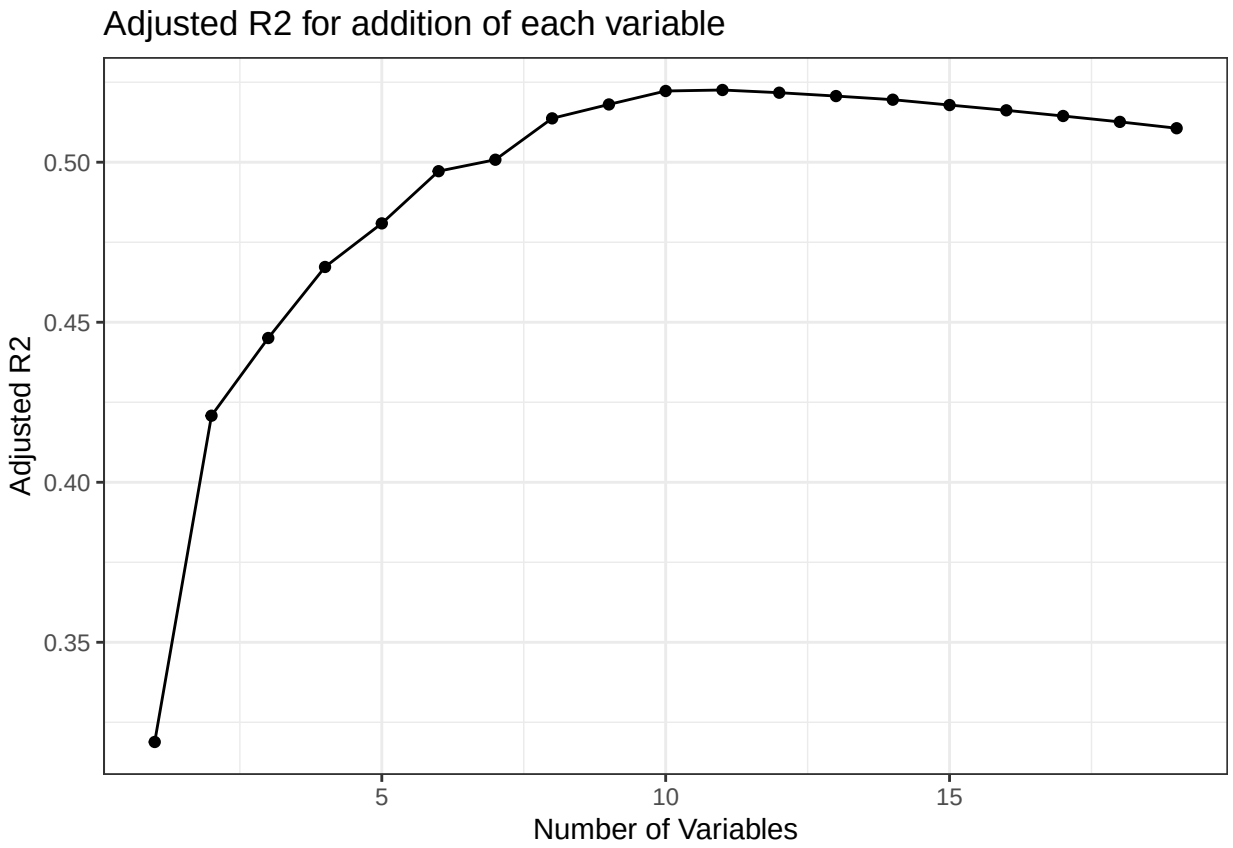
```r
# We know, from the readings!, that R2 should always increase for each new variable. Let's loo

reg.summary$rsq # get the R2 values
```

```
##  [1] 0.3214501 0.4252237 0.4514294 0.4754067 0.4908036 0.5087146 0.5141227
##  [8] 0.5285569 0.5346124 0.5404950 0.5426153 0.5436302 0.5444570 0.5452164
## [15] 0.5454692 0.5457656 0.5459518 0.5460945 0.5461159
```

```r
# Let's plot the RSS and the Adjusted R2! We'll use ggplot since y'all are more comfortable th

plot_metrics <- data.frame(rss = reg.summary$rss, adjr2 = reg.summary$adjr2, numvar = 1:19)

plot_metrics %>%
        ggplot(aes(y = rss, x = numvar)) +
        geom_point() +
        geom_line() +
        xlab("Number of Variables") + ylab("RSS") +
        theme_bw() +
        ggtitle("RSS for addition of each variable")
```



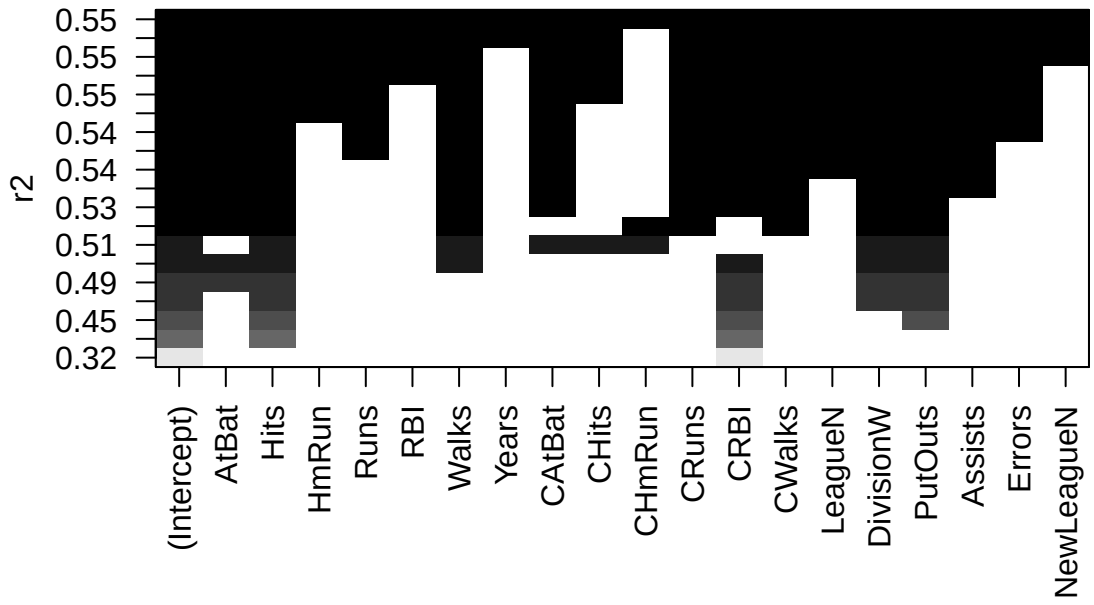

```
plot_metrics %>%
        ggplot(aes(y = adjr2, x = numvar)) +
        geom_point() +
        geom_line() +
        xlab("Number of Variables") + ylab("Adjusted R2") +
        theme_bw() +
        ggtitle("Adjusted R2 for addition of each variable")
```



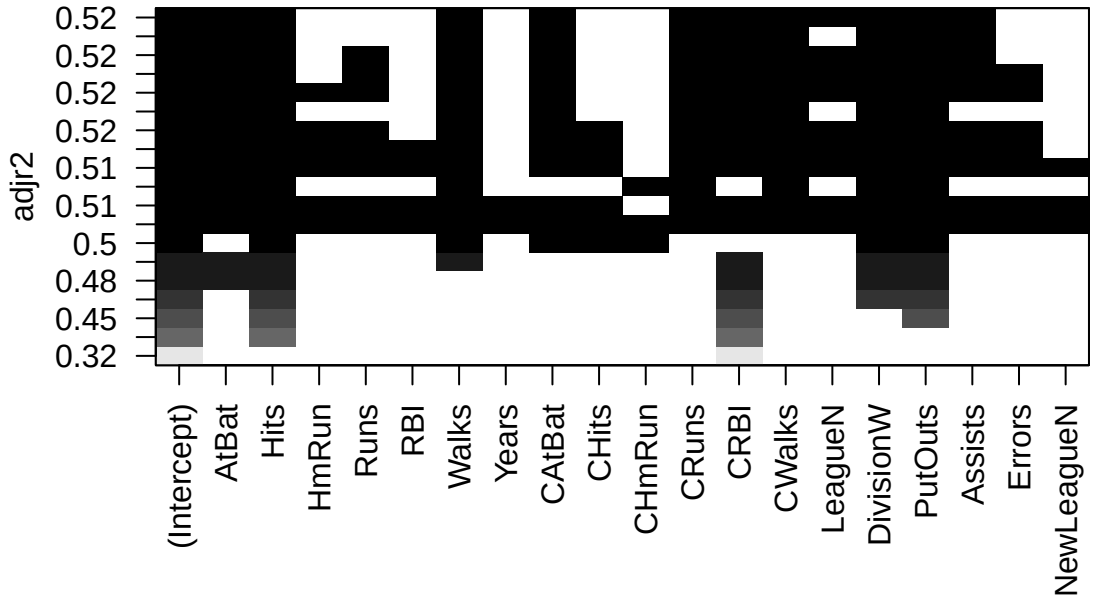

```
# We could also manually find which variable count has the best Adjusted R2
which.max(reg.summary$adjr2)
```

```
## [1] 11
```

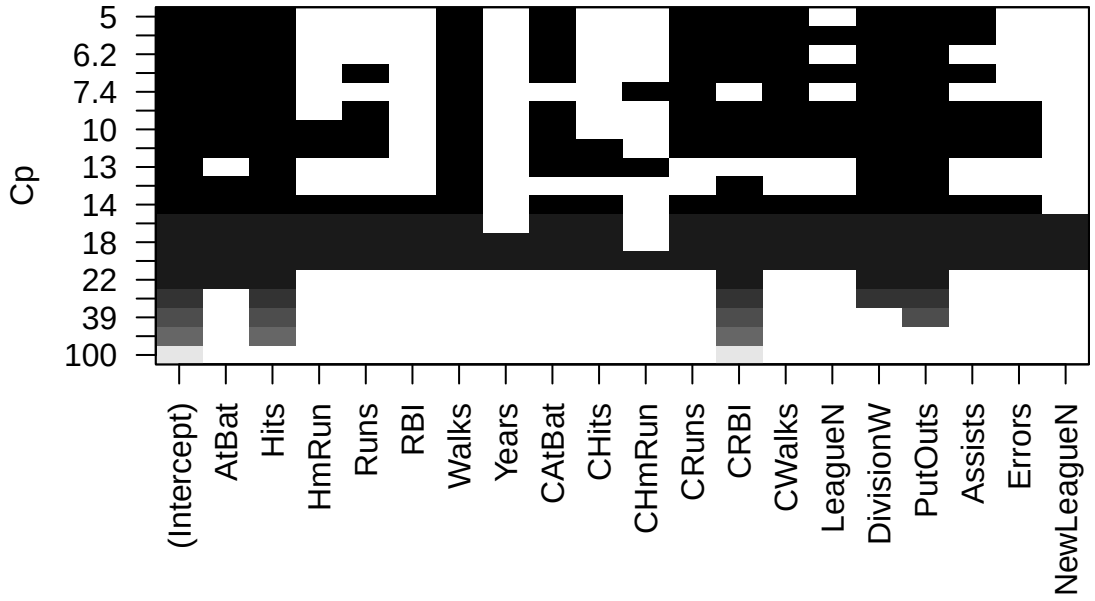
```
# Or, if we're in a hurry - we can just use the native plot implementation!
# You'll note these plots look MUCH different than what you'd expect - that's because the regs
# method imports a new form of plot() call!
plot(regfit.full, scale = "r2") # see the best models for R2 (at the top row of the plot)
```



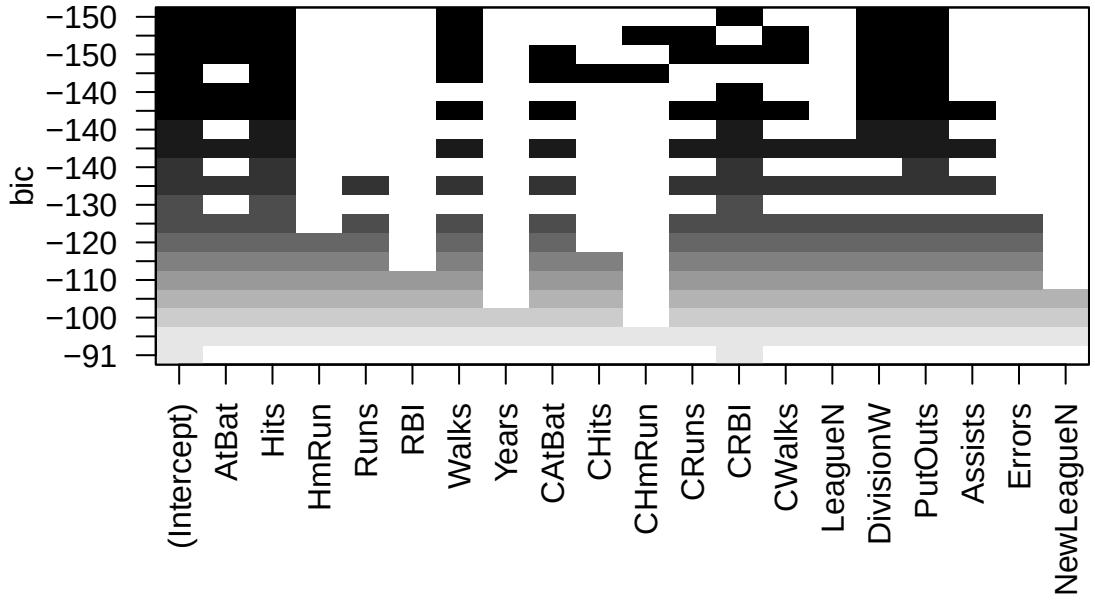

```
plot(regfit.full, scale = "adjr2") # same for adjusted R2
```




```
plot(regfit.full, scale = "Cp") # same for Cp
```




```
plot(regfit.full, scale = "bic") # same for BIC (more conservative)
```




```
# Notice how that BIC plot is a little different, and only contains six variables? If you'd li
# at those variables, you can just use the coef() function!

coef(regfit.full, 6)
```

```
##  (Intercept)        AtBat         Hits        Walks         CRBI    DivisionW
##   91.5117981   -1.8685892    7.6043976    3.6976468    0.6430169 -122.9515338
##      PutOuts
##    0.2643076
```

```r
summary(lm(data = Hitters_dropNA, Salary ~ AtBat + Hits + Walks + CRBI + Division + PutOuts))
```

```
##
## Call:
## lm(formula = Salary ~ AtBat + Hits + Walks + CRBI + Division +
##     PutOuts, data = Hitters_dropNA)
##
## Residuals:
##     Min      1Q  Median      3Q     Max
## -873.11 -181.72  -25.91  141.77 2040.47
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept)   91.51180   65.00006   1.408 0.160382
## AtBat         -1.86859    0.52742  -3.543 0.000470 ***
## Hits           7.60440    1.66254   4.574 7.46e-06 ***
## Walks          3.69765    1.21036   3.055 0.002488 **
## CRBI           0.64302    0.06443   9.979  < 2e-16 ***
## DivisionW   -122.95153   39.82029  -3.088 0.002239 **
## PutOuts        0.26431    0.07477   3.535 0.000484 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 319.9 on 256 degrees of freedom
## Multiple R-squared:  0.5087, Adjusted R-squared:  0.4972
## F-statistic: 44.18 on 6 and 256 DF,  p-value: < 2.2e-16
```

```r
# # ------------------------------------------------------------------
#
# Forward and Backward Selection
#
# # ------------------------------------------------------------------

# Let's do this forward!
regfit.fwd <- regsubsets(Salary ~ ., data = Hitters,
                         nvmax = 19, method = "forward")
summary(regfit.fwd)
```

```
## Subset selection object
## Call: regsubsets.formula(Salary ~ ., data = Hitters, nvmax = 19, method = "forward")
## 19 Variables  (and intercept)
##            Forced in Forced out
## AtBat          FALSE      FALSE
## Hits           FALSE      FALSE
## HmRun          FALSE      FALSE
## Runs           FALSE      FALSE
```

```
## RBI            FALSE      FALSE
## Walks          FALSE      FALSE
## Years          FALSE      FALSE
## CAtBat         FALSE      FALSE
## CHits          FALSE      FALSE
## CHmRun         FALSE      FALSE
## CRuns          FALSE      FALSE
## CRBI           FALSE      FALSE
## CWalks         FALSE      FALSE
## LeagueN        FALSE      FALSE
## DivisionW      FALSE      FALSE
## PutOuts        FALSE      FALSE
## Assists        FALSE      FALSE
## Errors         FALSE      FALSE
## NewLeagueN     FALSE      FALSE
## 1 subsets of each size up to 19
## Selection Algorithm: forward
##          AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun CRuns CRBI
## 1  ( 1 ) " "   " "  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 2  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 3  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 4  ( 1 ) " "   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 5  ( 1 ) "*"   "*"  " "   " "  " " " "   " "   " "    " "   " "    " "   "*"
## 6  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    " "   "*"
## 7  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    " "   "*"
## 8  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    "*"   "*"
## 9  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 10  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 11  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 12  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 13  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 14  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 15  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    "*"   " "    "*"   "*"
## 16  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 17  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 18  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   " "    "*"   "*"
## 19  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   "*"    "*"   "*"
##          CWalks LeagueN DivisionW PutOuts Assists Errors NewLeagueN
## 1  ( 1 ) " "    " "     " "       " "     " "     " "    " "
## 2  ( 1 ) " "    " "     " "       " "     " "     " "    " "
## 3  ( 1 ) " "    " "     " "       "*"     " "     " "    " "
## 4  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 5  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 6  ( 1 ) " "    " "     "*"       "*"     " "     " "    " "
## 7  ( 1 ) "*"    " "     "*"       "*"     " "     " "    " "
## 8  ( 1 ) "*"    " "     "*"       "*"     " "     " "    " "
## 9  ( 1 ) "*"    " "     "*"       "*"     " "     " "    " "
## 10  ( 1 ) "*"    " "     "*"       "*"     "*"     " "    " "
```

```
## 11  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 12  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 13  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 14  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 15  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 16  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 17  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 18  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 19  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
```

```
# Now backwards!
regfit.bwd <- regsubsets(Salary ~ ., data = Hitters,
                         nvmax = 19, method = "backward")
summary(regfit.bwd)
```

```
## Subset selection object
## Call: regsubsets.formula(Salary ~ ., data = Hitters, nvmax = 19, method = "backward")
## 19 Variables  (and intercept)
##             Forced in Forced out
## AtBat           FALSE      FALSE
## Hits            FALSE      FALSE
## HmRun           FALSE      FALSE
## Runs            FALSE      FALSE
## RBI             FALSE      FALSE
## Walks           FALSE      FALSE
## Years           FALSE      FALSE
## CAtBat          FALSE      FALSE
## CHits           FALSE      FALSE
## CHmRun          FALSE      FALSE
## CRuns           FALSE      FALSE
## CRBI            FALSE      FALSE
## CWalks          FALSE      FALSE
## LeagueN         FALSE      FALSE
## DivisionW       FALSE      FALSE
## PutOuts         FALSE      FALSE
## Assists         FALSE      FALSE
## Errors          FALSE      FALSE
## NewLeagueN      FALSE      FALSE
## 1 subsets of each size up to 19
## Selection Algorithm: backward
##           AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun CRuns CRBI
## 1  ( 1 )  " "   " "  " "   " "  " " " " " "   " "   " "    " "   " "    "*"   " "
## 2  ( 1 )  " "   "*"  " "   " "  " " " " " "   " "   " "    " "   " "    "*"   " "
## 3  ( 1 )  " "   "*"  " "   " "  " " " " " "   " "   " "    " "   " "    "*"   " "
## 4  ( 1 )  "*"   "*"  " "   " "  " " " " " "   " "   " "    " "   " "    "*"   " "
## 5  ( 1 )  "*"   "*"  " "   " "  " " " " "*"   " "   " "    " "   " "    "*"   " "
## 6  ( 1 )  "*"   "*"  " "   " "  " " " " "*"   " "   " "    " "   " "    "*"   " "
```

```
## 7  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    "*"   " "
## 8  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   " "    " "   " "    "*"   "*"
## 9  ( 1 )  "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 10  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 11  ( 1 ) "*"   "*"  " "   " "  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 12  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 13  ( 1 ) "*"   "*"  " "   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 14  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    " "   " "    "*"   "*"
## 15  ( 1 ) "*"   "*"  "*"   "*"  " " "*"   " "   "*"    "*"   " "    "*"   "*"
## 16  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 17  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   " "   "*"    "*"   " "    "*"   "*"
## 18  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   " "    "*"   "*"
## 19  ( 1 ) "*"   "*"  "*"   "*"  "*" "*"   "*"   "*"    "*"   "*"    "*"   "*"
##           CWalks LeagueN DivisionW PutOuts Assists Errors NewLeagueN
## 1  ( 1 )  " "    " "     " "       " "     " "     " "    " "
## 2  ( 1 )  " "    " "     " "       " "     " "     " "    " "
## 3  ( 1 )  " "    " "     " "       "*"     " "     " "    " "
## 4  ( 1 )  " "    " "     " "       "*"     " "     " "    " "
## 5  ( 1 )  " "    " "     " "       "*"     " "     " "    " "
## 6  ( 1 )  " "    " "     "*"       "*"     " "     " "    " "
## 7  ( 1 )  "*"    " "     "*"       "*"     " "     " "    " "
## 8  ( 1 )  "*"    " "     "*"       "*"     " "     " "    " "
## 9  ( 1 )  "*"    " "     "*"       "*"     " "     " "    " "
## 10  ( 1 ) "*"    " "     "*"       "*"     "*"     " "    " "
## 11  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 12  ( 1 ) "*"    "*"     "*"       "*"     "*"     " "    " "
## 13  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 14  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 15  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 16  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    " "
## 17  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 18  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
## 19  ( 1 ) "*"    "*"     "*"       "*"     "*"     "*"    "*"
```

```
# For instance, we see that using forward stepwise selection, the best one variable model cont
# and the best two-variable model additionally includes Hits. For this data, the best one-vari
# six variable models are each identical for best subset and forward selection.
# However, the best seven-variable models identified by forward stepwise selection,
# backward stepwise selection, and best subset selection are different. See below!

# Now compare them!
coef(regfit.full, 7)
```

```
##  (Intercept)         Hits        Walks       CAtBat        CHits       CHmRun
##   79.4509472    1.2833513    3.2274264   -0.3752350    1.4957073    1.4420538
##    DivisionW      PutOuts
## -129.9866432    0.2366813
```

```
coef(regfit.fwd, 7)
```

```
##  (Intercept)        AtBat         Hits        Walks         CRBI       CWalks
##  109.7873062   -1.9588851    7.4498772    4.9131401    0.8537622   -0.3053070
##    DivisionW      PutOuts
## -127.1223928    0.2533404
```

```
coef(regfit.bwd, 7)
```

```
##  (Intercept)        AtBat         Hits        Walks        CRuns       CWalks
##  105.6487488   -1.9762838    6.7574914    6.0558691    1.1293095   -0.7163346
##    DivisionW      PutOuts
## -116.1692169    0.3028847
```

```
# # ------------------------------------------------------------------
#
# STOP! Your turn!
#
# Load the data called Credit from the ISLR library with: data("Credit).
#
# Run a FORWARD subsets selection algorithm for all the variables
# (using Rating as the dependent variable)
# and tell me the optimal number of variables to include is (using BIC)
# and report the BIC value.
#
# # ------------------------------------------------------------------

data(Credit)
Credit
```

```
##      Income Limit Rating Cards Age Education Own Student Married Region Balance
## 1    14.891  3606    283     2  34        11  No      No     Yes  South     333
## 2   106.025  6645    483     3  82        15 Yes     Yes     Yes   West     903
## 3   104.593  7075    514     4  71        11  No      No      No   West     580
## 4   148.924  9504    681     3  36        11 Yes      No      No   West     964
## 5    55.882  4897    357     2  68        16  No      No     Yes  South     331
## 6    80.180  8047    569     4  77        10  No      No      No  South    1151
## 7    20.996  3388    259     2  37        12 Yes      No      No   East     203
## 8    71.408  7114    512     2  87         9  No      No      No   West     872
## 9    15.125  3300    266     5  66        13 Yes      No      No  South     279
## 10   71.061  6819    491     3  41        19 Yes     Yes     Yes   East    1350
## 11   63.095  8117    589     4  30        14  No      No     Yes  South    1407
## 12   15.045  1311    138     3  64        16  No      No      No  South       0
## 13   80.616  5308    394     1  57         7 Yes      No     Yes   West     204
## 14   43.682  6922    511     1  49         9  No      No     Yes  South    1081
```

```
##    Balance Income Limit Rating Cards Age Education Gender Student Married
## 15  19.144   3291   269      2    75          13   Yes     No      No
## 16  20.089   2525   200      3    57          15   Yes     No     Yes
## 17  53.598   3714   286      3    73          17   Yes     No     Yes
## 18  36.496   4378   339      3    69          15   Yes     No     Yes
## 19  49.570   6384   448      1    28           9   Yes     No     Yes
## 20  42.079   6626   479      2    44           9    No     No      No
## 21  17.700   2860   235      4    63          16   Yes     No      No
## 22  37.348   6378   458      1    72          17   Yes     No      No
## 23  20.103   2631   213      3    61          10    No     No     Yes
## 24  64.027   5179   398      5    48           8    No     No     Yes
## 25  10.742   1757   156      3    57          15   Yes     No      No
## 26  14.090   4323   326      5    25          16   Yes     No     Yes
## 27  42.471   3625   289      6    44          12   Yes    Yes      No
## 28  32.793   4534   333      2    44          16    No     No      No
## 29 186.634  13414   949      2    41          14   Yes     No     Yes
## 30  26.813   5611   411      4    55          16   Yes     No      No
## 31  34.142   5666   413      4    47           5   Yes     No     Yes
## 32  28.941   2733   210      5    43          16    No     No     Yes
## 33 134.181   7838   563      2    48          13   Yes     No      No
## 34  31.367   1829   162      4    30          10    No     No     Yes
## 35  20.150   2646   199      2    25          14   Yes     No     Yes
## 36  23.350   2558   220      3    49          12   Yes    Yes      No
## 37  62.413   6457   455      2    71          11   Yes     No     Yes
## 38  30.007   6481   462      2    69           9   Yes     No     Yes
## 39  11.795   3899   300      4    25          10   Yes     No      No
## 40  13.647   3461   264      4    47          14    No     No     Yes
## 41  34.950   3327   253      3    54          14   Yes     No      No
## 42 113.659   7659   538      2    66          15    No    Yes     Yes
## 43  44.158   4763   351      2    66          13   Yes     No     Yes
## 44  36.929   6257   445      1    24          14   Yes     No     Yes
## 45  31.861   6375   469      3    25          16   Yes     No     Yes
## 46  77.380   7569   564      3    50          12   Yes     No     Yes
## 47  19.531   5043   376      2    64          16   Yes    Yes     Yes
## 48  44.646   4431   320      2    49          15    No    Yes     Yes
## 49  44.522   2252   205      6    72          15    No     No     Yes
## 50  43.479   4569   354      4    49          13    No    Yes     Yes
## 51  36.362   5183   376      3    49          15    No     No     Yes
## 52  39.705   3969   301      2    27          20    No     No     Yes
## 53  44.205   5441   394      1    32          12    No     No     Yes
## 54  16.304   5466   413      4    66          10    No     No     Yes
## 55  15.333   1499   138      2    47           9   Yes     No     Yes
## 56  32.916   1786   154      2    60           8   Yes     No     Yes
## 57  57.100   4742   372      7    79          18   Yes     No     Yes
## 58  76.273   4779   367      4    65          14   Yes     No     Yes
## 59  10.354   3480   281      2    70          17    No     No     Yes
## 60  51.872   5294   390      4    81          17   Yes     No      No
## 61  35.510   5198   364      2    35          20   Yes     No      No
## 62  21.238   3089   254      3    59          10   Yes     No      No
##    Ethnicity Balance
## 15     East     148
## 16     East       0
## 17     East       0
## 18     West     368
## 19     West     891
## 20     West    1048
## 21     West      89
## 22    South     968
## 23     East       0
## 24     East     411
## 25    South       0
## 26     East     671
## 27    South     654
## 28     East     467
## 29     East    1809
## 30    South     915
## 31    South     863
## 32     West       0
## 33    South     526
## 34    South       0
## 35     West       0
## 36    South     419
## 37    South     762
## 38    South    1093
## 39    South     531
## 40    South     344
## 41     East      50
## 42     East    1155
## 43     West     385
## 44     West     976
## 45    South    1120
## 46    South     997
## 47     West    1241
## 48    South     797
## 49     West       0
## 50     East     902
## 51     East     654
## 52     East     211
## 53    South     607
## 54     West     957
## 55     West       0
## 56     West       0
## 57     West     379
## 58    South     133
## 59    South     333
## 60    South     531
## 61     West     631
## 62    South     108
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## 63   30.682  1671    160     2  77         7 Yes      No      No  South       0
## 64   14.132  2998    251     4  75        17  No      No      No  South     133
## 65   32.164  2937    223     2  79        15 Yes      No     Yes   East       0
## 66   12.000  4160    320     4  28        14 Yes      No     Yes  South     602
## 67  113.829  9704    694     4  38        13 Yes      No     Yes   West    1388
## 68   11.187  5099    380     4  69        16 Yes      No      No   East     889
## 69   27.847  5619    418     2  78        15 Yes      No     Yes  South     822
## 70   49.502  6819    505     4  55        14  No      No     Yes  South    1084
## 71   24.889  3954    318     4  75        12  No      No     Yes  South     357
## 72   58.781  7402    538     2  81        12 Yes      No     Yes   West    1103
## 73   22.939  4923    355     1  47        18 Yes      No     Yes   West     663
## 74   23.989  4523    338     4  31        15  No      No      No  South     601
## 75   16.103  5390    418     4  45        10 Yes      No     Yes  South     945
## 76   33.017  3180    224     2  28        16  No      No     Yes   East      29
## 77   30.622  3293    251     1  68        16  No     Yes      No  South     532
## 78   20.936  3254    253     1  30        15 Yes      No      No   West     145
## 79  110.968  6662    468     3  45        11 Yes      No     Yes  South     391
## 80   15.354  2101    171     2  65        14  No      No      No   West       0
## 81   27.369  3449    288     3  40         9 Yes      No     Yes  South     162
## 82   53.480  4263    317     1  83        15  No      No      No  South      99
## 83   23.672  4433    344     3  63        11  No      No      No  South     503
## 84   19.225  1433    122     3  38        14 Yes      No      No  South       0
## 85   43.540  2906    232     4  69        11  No      No      No  South       0
## 86  152.298 12066    828     4  41        12 Yes      No     Yes   West    1779
## 87   55.367  6340    448     1  33        15  No      No     Yes  South     815
## 88   11.741  2271    182     4  59        12 Yes      No      No   West       0
## 89   15.560  4307    352     4  57         8  No      No     Yes   East     579
## 90   59.530  7518    543     3  52         9 Yes      No      No   East    1176
## 91   20.191  5767    431     4  42        16  No      No     Yes   East    1023
## 92   48.498  6040    456     3  47        16  No      No     Yes  South     812
## 93   30.733  2832    249     4  51        13  No      No      No  South       0
## 94   16.479  5435    388     2  26        16  No      No      No   East     937
## 95   38.009  3075    245     3  45        15 Yes      No      No   East       0
## 96   14.084   855    120     5  46        17 Yes      No     Yes   East       0
## 97   14.312  5382    367     1  59        17  No     Yes      No   West    1380
## 98   26.067  3388    266     4  74        17 Yes      No     Yes   East     155
## 99   36.295  2963    241     2  68        14 Yes     Yes      No   East     375
## 100  83.851  8494    607     5  47        18  No      No      No  South    1311
## 101  21.153  3736    256     1  41        11  No      No      No  South     298
## 102  17.976  2433    190     3  70        16 Yes     Yes      No  South     431
## 103  68.713  7582    531     2  56        16  No     Yes      No  South    1587
## 104 146.183  9540    682     6  66        15  No      No      No  South    1050
## 105  15.846  4768    365     4  53        12 Yes      No      No  South     745
## 106  12.031  3182    259     2  58        18 Yes      No     Yes  South     210
## 107  16.819  1337    115     2  74        15  No      No     Yes   West       0
## 108  39.110  3189    263     3  72        12  No      No      No   West       0
## 109 107.986  6033    449     4  64        14  No      No     Yes  South     227
## 110  13.561  3261    279     5  37        19  No      No     Yes   West     297
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## 111  34.537  3271    250     3  57        17 Yes      No     Yes   West      47
## 112  28.575  2959    231     2  60        11 Yes      No      No   East       0
## 113  46.007  6637    491     4  42        14  No      No     Yes  South    1046
## 114  69.251  6386    474     4  30        12 Yes      No     Yes   West     768
## 115  16.482  3326    268     4  41        15  No      No      No  South     271
## 116  40.442  4828    369     5  81         8 Yes      No      No   East     510
## 117  35.177  2117    186     3  62        16 Yes      No      No  South       0
## 118  91.362  9113    626     1  47        17  No      No     Yes   West    1341
## 119  27.039  2161    173     3  40        17 Yes      No      No  South       0
## 120  23.012  1410    137     3  81        16  No      No      No  South       0
## 121  27.241  1402    128     2  67        15 Yes      No     Yes   West       0
## 122 148.080  8157    599     2  83        13  No      No     Yes  South     454
## 123  62.602  7056    481     1  84        11 Yes      No      No  South     904
## 124  11.808  1300    117     3  77        14 Yes      No      No   East       0
## 125  29.564  2529    192     1  30        12 Yes      No     Yes  South       0
## 126  27.578  2531    195     1  34        15 Yes      No     Yes  South       0
## 127  26.427  5533    433     5  50        15 Yes     Yes     Yes   West    1404
## 128  57.202  3411    259     3  72        11 Yes      No      No  South       0
## 129 123.299  8376    610     2  89        17  No     Yes      No   East    1259
## 130  18.145  3461    279     3  56        15  No      No     Yes   East     255
## 131  23.793  3821    281     4  56        12 Yes     Yes     Yes   East     868
## 132  10.726  1568    162     5  46        19  No      No     Yes   West       0
## 133  23.283  5443    407     4  49        13  No      No     Yes   East     912
## 134  21.455  5829    427     4  80        12 Yes      No     Yes   East    1018
## 135  34.664  5835    452     3  77        15 Yes      No     Yes   East     835
## 136  44.473  3500    257     3  81        16 Yes      No      No   East       8
## 137  54.663  4116    314     2  70         8 Yes      No      No   East      75
## 138  36.355  3613    278     4  35         9  No      No     Yes   West     187
## 139  21.374  2073    175     2  74        11 Yes      No     Yes  South       0
## 140 107.841 10384    728     3  87         7  No      No      No   East    1597
## 141  39.831  6045    459     3  32        12 Yes     Yes     Yes   East    1425
## 142  91.876  6754    483     2  33        10  No      No     Yes  South     605
## 143 103.893  7416    549     3  84        17  No      No      No   West     669
## 144  19.636  4896    387     3  64        10 Yes      No      No   East     710
## 145  17.392  2748    228     3  32        14  No      No     Yes  South      68
## 146  19.529  4673    341     2  51        14  No      No      No   West     642
## 147  17.055  5110    371     3  55        15 Yes      No     Yes  South     805
## 148  23.857  1501    150     3  56        16  No      No     Yes  South       0
## 149  15.184  2420    192     2  69        11 Yes      No     Yes  South       0
## 150  13.444   886    121     5  44        10  No      No     Yes   West       0
## 151  63.931  5728    435     3  28        14 Yes      No     Yes   East     581
## 152  35.864  4831    353     3  66        13 Yes      No     Yes  South     534
## 153  41.419  2120    184     4  24        11 Yes     Yes      No  South     156
## 154  92.112  4612    344     3  32        17  No      No      No  South       0
## 155  55.056  3155    235     2  31        16  No      No     Yes   East       0
## 156  19.537  1362    143     4  34         9 Yes      No     Yes   West       0
## 157  31.811  4284    338     5  75        13 Yes      No     Yes  South     429
## 158  56.256  5521    406     2  72        16 Yes     Yes     Yes  South    1020
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## 159  42.357  5550  406  2  83  12 Yes  No  Yes  West  653
## 160  53.319  3000  235  3  53  13  No  No  No  West  0
## 161  12.238  4865  381  5  67  11 Yes  No  No  South  836
## 162  31.353  1705  160  3  81  14  No  No  Yes  South  0
## 163  63.809  7530  515  1  56  12  No  No  Yes  South  1086
## 164  13.676  2330  203  5  80  16 Yes  No  No  East  0
## 165  76.782  5977  429  4  44  12  No  No  Yes  West  548
## 166  25.383  4527  367  4  46  11  No  No  Yes  South  570
## 167  35.691  2880  214  2  35  15  No  No  No  East  0
## 168  29.403  2327  178  1  37  14 Yes  No  Yes  South  0
## 169  27.470  2820  219  1  32  11 Yes  No  Yes  West  0
## 170  27.330  6179  459  4  36  12 Yes  No  Yes  South  1099
## 171  34.772  2021  167  3  57  9  No  No  No  West  0
## 172  36.934  4270  299  1  63  9 Yes  No  Yes  South  283
## 173  76.348  4697  344  4  60  18  No  No  No  West  108
## 174  14.887  4745  339  3  58  12  No  No  Yes  East  724
## 175 121.834 10673  750  3  54  16  No  No  No  East  1573
## 176  30.132  2168  206  3  52  17  No  No  No  South  0
## 177  24.050  2607  221  4  32  18  No  No  Yes  South  0
## 178  22.379  3965  292  2  34  14 Yes  No  Yes  West  384
## 179  28.316  4391  316  2  29  10 Yes  No  No  South  453
## 180  58.026  7499  560  5  67  11 Yes  No  No  South  1237
## 181  10.635  3584  294  5  69  16  No  No  Yes  West  423
## 182  46.102  5180  382  3  81  12  No  No  Yes  East  516
## 183  58.929  6420  459  2  66  9 Yes  No  Yes  East  789
## 184  80.861  4090  335  3  29  15 Yes  No  Yes  West  0
## 185 158.889 11589  805  1  62  17 Yes  No  Yes  South  1448
## 186  30.420  4442  316  1  30  14 Yes  No  No  East  450
## 187  36.472  3806  309  2  52  13  No  No  No  East  188
## 188  23.365  2179  167  2  75  15  No  No  No  West  0
## 189  83.869  7667  554  2  83  11  No  No  No  East  930
## 190  58.351  4411  326  2  85  16 Yes  No  Yes  South  126
## 191  55.187  5352  385  4  50  17 Yes  No  Yes  South  538
## 192 124.290  9560  701  3  52  17 Yes  Yes  No  West  1687
## 193  28.508  3933  287  4  56  14  No  No  Yes  West  336
## 194 130.209 10088  730  7  39  19 Yes  No  Yes  South  1426
## 195  30.406  2120  181  2  79  14  No  No  Yes  East  0
## 196  23.883  5384  398  2  73  16 Yes  No  Yes  East  802
## 197  93.039  7398  517  1  67  12  No  No  Yes  East  749
## 198  50.699  3977  304  2  84  17 Yes  No  No  East  69
## 199  27.349  2000  169  4  51  16 Yes  No  Yes  East  0
## 200  10.403  4159  310  3  43  7  No  No  Yes  West  571
## 201  23.949  5343  383  2  40  18  No  No  Yes  East  829
## 202  73.914  7333  529  6  67  15 Yes  No  Yes  South  1048
## 203  21.038  1448  145  2  58  13 Yes  No  Yes  South  0
## 204  68.206  6784  499  5  40  16 Yes  Yes  No  East  1411
## 205  57.337  5310  392  2  45  7 Yes  No  No  South  456
## 206  10.793  3878  321  8  29  13  No  No  No  South  638
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## 207  23.450  2450    180     2  78        13  No      No      No  South       0
## 208  10.842  4391    358     5  37        10 Yes     Yes     Yes  South    1216
## 209  51.345  4327    320     3  46        15  No      No      No   East     230
## 210 151.947  9156    642     2  91        11 Yes      No     Yes   East     732
## 211  24.543  3206    243     2  62        12 Yes      No     Yes  South      95
## 212  29.567  5309    397     3  25        15  No      No      No  South     799
## 213  39.145  4351    323     2  66        13  No      No     Yes  South     308
## 214  39.422  5245    383     2  44        19  No      No      No   East     637
## 215  34.909  5289    410     2  62        16 Yes      No     Yes  South     681
## 216  41.025  4229    337     3  79        19 Yes      No     Yes  South     246
## 217  15.476  2762    215     3  60        18  No      No      No   West      52
## 218  12.456  5395    392     3  65        14  No      No     Yes  South     955
## 219  10.627  1647    149     2  71        10 Yes     Yes     Yes   West     195
## 220  38.954  5222    370     4  76        13 Yes      No      No  South     653
## 221  44.847  5765    437     3  53        13 Yes     Yes      No   West    1246
## 222  98.515  8760    633     5  78        11 Yes      No      No   East    1230
## 223  33.437  6207    451     4  44         9  No     Yes      No  South    1549
## 224  27.512  4613    344     5  72        17  No      No     Yes   West     573
## 225 121.709  7818    584     4  50         6  No      No     Yes  South     701
## 226  15.079  5673    411     4  28        15 Yes      No     Yes   West    1075
## 227  59.879  6906    527     6  78        15 Yes      No      No  South    1032
## 228  66.989  5614    430     3  47        14 Yes      No     Yes  South     482
## 229  69.165  4668    341     2  34        11 Yes      No      No   East     156
## 230  69.943  7555    547     3  76         9  No      No     Yes   West    1058
## 231  33.214  5137    387     3  59         9  No      No      No   East     661
## 232  25.124  4776    378     4  29        12  No      No     Yes  South     657
## 233  15.741  4788    360     1  39        14  No      No     Yes   West     689
## 234  11.603  2278    187     3  71        11  No      No     Yes  South       0
## 235  69.656  8244    579     3  41        14  No      No     Yes   East    1329
## 236  10.503  2923    232     3  25        18 Yes      No     Yes   East     191
## 237  42.529  4986    369     2  37        11  No      No     Yes   West     489
## 238  60.579  5149    388     5  38        15  No      No     Yes   West     443
## 239  26.532  2910    236     6  58        19 Yes      No     Yes  South      52
## 240  27.952  3557    263     1  35        13 Yes      No     Yes   West     163
## 241  29.705  3351    262     5  71        14 Yes      No     Yes   West     148
## 242  15.602   906    103     2  36        11  No      No     Yes   East       0
## 243  20.918  1233    128     3  47        18 Yes     Yes     Yes   West      16
## 244  58.165  6617    460     1  56        12 Yes      No     Yes  South     856
## 245  22.561  1787    147     4  66        15 Yes      No      No  South       0
## 246  34.509  2001    189     5  80        18 Yes      No     Yes   East       0
## 247  19.588  3211    265     4  59        14 Yes      No      No   West     199
## 248  36.364  2220    188     3  50        19  No      No      No  South       0
## 249  15.717   905     93     1  38        16  No     Yes     Yes  South       0
## 250  22.574  1551    134     3  43        13 Yes     Yes     Yes  South      98
## 251  10.363  2430    191     2  47        18 Yes      No     Yes   West       0
## 252  28.474  3202    267     5  66        12  No      No     Yes  South     132
## 253  72.945  8603    621     3  64         8 Yes      No      No  South    1355
## 254  85.425  5182    402     6  60        12  No      No     Yes   East     218
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## 255  36.508  6386    469     4  79         6 Yes      No     Yes  South    1048
## 256  58.063  4221    304     3  50         8  No      No      No   East     118
## 257  25.936  1774    135     2  71        14 Yes      No      No   West       0
## 258  15.629  2493    186     1  60        14  No      No     Yes   West       0
## 259  41.400  2561    215     2  36        14  No      No     Yes  South       0
## 260  33.657  6196    450     6  55         9 Yes      No      No  South    1092
## 261  67.937  5184    383     4  63        12  No      No     Yes   West     345
## 262 180.379  9310    665     3  67         8 Yes     Yes     Yes   West    1050
## 263  10.588  4049    296     1  66        13 Yes      No     Yes  South     465
## 264  29.725  3536    270     2  52        15 Yes      No      No   East     133
## 265  27.999  5107    380     1  55        10  No      No     Yes  South     651
## 266  40.885  5013    379     3  46        13 Yes      No     Yes   East     549
## 267  88.830  4952    360     4  86        16 Yes      No     Yes  South      15
## 268  29.638  5833    433     3  29        15 Yes      No     Yes   West     942
## 269  25.988  1349    142     4  82        12  No      No      No  South       0
## 270  39.055  5565    410     4  48        18 Yes      No     Yes  South     772
## 271  15.866  3085    217     1  39        13  No      No      No  South     136
## 272  44.978  4866    347     1  30        10 Yes      No      No  South     436
## 273  30.413  3690    299     2  25        15 Yes     Yes      No   West     728
## 274  16.751  4706    353     6  48        14  No     Yes      No   West    1255
## 275  30.550  5869    439     5  81         9 Yes      No      No   East     967
## 276 163.329  8732    636     3  50        14  No      No     Yes  South     529
## 277  23.106  3476    257     2  50        15 Yes      No      No  South     209
## 278  41.532  5000    353     2  50        12  No      No     Yes  South     531
## 279 128.040  6982    518     2  78        11 Yes      No     Yes  South     250
## 280  54.319  3063    248     3  59         8 Yes     Yes      No  South     269
## 281  53.401  5319    377     3  35        12 Yes      No      No   East     541
## 282  36.142  1852    183     3  33        13 Yes      No      No   East       0
## 283  63.534  8100    581     2  50        17 Yes      No     Yes  South    1298
## 284  49.927  6396    485     3  75        17 Yes      No     Yes  South     890
## 285  14.711  2047    167     2  67         6  No      No     Yes  South       0
## 286  18.967  1626    156     2  41        11 Yes      No     Yes   West       0
## 287  18.036  1552    142     2  48        15 Yes      No      No  South       0
## 288  60.449  3098    272     4  69         8  No      No     Yes  South       0
## 289  16.711  5274    387     3  42        16 Yes      No     Yes   West     863
## 290  10.852  3907    296     2  30         9  No      No      No  South     485
## 291  26.370  3235    268     5  78        11  No      No     Yes   West     159
## 292  24.088  3665    287     4  56        13 Yes      No     Yes  South     309
## 293  51.532  5096    380     2  31        15  No      No     Yes  South     481
## 294 140.672 11200    817     7  46         9  No      No     Yes   East    1677
## 295  42.915  2532    205     4  42        13  No      No     Yes   West       0
## 296  27.272  1389    149     5  67        10 Yes      No     Yes  South       0
## 297  65.896  5140    370     1  49        17 Yes      No     Yes  South     293
## 298  55.054  4381    321     3  74        17  No      No     Yes   West     188
## 299  20.791  2672    204     1  70        18 Yes      No      No   East       0
## 300  24.919  5051    372     3  76        11 Yes      No     Yes   East     711
## 301  21.786  4632    355     1  50        17  No      No     Yes  South     580
## 302  31.335  3526    289     3  38         7 Yes      No      No  South     172
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## 303  59.855  4964    365     1  46        13 Yes      No     Yes  South     295
## 304  44.061  4970    352     1  79        11  No      No     Yes   East     414
## 305  82.706  7506    536     2  64        13 Yes      No     Yes   West     905
## 306  24.460  1924    165     2  50        14 Yes      No     Yes   West       0
## 307  45.120  3762    287     3  80         8  No      No     Yes  South      70
## 308  75.406  3874    298     3  41        14 Yes      No     Yes   West       0
## 309  14.956  4640    332     2  33         6  No      No      No   West     681
## 310  75.257  7010    494     3  34        18 Yes      No     Yes  South     885
## 311  33.694  4891    369     1  52        16  No     Yes      No   East    1036
## 312  23.375  5429    396     3  57        15 Yes      No     Yes  South     844
## 313  27.825  5227    386     6  63        11  No      No     Yes  South     823
## 314  92.386  7685    534     2  75        18 Yes      No     Yes   West     843
## 315 115.520  9272    656     2  69        14  No      No      No   East    1140
## 316  14.479  3907    296     3  43        16  No      No     Yes  South     463
## 317  52.179  7306    522     2  57        14  No      No      No   West    1142
## 318  68.462  4712    340     2  71        16  No      No     Yes  South     136
## 319  18.951  1485    129     3  82        13 Yes      No      No  South       0
## 320  27.590  2586    229     5  54        16  No      No     Yes   East       0
## 321  16.279  1160    126     3  78        13  No     Yes     Yes   East       5
## 322  25.078  3096    236     2  27        15 Yes      No     Yes  South      81
## 323  27.229  3484    282     6  51        11  No      No      No  South     265
## 324 182.728 13913    982     4  98        17  No      No     Yes  South    1999
## 325  31.029  2863    223     2  66        17  No     Yes     Yes   West     415
## 326  17.765  5072    364     1  66        12 Yes      No     Yes  South     732
## 327 125.480 10230    721     3  82        16  No      No     Yes  South    1361
## 328  49.166  6662    508     3  68        14 Yes      No      No   West     984
## 329  41.192  3673    297     3  54        16 Yes      No     Yes  South     121
## 330  94.193  7576    527     2  44        16 Yes      No     Yes  South     846
## 331  20.405  4543    329     2  72        17  No     Yes      No   West    1054
## 332  12.581  3976    291     2  48        16  No      No     Yes  South     474
## 333  62.328  5228    377     3  83        15  No      No      No  South     380
## 334  21.011  3402    261     2  68        17  No      No     Yes   East     182
## 335  24.230  4756    351     2  64        15 Yes      No     Yes  South     594
## 336  24.314  3409    270     2  23         7 Yes      No     Yes  South     194
## 337  32.856  5884    438     4  68        13  No      No      No  South     926
## 338  12.414   855    119     3  32        12  No      No     Yes   East       0
## 339  41.365  5303    377     1  45        14  No      No      No  South     606
## 340 149.316 10278    707     1  80        16  No      No      No   East    1107
## 341  27.794  3807    301     4  35         8 Yes      No     Yes   East     320
## 342  13.234  3922    299     2  77        17 Yes      No     Yes  South     426
## 343  14.595  2955    260     5  37         9  No      No     Yes   East     204
## 344  10.735  3746    280     2  44        17 Yes      No     Yes  South     410
## 345  48.218  5199    401     7  39        10  No      No     Yes   West     633
## 346  30.012  1511    137     2  33        17  No      No     Yes  South       0
## 347  21.551  5380    420     5  51        18  No      No     Yes   West     907
## 348 160.231 10748    754     2  69        17  No      No      No  South    1192
## 349  13.433  1134    112     3  70        14  No      No     Yes  South       0
## 350  48.577  5145    389     3  71        13 Yes      No     Yes   West     503
```

```
## 351  30.002  1561    155     4  70        13 Yes      No     Yes  South       0
## 352  61.620  5140    374     1  71         9  No      No     Yes  South     302
## 353 104.483  7140    507     2  41        14  No      No     Yes   East     583
## 354  41.868  4716    342     2  47        18  No      No      No  South     425
## 355  12.068  3873    292     1  44        18 Yes      No     Yes   West     413
## 356 180.682 11966    832     2  58         8 Yes      No     Yes   East    1405
## 357  34.480  6090    442     3  36        14  No      No      No  South     962
## 358  39.609  2539    188     1  40        14  No      No     Yes   West       0
## 359  30.111  4336    339     1  81        18  No      No     Yes  South     347
## 360  12.335  4471    344     3  79        12  No      No     Yes   East     611
## 361  53.566  5891    434     4  82        10 Yes      No      No  South     712
## 362  53.217  4943    362     2  46        16 Yes      No     Yes   West     382
## 363  26.162  5101    382     3  62        19 Yes      No      No   East     710
## 364  64.173  6127    433     1  80        10  No      No     Yes  South     578
## 365 128.669  9824    685     3  67        16  No      No     Yes   West    1243
## 366 113.772  6442    489     4  69        15  No     Yes     Yes  South     790
## 367  61.069  7871    564     3  56        14  No      No     Yes  South    1264
## 368  23.793  3615    263     2  70        14  No      No      No   East     216
## 369  89.000  5759    440     3  37         6 Yes      No      No  South     345
## 370  71.682  8028    599     3  57        16  No      No     Yes  South    1208
## 371  35.610  6135    466     4  40        12  No      No      No  South     992
## 372  39.116  2150    173     4  75        15  No      No      No  South       0
## 373  19.782  3782    293     2  46        16 Yes     Yes      No  South     840
## 374  55.412  5354    383     2  37        16 Yes     Yes     Yes  South    1003
## 375  29.400  4840    368     3  76        18 Yes      No     Yes  South     588
## 376  20.974  5673    413     5  44        16 Yes      No     Yes  South    1000
## 377  87.625  7167    515     2  46        10 Yes      No      No   East     767
## 378  28.144  1567    142     3  51        10  No      No     Yes  South       0
## 379  19.349  4941    366     1  33        19  No      No     Yes  South     717
## 380  53.308  2860    214     1  84        10  No      No     Yes  South       0
## 381 115.123  7760    538     3  83        14 Yes      No      No   East     661
## 382 101.788  8029    574     2  84        11  No      No     Yes  South     849
## 383  24.824  5495    409     1  33         9  No     Yes      No  South    1352
## 384  14.292  3274    282     9  64         9  No      No     Yes  South     382
## 385  20.088  1870    180     3  76        16  No      No      No   East       0
## 386  26.400  5640    398     3  58        15 Yes      No      No   West     905
## 387  19.253  3683    287     4  57        10  No      No      No   East     371
## 388  16.529  1357    126     3  62         9  No      No      No   West       0
## 389  37.878  6827    482     2  80        13 Yes      No      No  South    1129
## 390  83.948  7100    503     2  44        18  No      No      No  South     806
## 391 135.118 10578    747     3  81        15 Yes      No     Yes   West    1393
## 392  73.327  6555    472     2  43        15 Yes      No      No  South     721
## 393  25.974  2308    196     2  24        10  No      No      No   West       0
## 394  17.316  1335    138     2  65        13  No      No      No   East       0
## 395  49.794  5758    410     4  40         8  No      No      No  South     734
## 396  12.096  4100    307     3  32        13  No      No     Yes  South     560
## 397  13.364  3838    296     5  65        17  No      No      No   East     480
## 398  57.872  4171    321     5  67        12 Yes      No     Yes  South     138
```

```
## 399  37.728  2525    192     1  44         13  No      No      Yes  South       0
## 400  18.701  5524    415     5  64          7 Yes      No       No   West     966
```

```
Credit <- na.omit(Credit)

regfit.fwd <- regsubsets(Rating ~ ., data = Credit,
                         nvmax = 19, method = "forward")
summary(regfit.fwd)
```

```
## Subset selection object
## Call: regsubsets.formula(Rating ~ ., data = Credit, nvmax = 19, method = "forward")
## 11 Variables  (and intercept)
##             Forced in Forced out
## Income          FALSE      FALSE
## Limit           FALSE      FALSE
## Cards           FALSE      FALSE
## Age             FALSE      FALSE
## Education       FALSE      FALSE
## OwnYes          FALSE      FALSE
## StudentYes      FALSE      FALSE
## MarriedYes      FALSE      FALSE
## RegionSouth     FALSE      FALSE
## RegionWest      FALSE      FALSE
## Balance         FALSE      FALSE
## 1 subsets of each size up to 11
## Selection Algorithm: forward
##           Income Limit Cards Age Education OwnYes StudentYes MarriedYes
## 1  ( 1 )  " "    "*"   " "   " " " "       " "    " "        " "
## 2  ( 1 )  " "    "*"   "*"   " " " "       " "    " "        " "
## 3  ( 1 )  " "    "*"   "*"   " " " "       " "    " "        "*"
## 4  ( 1 )  " "    "*"   "*"   " " " "       " "    "*"        "*"
## 5  ( 1 )  " "    "*"   "*"   " " "*"       " "    "*"        "*"
## 6  ( 1 )  " "    "*"   "*"   " " "*"       " "    "*"        "*"
## 7  ( 1 )  "*"    "*"   "*"   " " "*"       " "    "*"        "*"
## 8  ( 1 )  "*"    "*"   "*"   " " "*"       " "    "*"        "*"
## 9  ( 1 )  "*"    "*"   "*"   "*" "*"       " "    "*"        "*"
## 10  ( 1 ) "*"    "*"   "*"   "*" "*"       " "    "*"        "*"
## 11  ( 1 ) "*"    "*"   "*"   "*" "*"       "*"    "*"        "*"
##           RegionSouth RegionWest Balance
## 1  ( 1 )  " "         " "        " "
## 2  ( 1 )  " "         " "        " "
## 3  ( 1 )  " "         " "        " "
## 4  ( 1 )  " "         " "        " "
## 5  ( 1 )  " "         " "        " "
## 6  ( 1 )  " "         "*"        " "
## 7  ( 1 )  " "         "*"        " "
## 8  ( 1 )  " "         "*"        "*"
```

```
## 9  ( 1 )  " "         "*"        "*"
## 10  ( 1 ) "*"         "*"        "*"
## 11  ( 1 ) "*"         "*"        "*"
```

```
reg.summary <- summary(regfit.fwd)
reg.summary
```

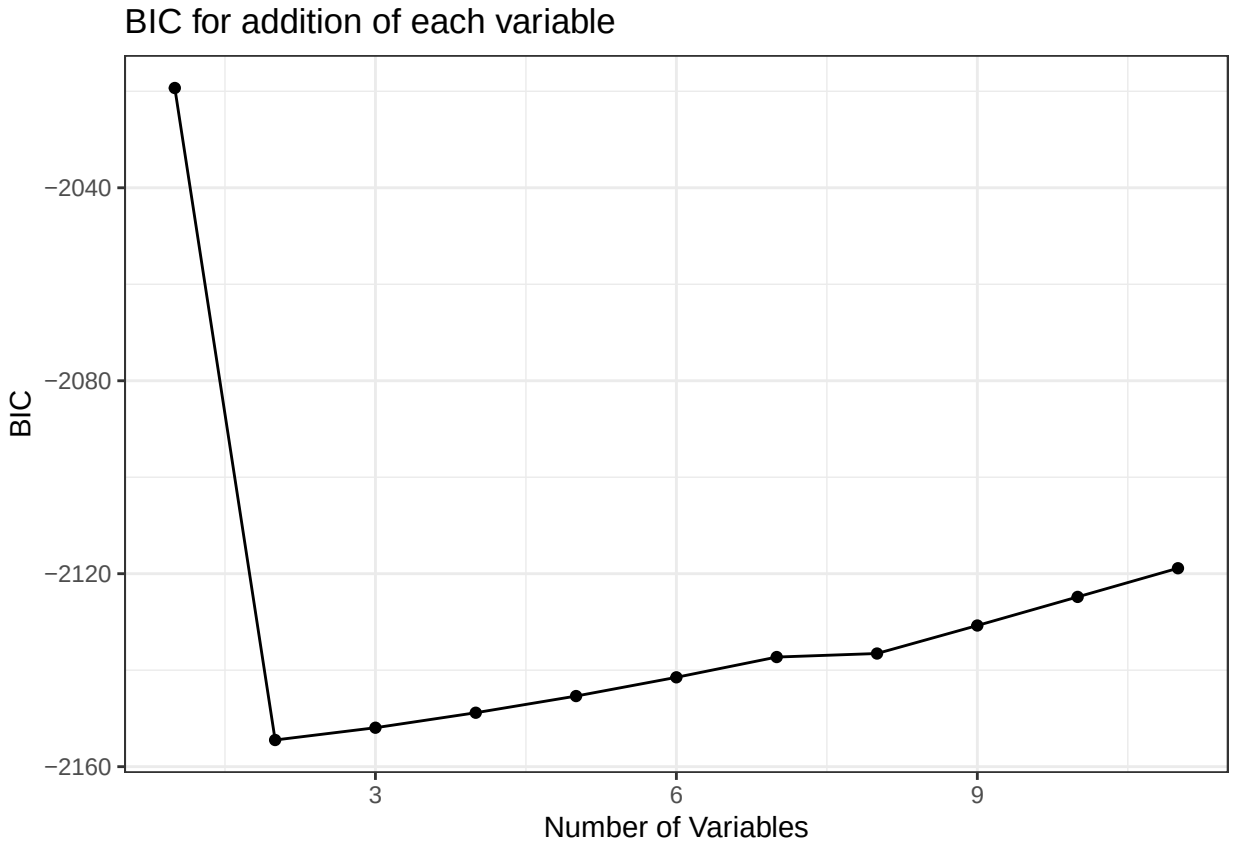
```
## Subset selection object
## Call: regsubsets.formula(Rating ~ ., data = Credit, nvmax = 19, method = "forward")
## 11 Variables  (and intercept)
##             Forced in Forced out
## Income          FALSE      FALSE
## Limit           FALSE      FALSE
## Cards           FALSE      FALSE
## Age             FALSE      FALSE
## Education       FALSE      FALSE
## OwnYes          FALSE      FALSE
## StudentYes      FALSE      FALSE
## MarriedYes      FALSE      FALSE
## RegionSouth     FALSE      FALSE
## RegionWest      FALSE      FALSE
## Balance         FALSE      FALSE
## 1 subsets of each size up to 11
## Selection Algorithm: forward
##           Income Limit Cards Age Education OwnYes StudentYes MarriedYes
## 1  ( 1 )  " "    "*"   " "   " " " "       " "    " "        " "
## 2  ( 1 )  " "    "*"   "*"   " " " "       " "    " "        " "
## 3  ( 1 )  " "    "*"   "*"   " " " "       " "    " "        "*"
## 4  ( 1 )  " "    "*"   "*"   " " " "       " "    "*"        "*"
## 5  ( 1 )  " "    "*"   "*"   " " "*"       " "    "*"        "*"
## 6  ( 1 )  " "    "*"   "*"   " " "*"       " "    "*"        "*"
## 7  ( 1 )  "*"    "*"   "*"   " " "*"       " "    "*"        "*"
## 8  ( 1 )  "*"    "*"   "*"   " " "*"       " "    "*"        "*"
## 9  ( 1 )  "*"    "*"   "*"   "*" "*"       " "    "*"        "*"
## 10  ( 1 ) "*"    "*"   "*"   "*" "*"       " "    "*"        "*"
## 11  ( 1 ) "*"    "*"   "*"   "*" "*"       "*"    "*"        "*"
##           RegionSouth RegionWest Balance
## 1  ( 1 )  " "         " "        " "
## 2  ( 1 )  " "         " "        " "
## 3  ( 1 )  " "         " "        " "
## 4  ( 1 )  " "         " "        " "
## 5  ( 1 )  " "         " "        " "
## 6  ( 1 )  " "         "*"        " "
## 7  ( 1 )  " "         "*"        " "
## 8  ( 1 )  " "         "*"        "*"
## 9  ( 1 )  " "         "*"        "*"
## 10  ( 1 ) "*"         "*"        "*"
```

```
## 11  ( 1 ) "*"         "*"         "*"
```

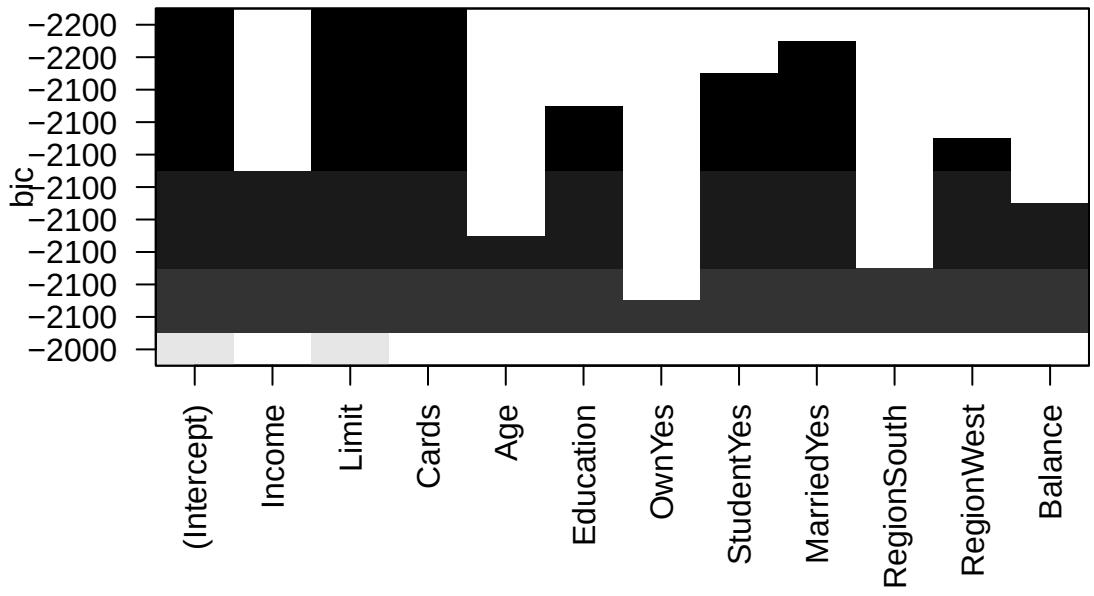
```
plot_metrics <- data.frame(bic = reg.summary$bic, numvar = 1:11)
plot_metrics
```

```
##          bic numvar
## 1  -2019.318      1
## 2  -2154.474      2
## 3  -2151.927      3
## 4  -2148.819      4
## 5  -2145.364      5
## 6  -2141.478      6
## 7  -2137.278      7
## 8  -2136.546      8
## 9  -2130.739      9
## 10 -2124.809     10
## 11 -2118.866     11
```

```
plot_metrics %>%
        ggplot(aes(y = bic, x = numvar)) +
        geom_point() +
        geom_line() +
        xlab("Number of Variables") + ylab("BIC") +
        theme_bw() +
        ggtitle("BIC for addition of each variable")
```




```
plot(regfit.fwd, scale = "bic")
```




```
which.min(reg.summary$bic)
```

```
## [1] 2
```

```
reg.summary$bic[2]
```

```
## [1] -2154.474
```

```
# # ------------------------------------------------------------------
#
# Ridge Regression
#
# # ------------------------------------------------------------------

# Let's once again use the Hitters data.

# We will use the glmnet package in order to perform ridge regression and
# the lasso. The main function in this package is glmnet(), which can use
# glmnet() to fit ridge regression models, lasso models, and more. This function has
# slightly different syntax from other model-fitting functions that we have
# encountered thus far. In particular, we must pass in an x
# matrix as well as a y vector, and we do not use the y ~ x syntax. We will
# now perform ridge regression and the lasso in order to predict Salary on
# the Hitters data. Before proceeding ensure that the missing values have
# been removed from the data (which we've already done above!)

x <- model.matrix(Salary ~ ., Hitters_dropNA)[, -1] # x is a matrix of the data set, minus the
y <- Hitters_dropNA$Salary # y is the vector of salary values

# Let's look at x

x
```

```
##                     AtBat Hits HmRun Runs RBI Walks Years CAtBat CHits CHmRun
## -Alan Ashby           315   81     7   24  38    39    14   3449   835     69
## -Alvin Davis          479  130    18   66  72    76     3   1624   457     63
## -Andre Dawson         496  141    20   65  78    37    11   5628  1575    225
## -Andres Galarraga     321   87    10   39  42    30     2    396   101     12
## -Alfredo Griffin      594  169     4   74  51    35    11   4408  1133     19
## -Al Newman            185   37     1   23   8    21     2    214    42      1
## -Argenis Salazar      298   73     0   24  24     7     3    509   108      0
## -Andres Thomas        323   81     6   26  32     8     2    341    86      6
## -Andre Thornton       401   92    17   49  66    65    13   5206  1332    253
## -Alan Trammell        574  159    21  107  75    59    10   4631  1300     90
## -Alex Trevino         202   53     4   31  26    27     9   1876   467     15
## -Andy VanSlyke        418  113    13   48  61    47     4   1512   392     41
## -Alan Wiggins         239   60     0   30  11    22     6   1941   510      4
## -Bill Almon           196   43     7   29  27    30    13   3231   825     36
## -Buddy Bell           568  158    20   89  75    73    15   8068  2273    177
## -Buddy Biancalana     190   46     2   24   8    15     5    479   102      5
```

```
## -Bruce Bochy         127   32     8   16  22    14     8    727   180     24
## -Barry Bonds         413   92    16   72  48    65     1    413    92     16
## -Bobby Bonilla       426  109     3   55  43    62     1    426   109      3
## -Bob Brenly          472  116    16   60  62    74     6   1924   489     67
## -Bill Buckner        629  168    18   73 102    40    18   8424  2464    164
## -Brett Butler        587  163     4   92  51    70     6   2695   747     17
## -Bob Dernier         324   73     4   32  18    22     7   1931   491     13
## -Bo Diaz             474  129    10   50  56    40    10   2331   604     61
## -Bill Doran          550  152     6   92  37    81     5   2308   633     32
## -Brian Downing       513  137    20   90  95    90    14   5201  1382    166
## -Billy Hatcher       419  108     6   55  36    22     3    591   149      8
## -Brook Jacoby        583  168    17   83  80    56     5   1646   452     44
## -Bob Kearney         204   49     6   23  25    12     7   1309   308     27
## -Bill Madlock        379  106    10   38  60    30    14   6207  1906    146
## -Bob Melvin          268   60     5   24  25    15     2    350    78      5
## -BillyJo Robidoux    181   41     1   15  21    33     2    232    50      4
## -Bill Schroeder      217   46     7   32  19     9     4    694   160     32
## -Chris Bando         254   68     2   28  26    22     6    999   236     21
## -Chris Brown         416  132     7   57  49    33     3    932   273     24
## -Carmen Castillo     205   57     8   34  32     9     5    756   192     32
## -Chili Davis         526  146    13   71  70    84     6   2648   715     77
## -Carlton Fisk        457  101    14   42  63    22    17   6521  1767    281
## -Curt Ford           214   53     2   30  29    23     2    226    59      2
## -Carney Lansford     591  168    19   80  72    39     9   4478  1307    113
## -Chet Lemon          403  101    12   45  53    39    12   5150  1429    166
## -Candy Maldonado     405  102    18   49  85    20     6    950   231     29
## -Carmelo Martinez    244   58     9   28  25    35     4   1335   333     49
## -Craig Reynolds      313   78     6   32  41    12    12   3742   968     35
## -Cal Ripken          627  177    25   98  81    70     6   3210   927    133
## -Cory Snyder         416  113    24   58  69    16     1    416   113     24
## -Chris Speier        155   44     6   21  23    15    16   6631  1634     98
## -Curt Wilkerson      236   56     0   27  15    11     4   1115   270      1
## -Dave Anderson       216   53     1   31  15    22     4    926   210      9
## -Don Baylor          585  139    31   93  94    62    17   7546  1982    315
## -Daryl Boston        199   53     5   29  22    21     3    514   120      8
## -Darnell Coles       521  142    20   67  86    45     4    815   205     22
## -Dave Concepcion     311   81     3   42  30    26    17   8247  2198    100
## -Doug DeCinces       512  131    26   69  96    52    14   5347  1397    221
## -Darrell Evans       507  122    29   78  85    91    18   7761  1947    347
## -Dwight Evans        529  137    26   86  97    97    15   6661  1785    291
## -Damaso Garcia       424  119     6   57  46    13     9   3651  1046     32
## -Dan Gladden         351   97     4   55  29    39     4   1258   353     16
## -Dave Henderson      388  103    15   59  47    39     6   2174   555     80
## -Donnie Hill         339   96     4   37  29    23     4   1064   290     11
## -Davey Lopes         255   70     7   49  35    43    15   6311  1661    154
## -Don Mattingly       677  238    31  117 113    53     5   2223   737     93
## -Dale Murphy         614  163    29   89  83    75    11   5017  1388    266
## -Dwayne Murphy       329   83     9   50  39    56     9   3828   948    145
```

```
## -Dave Parker          637  174    31    89 116    56    14   6727  2024    247
## -Dan Pasqua           280   82    16    44  45    47     2    428   113     25
## -Darrell Porter       155   41    12    21  29    22    16   5409  1338    181
## -Dick Schofield       458  114    13    67  57    48     4   1350   298     28
## -Don Slaught          314   83    13    39  46    16     5   1457   405     28
## -Darryl Strawberry    475  123    27    76  93    72     4   1810   471    108
## -Dale Sveum           317   78     7    35  35    32     1    317    78      7
## -Danny Tartabull      511  138    25    76  96    61     3    592   164     28
## -Denny Walling        382  119    13    54  58    36    12   2133   594     41
## -Dave Winfield        565  148    24    90 104    77    14   7287  2083    305
## -Eric Davis           415  115    27    97  71    68     3    711   184     45
## -Eddie Milner         424  110    15    70  47    36     7   2130   544     38
## -Eddie Murray         495  151    17    61  84    78    10   5624  1679    275
## -Ed Romero            233   49     2    41  23    18     8   1350   336      7
## -Frank White          566  154    22    76  84    43    14   6100  1583    131
## -George Bell          641  198    31   101 108    41     5   2129   610     92
## -Glenn Braggs         215   51     4    19  18    11     1    215    51      4
## -George Brett         441  128    16    70  73    80    14   6675  2095    209
## -Greg Brock           325   76    16    33  52    37     5   1506   351     71
## -Gary Carter          490  125    24    81 105    62    13   6063  1646    271
## -Glenn Davis          574  152    31    91 101    64     3    985   260     53
## -Gary Gaetti          596  171    34    91 108    52     6   2862   728    107
## -Greg Gagne           472  118    12    63  54    30     4    793   187     14
## -George Hendrick      283   77    14    45  47    26    16   6840  1910    259
## -Glenn Hubbard        408   94     4    42  36    66     9   3573   866     59
## -Garth Iorg           327   85     3    30  44    20     8   2140   568     16
## -Gary Matthews        370   96    21    49  46    60    15   6986  1972    231
## -Graig Nettles        354   77    16    36  55    41    20   8716  2172    384
## -Gary Pettis          539  139     5    93  58    69     5   1469   369     12
## -Gary Redus           340   84    11    62  33    47     5   1516   376     42
## -Garry Templeton      510  126     2    42  44    35    11   5562  1578     44
## -Greg Walker          282   78    13    37  51    29     5   1649   453     73
## -Gary Ward            380  120     5    54  51    31     8   3118   900     92
## -Glenn Wilson         584  158    15    70  84    42     5   2358   636     58
## -Harold Baines        570  169    21    72  88    38     7   3754  1077    140
## -Hubie Brooks         306  104    14    50  58    25     7   2954   822     55
## -Howard Johnson       220   54    10    30  39    31     5   1185   299     40
## -Hal McRae            278   70     7    22  37    18    18   7186  2081    190
## -Harold Reynolds      445   99     1    46  24    29     4    618   129      1
## -Harry Spilman        143   39     5    18  30    15     9    639   151     16
## -Herm Winningham      185   40     4    23  11    18     3    524   125      7
## -Jesse Barfield       589  170    40   107 108    69     6   2325   634    128
## -Juan Beniquez        343  103     6    48  36    40    15   4338  1193     70
## -John Cangelosi       438  103     2    65  32    71     2    440   103      2
## -Jose Canseco         600  144    33    85 117    65     2    696   173     38
## -Joe Carter           663  200    29   108 121    32     4   1447   404     57
## -Jack Clark           232   55     9    34  23    45    12   4405  1213    194
## -Jose Cruz            479  133    10    48  72    55    17   7472  2147    153
```

```
## -Jody Davis          528  132    21   61  74    41     6  2641   671     97
## -Jim Dwyer           160   39     8   18  31    22    14  2128   543     56
## -Julio Franco        599  183    10   80  74    32     5  2482   715     27
## -Jim Gantner         497  136     7   58  38    26    11  3871  1066     40
## -Johnny Grubb        210   70    13   32  51    28    15  4040  1130     97
## -Jack Howell         151   41     4   26  21    19     2   288    68      9
## -John Kruk           278   86     4   33  38    45     1   278    86      4
## -Jeffrey Leonard     341   95     6   48  42    20    10  2964   808     81
## -Jim Morrison        537  147    23   58  88    47    10  2744   730     97
## -John Moses          399  102     3   56  34    34     5   670   167      4
## -Jerry Mumphrey      309   94     5   37  32    26    13  4618  1330     57
## -Jim Presley         616  163    27   83 107    32     3  1437   377     65
## -Johnny Ray          579  174     7   67  78    58     6  3053   880     32
## -Jeff Reed           165   39     2   13   9    16     3   196    44      2
## -Jim Rice            618  200    20   98 110    62    13  7127  2163    351
## -Jerry Royster       257   66     5   31  26    32    14  3910   979     33
## -John Russell        315   76    13   35  60    25     3   630   151     24
## -Juan Samuel         591  157    16   90  78    26     4  2020   541     52
## -John Shelby         404   92    11   54  49    18     6  1354   325     30
## -Joel Skinner        315   73     5   23  37    16     4   450   108      6
## -Jim Sundberg        429   91    12   41  42    57    13  5590  1397     83
## -Jose Uribe          453  101     3   46  43    61     3   948   218      6
## -Joel Youngblood     184   47     5   20  28    18    11  3327   890     74
## -Kevin Bass          591  184    20   83  79    38     5  1689   462     40
## -Kal Daniels         181   58     6   34  23    22     1   181    58      6
## -Kirk Gibson         441  118    28   84  86    68     8  2723   750    126
## -Ken Griffey         490  150    21   69  58    35    14  6126  1839    121
## -Keith Hernandez     551  171    13   94  83    94    13  6090  1840    128
## -Kent Hrbek          550  147    29   85  91    71     6  2816   815    117
## -Ken Landreaux       283   74     4   34  29    22    10  3919  1062     85
## -Kevin McReynolds    560  161    26   89  96    66     4  1789   470     65
## -Kevin Mitchell      328   91    12   51  43    33     2   342    94     12
## -Keith Moreland      586  159    12   72  79    53     9  3082   880     83
## -Ken Oberkfell       503  136     5   62  48    83    10  3423   970     20
## -Ken Phelps          344   85    24   69  64    88     7   911   214     64
## -Kirby Puckett       680  223    31  119  96    34     3  1928   587     35
## -Kurt Stillwell      279   64     0   31  26    30     1   279    64      0
## -Leon Durham         484  127    20   66  65    67     7  3006   844    116
## -Len Dykstra         431  127     8   77  45    58     2   667   187      9
## -Larry Herndon       283   70     8   33  37    27    12  4479  1222     94
## -Lee Lacy            491  141    11   77  47    37    15  4291  1240     84
## -Len Matuszek        199   52     9   26  28    21     6   805   191     30
## -Lloyd Moseby        589  149    21   89  86    64     7  3558   928    102
## -Lance Parrish       327   84    22   53  62    38    10  4273  1123    212
## -Larry Parrish       464  128    28   67  94    52    13  5829  1552    210
## -Larry Sheets        338   92    18   42  60    21     3   682   185     36
## -Lou Whitaker        584  157    20   95  73    63    10  4704  1320     93
## -Mike Aldrete        216   54     2   27  25    33     1   216    54      2
```

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## -Marty Barrett       625  179     4   94  60    65     5  1696   476     12
## -Mike Davis          489  131    19   77  55    34     7  2051   549     62
## -Mike Diaz           209   56    12   22  36    19     2   216    58     12
## -Mariano Duncan      407   93     8   47  30    30     2   969   230     14
## -Mike Easler         490  148    14   64  78    49    13  3400  1000    113
## -Mel Hall            442  131    18   68  77    33     6  1416   398     47
## -Mike Heath          288   65     8   30  36    27     9  2815   698     55
## -Mike Kingery        209   54     3   25  14    12     1   209    54      3
## -Mike LaValliere     303   71     3   18  30    36     3   344    76      3
## -Mike Marshall       330   77    19   47  53    27     6  1928   516     90
## -Mike Pagliarulo     504  120    28   71  71    54     3  1085   259     54
## -Mark Salas          258   60     8   28  33    18     3   638   170     17
## -Mike Schmidt         20    1     0    0   0     0     2    41     9      2
## -Mike Scioscia       374   94     5   36  26    62     7  1968   519     26
## -Mickey Tettleton    211   43    10   26  35    39     3   498   116     14
## -Milt Thompson       299   75     6   38  23    26     3   580   160      8
## -Mitch Webster       576  167     8   89  49    57     4   822   232     19
## -Mookie Wilson       381  110     9   61  45    32     7  3015   834     40
## -Marvell Wynne       288   76     7   34  37    15     4  1644   408     16
## -Mike Young          369   93     9   43  42    49     5  1258   323     54
## -Ozzie Guillen       547  137     2   58  47    12     2  1038   271      3
## -Oddibe McDowell     572  152    18  105  49    65     2   978   249     36
## -Ozzie Smith         514  144     0   67  54    79     9  4739  1169     13
## -Ozzie Virgil        359   80    15   45  48    63     7  1493   359     61
## -Phil Bradley        526  163    12   88  50    77     4  1556   470     38
## -Phil Garner         313   83     9   43  41    30    14  5885  1543    104
## -Pete Incaviglia     540  135    30   82  88    55     1   540   135     30
## -Paul Molitor        437  123     9   62  55    40     9  4139  1203     79
## -Pete Rose           237   52     0   15  25    30    24 14053  4256    160
## -Pat Sheridan        236   56     6   41  19    21     5  1257   329     24
## -Pat Tabler          473  154     6   61  48    29     6  1966   566     29
## -Rafael Belliard     309   72     0   33  31    26     5   354    82      0
## -Rick Burleson       271   77     5   35  29    33    12  4933  1358     48
## -Randy Bush          357   96     7   50  45    39     5  1394   344     43
## -Rick Cerone         216   56     4   22  18    15    12  2796   665     43
## -Ron Cey             256   70    13   42  36    44    16  7058  1845    312
## -Rob Deer            466  108    33   75  86    72     3   652   142     44
## -Rick Dempsey        327   68    13   42  29    45    18  3949   939     78
## -Ron Hassey          341  110     9   45  49    46     9  2331   658     50
## -Rickey Henderson    608  160    28  130  74    89     8  4071  1182    103
## -Reggie Jackson      419  101    18   65  58    92    20  9528  2510    548
## -Ron Kittle          376   82    21   42  60    35     5  1770   408    115
## -Ray Knight          486  145    11   51  76    40    11  3967  1102     67
## -Rick Leach          246   76     5   35  39    13     6   912   234     12
## -Rick Manning        205   52     8   31  27    17    12  5134  1323     56
## -Rance Mulliniks     348   90    11   50  45    43    10  2288   614     43
## -Ron Oester          523  135     8   52  44    52     9  3368   895     39
## -Rey Quinones        312   68     2   32  22    24     1   312    68      2
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## -Rafael Ramirez      496  119    8   57  33   21    7  3358  882   36
## -Ronn Reynolds       126   27    3    8  10    5    4   239   49    3
## -Ron Roenicke        275   68    5   42  42   61    6   961  238   16
## -Ryne Sandberg       627  178   14   68  76   46    6  3146  902   74
## -Rafael Santana      394   86    1   38  28   36    4  1089  267    3
## -Rick Schu           208   57    8   32  25   18    3   653  170   17
## -Ruben Sierra        382  101   16   50  55   22    1   382  101   16
## -Roy Smalley         459  113   20   59  57   68   12  5348 1369  155
## -Robby Thompson      549  149    7   73  47   42    1   549  149    7
## -Rob Wilfong         288   63    3   25  33   16   10  2682  667   38
## -Robin Yount         522  163    9   82  46   62   13  7037 2019  153
## -Steve Balboni       512  117   29   54  88   43    6  1750  412  100
## -Scott Bradley       220   66    5   20  28   13    3   290   80    5
## -Sid Bream           522  140   16   73  77   60    4   730  185   22
## -Steve Buechele      461  112   18   54  54   35    2   680  160   24
## -Shawon Dunston      581  145   17   66  68   21    2   831  210   21
## -Scott Fletcher      530  159    3   82  50   47    6  1619  426   11
## -Steve Garvey        557  142   21   58  81   23   18  8759 2583  271
## -Steve Jeltz         439   96    0   44  36   65    4   711  148    1
## -Steve Lombardozzi   453  103    8   53  33   52    2   507  123    8
## -Spike Owen          528  122    1   67  45   51    4  1716  403   12
## -Steve Sax           633  210    6   91  56   59    6  3070  872   19
## -Tony Bernazard      562  169   17   88  73   53    8  3181  841   61
## -Tom Brookens        281   76    3   42  25   20    8  2658  657   48
## -Tom Brunansky       593  152   23   69  75   53    6  2765  686  133
## -Tony Fernandez      687  213   10   91  65   27    4  1518  448   15
## -Tim Flannery        368  103    3   48  28   54    8  1897  493    9
## -Tom Foley           263   70    1   26  23   30    4   888  220    9
## -Tony Gwynn          642  211   14  107  59   52    5  2364  770   27
## -Terry Harper        265   68    8   26  30   29    7  1337  339   32
## -Tommy Herr          559  141    2   48  61   73    8  3162  874   16
## -Tim Hulett          520  120   17   53  44   21    4   927  227   22
## -Terry Kennedy        19    4    1    2   3    1    1    19    4    1
## -Tito Landrum        205   43    2   24  17   20    7   854  219   12
## -Tim Laudner         193   47   10   21  29   24    6  1136  256   42
## -Tom Paciorek        213   61    4   17  22    3   17  4061 1145   83
## -Tony Pena           510  147   10   56  52   53    7  2872  821   63
## -Terry Pendleton     578  138    1   56  59   34    3  1399  357    7
## -Tony Phillips       441  113    5   76  52   76    5  1546  397   17
## -Terry Puhl          172   42    3   17  14   15   10  4086 1150   57
## -Ted Simmons         127   32    4   14  25   12   19  8396 2402  242
## -Tim Teufel          279   69    4   35  31   32    4  1359  355   31
## -Tim Wallach         480  112   18   50  71   44    7  3031  771  110
## -Vince Coleman       600  139    0   94  29   60    2  1236  309    1
## -Von Hayes           610  186   19  107  98   74    6  2728  753   69
## -Vance Law           360   81    5   37  44   37    7  2268  566   41
## -Wally Backman       387  124    1   67  27   36    7  1775  506    6
## -Wade Boggs          580  207    8  107  71  105    5  2778  978   32
```

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## -Will Clark          408  117    11   66  41    34     1    408   117     11
## -Wally Joyner        593  172    22   82 100    57     1    593   172     22
## -Willie McGee        497  127     7   65  48    37     5   2703   806     32
## -Willie Randolph     492  136     5   76  50    94    12   5511  1511     39
## -Wayne Tolleson      475  126     3   61  43    52     6   1700   433      7
## -Willie Upshaw       573  144     9   85  60    78     8   3198   857     97
## -Willie Wilson       631  170     9   77  44    31    11   4908  1457     30
##                    CRuns CRBI CWalks LeagueN DivisionW PutOuts Assists Errors
## -Alan Ashby          321  414    375       1         1     632      43     10
## -Alvin Davis         224  266    263       0         1     880      82     14
## -Andre Dawson        828  838    354       1         0     200      11      3
## -Andres Galarraga     48   46     33       1         0     805      40      4
## -Alfredo Griffin     501  336    194       0         1     282     421     25
## -Al Newman            30    9     24       1         0      76     127      7
## -Argenis Salazar      41   37     12       0         1     121     283      9
## -Andres Thomas        32   34      8       1         1     143     290     19
## -Andre Thornton      784  890    866       0         0       0       0      0
## -Alan Trammell       702  504    488       0         0     238     445     22
## -Alex Trevino        192  186    161       1         1     304      45     11
## -Andy VanSlyke       205  204    203       1         0     211      11      7
## -Alan Wiggins        309  103    207       0         0     121     151      6
## -Bill Almon          376  290    238       1         0      80      45      8
## -Buddy Bell         1045  993    732       1         1     105     290     10
## -Buddy Biancalana     65   23     39       0         1     102     177     16
## -Bruce Bochy          67   82     56       1         1     202      22      2
## -Barry Bonds          72   48     65       1         0     280       9      5
## -Bobby Bonilla        55   43     62       0         1     361      22      2
## -Bob Brenly          242  251    240       1         1     518      55      3
## -Bill Buckner       1008 1072    402       0         0    1067     157     14
## -Brett Butler        442  198    317       0         0     434       9      3
## -Bob Dernier         291  108    180       1         0     222       3      3
## -Bo Diaz             246  327    166       1         1     732      83     13
## -Bill Doran          349  182    308       1         1     262     329     16
## -Brian Downing       763  734    784       0         1     267       5      3
## -Billy Hatcher        80   46     31       1         1     226       7      4
## -Brook Jacoby        219  208    136       0         0     109     292     25
## -Bob Kearney         126  132     66       0         1     419      46      5
## -Bill Madlock        859  803    571       1         1      72     170     24
## -Bob Melvin           34   29     18       1         1     442      59      6
## -BillyJo Robidoux     20   29     45       0         0     326      29      5
## -Bill Schroeder       86   76     32       0         0     307      25      1
## -Chris Bando         108  117    118       0         0     359      30      4
## -Chris Brown         113  121     80       1         1      73     177     18
## -Carmen Castillo     117  107     51       0         0      58       4      4
## -Chili Davis         352  342    289       1         1     303       9      9
## -Carlton Fisk       1003  977    619       0         1     389      39      4
## -Curt Ford            32   32     27       1         0     109       7      3
## -Carney Lansford     634  563    319       0         1      67     147      4
```

```
## -Chet Lemon          747  666    526       0         0     316       6      5
## -Candy Maldonado      99  138     64       1         1     161      10      3
## -Carmelo Martinez    164  179    194       1         1     142      14      2
## -Craig Reynolds      409  321    170       1         1     106     206      7
## -Cal Ripken          529  472    313       0         0     240     482     13
## -Cory Snyder          58   69     16       0         0     203      70     10
## -Chris Speier        698  661    777       1         0      53      88      3
## -Curt Wilkerson      116   64     57       0         1     125     199     13
## -Dave Anderson       118   69    114       1         1      73     152     11
## -Don Baylor         1141 1179    727       0         0       0       0      0
## -Daryl Boston         57   40     39       0         1     152       3      5
## -Darnell Coles        99  103     78       0         0     107     242     23
## -Dave Concepcion     950  909    690       1         1     153     223     10
## -Doug DeCinces       712  815    548       0         1     119     216     12
## -Darrell Evans      1175 1152   1380       0         0     808     108      2
## -Dwight Evans       1082  949    989       0         0     280      10      5
## -Damaso Garcia       461  301    112       0         0     224     286      8
## -Dan Gladden         196  110    117       1         1     226       7      3
## -Dave Henderson      285  274    186       0         1     182       9      4
## -Donnie Hill         123  108     55       0         1     104     213      9
## -Davey Lopes        1019  608    820       1         0      51      54      8
## -Don Mattingly       349  401    171       0         0    1377     100      6
## -Dale Murphy         813  822    617       1         1     303       6      6
## -Dwayne Murphy       575  528    635       0         1     276       6      2
## -Dave Parker         978 1093    495       1         1     278       9      9
## -Dan Pasqua           61   70     63       0         0     148       4      2
## -Darrell Porter      746  805    875       0         1     165       9      1
## -Dick Schofield      160  123    122       0         1     246     389     18
## -Don Slaught         156  159     76       0         1     533      40      4
## -Darryl Strawberry   292  343    267       1         0     226      10      6
## -Dale Sveum           35   35     32       0         0      45     122     26
## -Danny Tartabull      87  110     71       0         1     157       7      8
## -Denny Walling       287  294    227       1         1      59     156      9
## -Dave Winfield      1135 1234    791       0         0     292       9      5
## -Eric Davis          156  119     99       1         1     274       2      7
## -Eddie Milner        335  174    258       1         1     292       6      3
## -Eddie Murray        884 1015    709       0         0    1045      88     13
## -Ed Romero           166  122    106       0         0     102     132     10
## -Frank White         743  693    300       0         1     316     439     10
## -George Bell         297  319    117       0         0     269      17     10
## -Glenn Braggs         19   18     11       0         0     116       5     12
## -George Brett        1072 1050   695       0         1      97     218     16
## -Greg Brock          195  219    214       1         1     726      87      3
## -Gary Carter         847  999    680       1         0     869      62      8
## -Glenn Davis         148  173     95       1         1    1253     111     11
## -Gary Gaetti         361  401    224       0         1     118     334     21
## -Greg Gagne          102   80     50       0         1     228     377     26
## -George Hendrick     915 1067    546       0         1     144       6      5
```

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## -Glenn Hubbard       429  365    410        1         1     282     487     19
## -Garth Iorg          216  208     93        0         0      91     185     12
## -Gary Matthews      1070  955    921        1         0     137       5      9
## -Graig Nettles      1172 1267   1057        1         1      83     174     16
## -Gary Pettis         247  126    198        0         1     462       9      7
## -Gary Redus          284  141    219        1         0     185       8      4
## -Garry Templeton     703  519    256        1         1     207     358     20
## -Greg Walker         211  280    138        0         1     670      57      5
## -Gary Ward           444  419    240        0         1     237       8      1
## -Glenn Wilson        265  316    134        1         0     331      20      4
## -Harold Baines       492  589    263        0         1     295      15      5
## -Hubie Brooks        313  377    187        1         0     116     222     15
## -Howard Johnson      145  154    128        1         0      50     136     20
## -Hal McRae           935 1088    643        0         1       0       0      0
## -Harold Reynolds      72   31     48        0         1     278     415     16
## -Harry Spilman        80   97     61        1         1     138      15      1
## -Herm Winningham      58   37     47        1         0      97       2      2
## -Jesse Barfield      371  376    238        0         0     368      20      3
## -Juan Beniquez       581  421    325        0         0     211      56     13
## -John Cangelosi       67   32     71        0         1     276       7      9
## -Jose Canseco        101  130     69        0         1     319       4     14
## -Joe Carter          210  222     68        0         0     241       8      6
## -Jack Clark          702  705    625        1         0     623      35      3
## -Jose Cruz           980 1032    854        1         1     237       5      4
## -Jody Davis          273  383    226        1         0     885     105      8
## -Jim Dwyer           304  268    298        0         0      33       3      0
## -Julio Franco        330  326    158        0         0     231     374     18
## -Jim Gantner         450  367    241        0         0     304     347     10
## -Johnny Grubb        544  462    551        0         0       0       0      0
## -Jack Howell          45   39     35        0         1      28      56      2
## -John Kruk            33   38     45        1         1     102       4      2
## -Jeffrey Leonard     379  428    221        1         1     158       4      5
## -Jim Morrison        302  351    174        1         0      92     257     20
## -John Moses           89   48     54        0         1     211       9      3
## -Jerry Mumphrey      616  522    436        1         0     161       3      3
## -Jim Presley         181  227     82        0         1     110     308     15
## -Johnny Ray          366  337    218        1         0     280     479      5
## -Jeff Reed            18   10     18        0         1     332      19      2
## -Jim Rice           1104 1289    564        0         0     330      16      8
## -Jerry Royster       518  324    382        1         1      87     166     14
## -John Russell         68   94     55        1         0     498      39     13
## -Juan Samuel         310  226     91        1         0     290     440     25
## -John Shelby         188  135     63        0         0     222       5      5
## -Joel Skinner         38   46     28        0         1     227      15      3
## -Jim Sundberg        578  579    644        0         1     686      46      4
## -Jose Uribe           96   72     91        1         1     249     444     16
## -Joel Youngblood     419  382    304        1         1      49       2      0
## -Kevin Bass          219  195     82        1         1     303      12      5
```

```
## -Kal Daniels          34   23     22        1         1       88        0      3
## -Kirk Gibson         433  420    309        0         0      190        2      2
## -Ken Griffey         983  707    600        0         0       96        5      3
## -Keith Hernandez     969  900    917        1         0     1199      149      5
## -Kent Hrbek          405  474    319        0         1     1218      104     10
## -Ken Landreaux       505  456    283        1         1      145        5      7
## -Kevin McReynolds    233  260    155        1         1      332        9      8
## -Kevin Mitchell       51   44     33        1         0      145       59      8
## -Keith Moreland      363  477    295        1         0      181       13      4
## -Ken Oberkfell       408  303    414        1         1       65      258      8
## -Ken Phelps          150  156    187        0         1        0        0      0
## -Kirby Puckett       262  201     91        0         1      429        8      6
## -Kurt Stillwell       31   26     30        1         1      107      205     16
## -Leon Durham         436  458    377        1         0     1231       80      7
## -Len Dykstra         117   64     88        1         0      283        8      3
## -Larry Herndon       557  483    307        0         0      156        2      2
## -Lee Lacy            615  430    340        0         0      239        8      2
## -Len Matuszek        113  119     87        1         1      235       22      5
## -Lloyd Moseby        513  471    351        0         0      371        6      6
## -Lance Parrish       577  700    334        0         0      483       48      6
## -Larry Parrish       740  840    452        0         1        0        0      0
## -Larry Sheets         88  112     50        0         0        0        0      0
## -Lou Whitaker        724  522    576        0         0      276      421     11
## -Mike Aldrete         27   25     33        1         1      317       36      1
## -Marty Barrett       216  163    166        0         0      303      450     14
## -Mike Davis          300  263    153        0         1      310        9      9
## -Mike Diaz            24   37     19        1         0      201        6      3
## -Mariano Duncan      121   69     68        1         1      172      317     25
## -Mike Easler         445  491    301        0         0        0        0      0
## -Mel Hall            210  203    136        0         0      233        7      7
## -Mike Heath          315  325    189        1         0      259       30     10
## -Mike Kingery         25   14     12        0         1      102        6      3
## -Mike LaValliere      20   36     45        1         0      468       47      6
## -Mike Marshall       247  288    161        1         1      149        8      6
## -Mike Pagliarulo     150  167    114        0         0      103      283     19
## -Mark Salas           80   75     36        0         1      358       32      8
## -Mike Schmidt          6    7      4        1         0       78      220      6
## -Mike Scioscia       181  199    288        1         1      756       64     15
## -Mickey Tettleton     59   55     78        0         1      463       32      8
## -Milt Thompson        71   33     44        1         0      212        1      2
## -Mitch Webster       132   83     79        1         0      325       12      8
## -Mookie Wilson       451  249    168        1         0      228        7      5
## -Marvell Wynne       198  120    113        1         1      203        3      3
## -Mike Young          181  177    157        0         0      149        1      6
## -Ozzie Guillen       129   80     24        0         1      261      459     22
## -Oddibe McDowell     168   91    101        0         1      325       13      3
## -Ozzie Smith         583  374    528        1         0      229      453     15
## -Ozzie Virgil        176  202    175        1         1      682       93     13
```

```
## -Phil Bradley        245  167   174       0        1     250      11      1
## -Phil Garner         751  714   535       1        1      58     141     23
## -Pete Incaviglia      82   88    55       0        1     157       6     14
## -Paul Molitor        676  390   364       0        0      82     170     15
## -Pete Rose          2165 1314  1566       1        1     523      43      6
## -Pat Sheridan        166  125   105       0        0     172       1      4
## -Pat Tabler          250  252   178       0        0     846      84      9
## -Rafael Belliard      41   32    26       1        0     117     269     12
## -Rick Burleson       630  435   403       0        1      62      90      3
## -Randy Bush          178  192   136       0        1     167       2      4
## -Rick Cerone         266  304   198       0        0     391      44      4
## -Ron Cey             965 1128   990       1        0      41     118      8
## -Rob Deer            102  109   102       0        0     286       8      8
## -Rick Dempsey        438  380   466       0        0     659      53      7
## -Ron Hassey          249  322   274       0        0     251       9      4
## -Rickey Henderson    862  417   708       0        0     426       4      6
## -Reggie Jackson     1509 1659  1342       0        1       0       0      0
## -Ron Kittle          238  299   157       0        1       0       0      0
## -Ray Knight          410  497   284       1        0      88     204     16
## -Rick Leach          102   96    80       0        0      44       0      1
## -Rick Manning        643  445   459       0        0     155       3      2
## -Rance Mulliniks     295  273   269       0        0      60     176      6
## -Ron Oester          377  284   296       1        1     367     475     19
## -Rey Quinones         32   22    24       0        0      86     150     15
## -Rafael Ramirez      365  280   165       1        1     155     371     29
## -Ronn Reynolds        16   13    14       1        0     190       2      9
## -Ron Roenicke        128  104   172       1        0     181       3      2
## -Ryne Sandberg       494  345   242       1        0     309     492      5
## -Rafael Santana       94   71    76       1        0     203     369     16
## -Rick Schu            98   54    62       1        0      42      94     13
## -Ruben Sierra         50   55    22       0        1     200       7      6
## -Roy Smalley         713  660   735       0        1       0       0      0
## -Robby Thompson       73   47    42       1        1     255     450     17
## -Rob Wilfong         315  259   204       0        1     135     257      7
## -Robin Yount        1043  827   535       0        0     352       9      1
## -Steve Balboni       204  276   155       0        1    1236      98     18
## -Scott Bradley        27   31    15       0        1     281      21      3
## -Sid Bream            93  106    86       1        0    1320     166     17
## -Steve Buechele       76   75    49       0        1     111     226     11
## -Shawon Dunston      106   86    40       1        0     320     465     32
## -Scott Fletcher      218  149   163       0        1     196     354     15
## -Steve Garvey       1138 1299   478       1        1    1160      53      7
## -Steve Jeltz          68   56    99       1        0     229     406     22
## -Steve Lombardozzi    63   39    58       0        1     289     407      6
## -Spike Owen          211  146   155       0        1     209     372     17
## -Steve Sax           420  230   274       1        1     367     432     16
## -Tony Bernazard      450  342   373       0        0     351     442     17
## -Tom Brookens        324  300   179       0        0     106     144      7
```

```
## -Tom Brunansky       369  384    321       0        1     315      10      6
## -Tony Fernandez      196  137     89       0        0     294     445     13
## -Tim Flannery        207  162    198       1        1     209     246      3
## -Tom Foley            83   82     86       1        0      81     147      4
## -Tony Gwynn          352  230    193       1        1     337      19      4
## -Terry Harper        135  163    128       1        1      92       5      3
## -Tommy Herr          421  349    359       1        0     352     414      9
## -Tim Hulett          106   80     52       0        1      70     144     11
## -Terry Kennedy         2    3      1       1        1     692      70      8
## -Tito Landrum        105   99     71       1        0     131       6      1
## -Tim Laudner         129  139    106       0        1     299      13      5
## -Tom Paciorek        488  491    244       0        1     178      45      4
## -Tony Pena           307  340    174       1        0     810      99     18
## -Terry Pendleton     149  161     87       1        0     133     371     20
## -Tony Phillips       226  149    191       0        1     160     290     11
## -Terry Puhl          579  363    406       1        1      65       0      0
## -Ted Simmons        1048 1348    819       1        1     167      18      6
## -Tim Teufel          180  148    158       1        0     133     173      9
## -Tim Wallach         338  406    239       1        0      94     270     16
## -Vince Coleman       201   69    110       1        0     300      12      9
## -Von Hayes           399  366    286       1        0    1182      96     13
## -Vance Law           279  257    246       1        0     170     284      3
## -Wally Backman       272  125    194       1        0     186     290     17
## -Wade Boggs          474  322    417       0        0     121     267     19
## -Will Clark           66   41     34       1        1     942      72     11
## -Wally Joyner         82  100     57       0        1    1222     139     15
## -Willie McGee        379  311    138       1        0     325       9      3
## -Willie Randolph     897  451    875       0        0     313     381     20
## -Wayne Tolleson      217   93    146       0        1      37     113      7
## -Willie Upshaw       470  420    332       0        0    1314     131     12
## -Willie Wilson       775  357    249       0        1     408       4      3
##                   NewLeagueN
## -Alan Ashby                1
## -Alvin Davis               0
## -Andre Dawson              1
## -Andres Galarraga          1
## -Alfredo Griffin           0
## -Al Newman                 0
## -Argenis Salazar           0
## -Andres Thomas             1
## -Andre Thornton            0
## -Alan Trammell             0
## -Alex Trevino              1
## -Andy VanSlyke             1
## -Alan Wiggins              0
## -Bill Almon                1
## -Buddy Bell                1
## -Buddy Biancalana          0
```

```
## -Bruce Bochy              1
## -Barry Bonds              1
## -Bobby Bonilla            1
## -Bob Brenly               1
## -Bill Buckner             0
## -Brett Butler             0
## -Bob Dernier              1
## -Bo Diaz                  1
## -Bill Doran               1
## -Brian Downing            0
## -Billy Hatcher            1
## -Brook Jacoby             0
## -Bob Kearney              0
## -Bill Madlock             1
## -Bob Melvin               1
## -BillyJo Robidoux         0
## -Bill Schroeder           0
## -Chris Bando              0
## -Chris Brown              1
## -Carmen Castillo          0
## -Chili Davis              1
## -Carlton Fisk             0
## -Curt Ford                1
## -Carney Lansford          0
## -Chet Lemon               0
## -Candy Maldonado          1
## -Carmelo Martinez         1
## -Craig Reynolds           1
## -Cal Ripken               0
## -Cory Snyder              0
## -Chris Speier             1
## -Curt Wilkerson           0
## -Dave Anderson            1
## -Don Baylor               0
## -Daryl Boston             0
## -Darnell Coles            0
## -Dave Concepcion          1
## -Doug DeCinces            0
## -Darrell Evans            0
## -Dwight Evans             0
## -Damaso Garcia            1
## -Dan Gladden              0
## -Dave Henderson           0
## -Donnie Hill              0
## -Davey Lopes              1
## -Don Mattingly            0
## -Dale Murphy              1
## -Dwayne Murphy            0
```

```
## -Dave Parker               1
## -Dan Pasqua                0
## -Darrell Porter            0
## -Dick Schofield            0
## -Don Slaught               0
## -Darryl Strawberry         1
## -Dale Sveum                0
## -Danny Tartabull           0
## -Denny Walling             1
## -Dave Winfield             0
## -Eric Davis                1
## -Eddie Milner              1
## -Eddie Murray              0
## -Ed Romero                 0
## -Frank White               0
## -George Bell               0
## -Glenn Braggs              0
## -George Brett              0
## -Greg Brock                0
## -Gary Carter               1
## -Glenn Davis               1
## -Gary Gaetti               0
## -Greg Gagne                0
## -George Hendrick           0
## -Glenn Hubbard             1
## -Garth Iorg                0
## -Gary Matthews             1
## -Graig Nettles             1
## -Gary Pettis               0
## -Gary Redus                0
## -Garry Templeton           1
## -Greg Walker               0
## -Gary Ward                 0
## -Glenn Wilson              1
## -Harold Baines             0
## -Hubie Brooks              1
## -Howard Johnson            1
## -Hal McRae                 0
## -Harold Reynolds           0
## -Harry Spilman             1
## -Herm Winningham           1
## -Jesse Barfield            0
## -Juan Beniquez             0
## -John Cangelosi            1
## -Jose Canseco              0
## -Joe Carter                0
## -Jack Clark                1
## -Jose Cruz                 1
```

```
## -Jody Davis                1
## -Jim Dwyer                 0
## -Julio Franco              0
## -Jim Gantner               0
## -Johnny Grubb              0
## -Jack Howell               0
## -John Kruk                 1
## -Jeffrey Leonard           1
## -Jim Morrison              1
## -John Moses                0
## -Jerry Mumphrey            1
## -Jim Presley               0
## -Johnny Ray                1
## -Jeff Reed                 1
## -Jim Rice                  0
## -Jerry Royster             0
## -John Russell              1
## -Juan Samuel               1
## -John Shelby               0
## -Joel Skinner              0
## -Jim Sundberg              1
## -Jose Uribe                1
## -Joel Youngblood           1
## -Kevin Bass                1
## -Kal Daniels               1
## -Kirk Gibson               0
## -Ken Griffey               1
## -Keith Hernandez           1
## -Kent Hrbek                0
## -Ken Landreaux             1
## -Kevin McReynolds          1
## -Kevin Mitchell            1
## -Keith Moreland            1
## -Ken Oberkfell             1
## -Ken Phelps                0
## -Kirby Puckett             0
## -Kurt Stillwell            1
## -Leon Durham               1
## -Len Dykstra               1
## -Larry Herndon             0
## -Lee Lacy                  0
## -Len Matuszek              1
## -Lloyd Moseby              0
## -Lance Parrish             1
## -Larry Parrish             0
## -Larry Sheets              0
## -Lou Whitaker              0
## -Mike Aldrete              1
```

```
## -Marty Barrett             0
## -Mike Davis                0
## -Mike Diaz                 1
## -Mariano Duncan            1
## -Mike Easler               1
## -Mel Hall                  0
## -Mike Heath                0
## -Mike Kingery              0
## -Mike LaValliere           1
## -Mike Marshall             1
## -Mike Pagliarulo           0
## -Mark Salas                0
## -Mike Schmidt              1
## -Mike Scioscia             1
## -Mickey Tettleton          0
## -Milt Thompson             1
## -Mitch Webster             1
## -Mookie Wilson             1
## -Marvell Wynne             1
## -Mike Young                0
## -Ozzie Guillen             0
## -Oddibe McDowell           0
## -Ozzie Smith               1
## -Ozzie Virgil              1
## -Phil Bradley              0
## -Phil Garner               1
## -Pete Incaviglia           0
## -Paul Molitor              0
## -Pete Rose                 1
## -Pat Sheridan              0
## -Pat Tabler                0
## -Rafael Belliard           1
## -Rick Burleson             0
## -Randy Bush                0
## -Rick Cerone               0
## -Ron Cey                   0
## -Rob Deer                  0
## -Rick Dempsey              0
## -Ron Hassey                0
## -Rickey Henderson          0
## -Reggie Jackson            0
## -Ron Kittle                0
## -Ray Knight                0
## -Rick Leach                0
## -Rick Manning              0
## -Rance Mulliniks           0
## -Ron Oester                1
## -Rey Quinones              0
```

```
## -Rafael Ramirez            1
## -Ronn Reynolds             1
## -Ron Roenicke              1
## -Ryne Sandberg             1
## -Rafael Santana            1
## -Rick Schu                 1
## -Ruben Sierra              0
## -Roy Smalley               0
## -Robby Thompson            1
## -Rob Wilfong               0
## -Robin Yount               0
## -Steve Balboni             0
## -Scott Bradley             0
## -Sid Bream                 1
## -Steve Buechele            0
## -Shawon Dunston            1
## -Scott Fletcher            0
## -Steve Garvey              1
## -Steve Jeltz               1
## -Steve Lombardozzi         0
## -Spike Owen                0
## -Steve Sax                 1
## -Tony Bernazard            0
## -Tom Brookens              0
## -Tom Brunansky             0
## -Tony Fernandez            0
## -Tim Flannery              1
## -Tom Foley                 1
## -Tony Gwynn                1
## -Terry Harper              0
## -Tommy Herr                1
## -Tim Hulett                0
## -Terry Kennedy             0
## -Tito Landrum              1
## -Tim Laudner               0
## -Tom Paciorek              0
## -Tony Pena                 1
## -Terry Pendleton           1
## -Tony Phillips             0
## -Terry Puhl                1
## -Ted Simmons               1
## -Tim Teufel                1
## -Tim Wallach               1
## -Vince Coleman             1
## -Von Hayes                 1
## -Vance Law                 1
## -Wally Backman             1
## -Wade Boggs                0
```

```
## -Will Clark                1
## -Wally Joyner              0
## -Willie McGee              1
## -Willie Randolph           0
## -Wayne Tolleson            0
## -Willie Upshaw             0
## -Willie Wilson             0
```

```
# Let's perform the Ridge regression!

grid <- 10^seq(10, -2, length = 100)
# We need to build a grid of values for lambda to test. Remember: the value of lambda
# is extremely important to the outcome of the actual ridge regression, so we need to test a l
# of different values to find the best one.
# By default the glmnet() function performs ridge regression for an automatically selected rang
# lambda values.

ridge.mod <- glmnet(x, y, alpha = 0, lambda = grid)

# The glmnet() function has an alpha argument that determines what type
# of model is fit. If alpha=0 then a ridge regression model is fit, and if alpha=1
# then a lasso model is fit. We first fit a ridge regression model.
# It's also worth noting that glmnet() automatically standardizes the variables.
# ... do you remember what that means?

# Let's check out our outputs!

summary(ridge.mod)
```

```
##           Length Class     Mode
## a0         100   -none-    numeric
## beta      1900   dgCMatrix S4
## df         100   -none-    numeric
## dim          2   -none-    numeric
## lambda     100   -none-    numeric
## dev.ratio  100   -none-    numeric
## nulldev      1   -none-    numeric
## npasses      1   -none-    numeric
## jerr         1   -none-    numeric
## offset       1   -none-    logical
## call         5   -none-    call
## nobs         1   -none-    numeric
```

```
# woah...not what you were expecting, huh?

# Let's peek at the dimensions of the coefficients
dim(coef(ridge.mod))
```

```
## [1]  20 100
```

```
# Why do you think there is a 20 x 100 matrix of coefficient outputs?

coef(ridge.mod)
```

```
## 20 x 100 sparse Matrix of class "dgCMatrix"

##    [[ suppressing 100 column names 's0', 's1', 's2' ... ]]

##
## (Intercept)  5.359257e+02  5.359256e+02  5.359256e+02  5.359254e+02
## AtBat        5.443467e-08  7.195940e-08  9.512609e-08  1.257511e-07
## Hits         1.974589e-07  2.610289e-07  3.450649e-07  4.561554e-07
## HmRun        7.956523e-07  1.051805e-06  1.390424e-06  1.838059e-06
## Runs         3.339178e-07  4.414196e-07  5.835307e-07  7.713931e-07
## RBI          3.527222e-07  4.662778e-07  6.163918e-07  8.148335e-07
## Walks        4.151323e-07  5.487803e-07  7.254552e-07  9.590089e-07
## Years        1.697711e-06  2.244274e-06  2.966798e-06  3.921931e-06
## CAtBat       4.673743e-09  6.178412e-09  8.167496e-09  1.079695e-08
## CHits        1.720071e-08  2.273832e-08  3.005872e-08  3.973585e-08
## CHmRun       1.297171e-07  1.714783e-07  2.266842e-07  2.996631e-07
## CRuns        3.450846e-08  4.561814e-08  6.030449e-08  7.971898e-08
## CRBI         3.561348e-08  4.707892e-08  6.223556e-08  8.227173e-08
## CWalks       3.767877e-08  4.980911e-08  6.584471e-08  8.704281e-08
## LeagueN     -5.800263e-07 -7.667601e-07 -1.013611e-06 -1.339933e-06
## DivisionW   -7.807263e-06 -1.032074e-05 -1.364341e-05 -1.803579e-05
## PutOuts      2.180288e-08  2.882212e-08  3.810115e-08  5.036747e-08
## Assists      3.561198e-09  4.707694e-09  6.223294e-09  8.226828e-09
## Errors      -1.660460e-08 -2.195031e-08 -2.901702e-08 -3.835881e-08
## NewLeagueN  -1.152288e-07 -1.523253e-07 -2.013646e-07 -2.661912e-07
##
## (Intercept)  5.359253e+02  5.359251e+02  5.359249e+02  5.359246e+02
## AtBat        1.662355e-07  2.197535e-07  2.905011e-07  3.840251e-07
## Hits         6.030105e-07  7.971441e-07  1.053777e-06  1.393031e-06
## HmRun        2.429805e-06  3.212059e-06  4.246151e-06  5.613159e-06
## Runs         1.019736e-06  1.348031e-06  1.782017e-06  2.355720e-06
## RBI          1.077162e-06  1.423944e-06  1.882370e-06  2.488380e-06
## Walks        1.267753e-06  1.675895e-06  2.215433e-06  2.928671e-06
## Years        5.184561e-06  6.853682e-06  9.060161e-06  1.197699e-05
## CAtBat       1.427293e-08  1.886796e-08  2.494233e-08  3.297227e-08
## CHits        5.252844e-08  6.943949e-08  9.179488e-08  1.213474e-07
## CHmRun       3.961369e-07  5.236695e-07  6.922600e-07  9.151265e-07
## CRuns        1.053838e-07  1.393111e-07  1.841610e-07  2.434499e-07
## CRBI         1.087584e-07  1.437721e-07  1.900582e-07  2.512456e-07
## CWalks       1.150654e-07  1.521097e-07  2.010800e-07  2.658157e-07
## LeagueN     -1.771310e-06 -2.341563e-06 -3.095401e-06 -4.091926e-06
```

```
## DivisionW   -2.384225e-05 -3.151805e-05 -4.166500e-05 -5.507866e-05
## PutOuts      6.658282e-08  8.801855e-08  1.163553e-07  1.538148e-07
## Assists      1.087538e-08  1.437661e-08  1.900503e-08  2.512352e-08
## Errors      -5.070811e-08 -6.703317e-08 -8.861396e-08 -1.171425e-07
## NewLeagueN  -3.518874e-07 -4.651715e-07 -6.149243e-07 -8.128848e-07
##
## (Intercept)  5.359241e+02  5.359236e+02  5.359228e+02  5.359218e+02
## AtBat        5.076583e-07  6.710939e-07  8.871458e-07  1.172753e-06
## Hits         1.841504e-06  2.434358e-06  3.218075e-06  4.254101e-06
## HmRun        7.420260e-06  9.809139e-06  1.296709e-05  1.714170e-05
## Runs         3.114121e-06  4.116682e-06  5.442006e-06  7.194001e-06
## RBI          3.289490e-06  4.348509e-06  5.748467e-06  7.599123e-06
## Walks        3.871529e-06  5.117929e-06  6.765594e-06  8.943705e-06
## Years        1.583287e-05  2.093010e-05  2.766833e-05  3.657585e-05
## CAtBat       4.358737e-08  5.761989e-08  7.617002e-08  1.006921e-07
## CHits        1.604140e-07  2.120577e-07  2.803274e-07  3.705758e-07
## CHmRun       1.209743e-06  1.599207e-06  2.114055e-06  2.794652e-06
## CRuns        3.218262e-07  4.254349e-07  5.623992e-07  7.434574e-07
## CRBI         3.321316e-07  4.390581e-07  5.804082e-07  7.672642e-07
## CWalks       3.513925e-07  4.645197e-07  6.140668e-07  8.117587e-07
## LeagueN     -5.409262e-06 -7.150687e-06 -9.452719e-06 -1.249582e-05
## DivisionW   -7.281073e-05 -9.625147e-05 -1.272387e-04 -1.682020e-04
## PutOuts      2.033341e-07  2.687955e-07  3.553316e-07  4.697270e-07
## Assists      3.321180e-08  4.390401e-08  5.803847e-08  7.672336e-08
## Errors      -1.548557e-07 -2.047105e-07 -2.706157e-07 -3.577390e-07
## NewLeagueN  -1.074570e-06 -1.420491e-06 -1.877758e-06 -2.482203e-06
##
## (Intercept)  5.359205e+02  5.359188e+02  5.359165e+02  5.359135e+02
## AtBat        1.550308e-06  2.049411e-06  2.709192e-06  3.581378e-06
## Hits         5.623662e-06  7.434134e-06  9.827459e-06  1.299127e-05
## HmRun        2.266028e-05  2.995547e-05  3.959923e-05  5.234760e-05
## Runs         9.510029e-06  1.257167e-05  1.661895e-05  2.196918e-05
## RBI          1.004557e-05  1.327962e-05  1.755482e-05  2.320633e-05
## Walks        1.182303e-05  1.562931e-05  2.066097e-05  2.731247e-05
## Years        4.835102e-05  6.391703e-05  8.449425e-05  1.116959e-04
## CAtBat       1.331088e-07  1.759615e-07  2.326100e-07  3.074953e-07
## CHits        4.898784e-07  6.475887e-07  8.560711e-07  1.131670e-06
## CHmRun       3.694358e-06  4.883710e-06  6.455953e-06  8.534349e-06
## CRuns        9.828049e-07  1.299207e-06  1.717468e-06  2.270381e-06
## CRBI         1.014276e-06  1.340809e-06  1.772464e-06  2.343081e-06
## CWalks       1.073095e-06  1.418563e-06  1.875249e-06  2.478955e-06
## LeagueN     -1.651853e-05 -2.183616e-05 -2.886548e-05 -3.815735e-05
## DivisionW   -2.223530e-04 -2.939372e-04 -3.885671e-04 -5.136619e-04
## PutOuts      6.209506e-07  8.208588e-07  1.085125e-06  1.434467e-06
## Assists      1.014236e-07  1.340758e-07  1.772398e-07  2.342998e-07
## Errors      -4.729116e-07 -6.251642e-07 -8.264353e-07 -1.092508e-06
## NewLeagueN  -3.281181e-06 -4.337273e-06 -5.733176e-06 -7.578145e-06
##
```

```
## (Intercept)  5.359095e+02  5.359042e+02  5.358972e+02  5.358880e+02
## AtBat         4.734346e-06  6.258482e-06  8.273267e-06  1.093664e-05
## Hits          1.717361e-05  2.270236e-05  3.001092e-05  3.967221e-05
## HmRun         6.920001e-05  9.147759e-05  1.209267e-04  1.598556e-04
## Runs          2.904181e-05  3.839128e-05  5.075051e-05  6.708833e-05
## RBI           3.067722e-05  4.055316e-05  5.360832e-05  7.086606e-05
## Walks         3.610528e-05  4.772871e-05  6.309393e-05  8.340541e-05
## Years         1.476545e-04  1.951889e-04  2.580254e-04  3.410894e-04
## CAtBat        4.064882e-07  5.373491e-07  7.103364e-07  9.390097e-07
## CHits         1.495993e-06  1.977598e-06  2.614240e-06  3.455823e-06
## CHmRun        1.128183e-05  1.491379e-05  1.971494e-05  2.606160e-05
## CRuns         3.001290e-06  3.967495e-06  5.244735e-06  6.933126e-06
## CRBI          3.097394e-06  4.094536e-06  5.412672e-06  7.155123e-06
## CWalks        3.277009e-06  4.331970e-06  5.726535e-06  7.570013e-06
## LeagueN      -5.043982e-05 -6.667507e-05 -8.813458e-05 -1.164983e-04
## DivisionW    -6.790292e-04 -8.976337e-04 -1.186614e-03 -1.568625e-03
## PutOuts       1.896273e-06  2.506748e-06  3.313751e-06  4.380543e-06
## Assists       3.097292e-07  4.094413e-07  5.412531e-07  7.154972e-07
## Errors       -1.444246e-06 -1.909236e-06 -2.523944e-06 -3.336588e-06
## NewLeagueN   -1.001651e-05 -1.323886e-05 -1.749685e-05 -2.312257e-05
##
## (Intercept)  5.358758e+02  5.358597e+02  5.358383e+02  5.358102e+02
## AtBat         1.445735e-05  1.911136e-05  2.526337e-05  3.339542e-05
## Hits          5.244352e-05  6.932585e-05  9.164225e-05  1.211414e-04
## HmRun         2.113157e-04  2.793399e-04  3.692586e-04  4.881167e-04
## Runs          8.868531e-05  1.172341e-04  1.549720e-04  2.048558e-04
## RBI           9.367905e-05  1.238352e-04  1.636976e-04  2.163893e-04
## Walks         1.102552e-04  1.457476e-04  1.926641e-04  2.546808e-04
## Years         4.508915e-04  5.960369e-04  7.878993e-04  1.041510e-03
## CAtBat        1.241292e-06  1.640875e-06  2.169070e-06  2.867259e-06
## CHits         4.568310e-06  6.038888e-06  7.982794e-06  1.055233e-05
## CHmRun        3.445123e-05  4.554132e-05  6.020089e-05  7.957843e-05
## CRuns         9.165002e-06  1.211527e-05  1.601512e-05  2.117008e-05
## CRBI          9.458457e-06  1.250318e-05  1.652788e-05  2.184784e-05
## CWalks        1.000688e-05  1.322812e-05  1.748610e-05  2.311438e-05
## LeagueN      -1.539858e-04 -2.035284e-04 -2.689971e-04 -3.555015e-04
## DivisionW    -2.073614e-03 -2.741169e-03 -3.623616e-03 -4.790124e-03
## PutOuts       5.790751e-06  7.654909e-06  1.011913e-05  1.337652e-05
## Assists       9.458322e-07  1.250312e-06  1.652799e-06  2.184833e-06
## Errors       -4.410917e-06 -5.831225e-06 -7.708976e-06 -1.019158e-05
## NewLeagueN   -3.055403e-05 -4.036852e-05 -5.332619e-05 -7.042660e-05
##
## (Intercept)  5.357729e+02  5.357237e+02  5.356586e+02  5.355726e+02
## AtBat         4.414457e-05  5.835267e-05  7.713205e-05  1.019523e-04
## Hits          1.601343e-04  2.116751e-04  2.797992e-04  3.698382e-04
## HmRun         6.452240e-04  8.528825e-04  1.127346e-03  1.490084e-03
## Runs          2.707932e-04  3.579481e-04  4.731433e-04  6.253924e-04
## RBI           2.860379e-04  3.780973e-04  4.997733e-04  6.605853e-04
```

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## Walks         3.366558e-04  4.450089e-04  5.882229e-04  7.775040e-04
## Years         1.376735e-03  1.819821e-03  2.405450e-03  3.179433e-03
## CAtBat        3.790132e-06  5.009955e-06  6.622207e-06  8.753018e-06
## CHits         1.394876e-05  1.843805e-05  2.437160e-05  3.221357e-05
## CHmRun        1.051917e-04  1.390463e-04  1.837918e-04  2.429284e-04
## CRuns         2.798389e-05  3.699008e-05  4.889352e-05  6.462528e-05
## CRBI          2.887975e-05  3.817415e-05  5.045844e-05  6.669341e-05
## CWalks        3.055374e-05  4.038655e-05  5.338219e-05  7.055683e-05
## LeagueN      -4.697827e-04 -6.207293e-04 -8.200508e-04 -1.083156e-03
## DivisionW    -6.332117e-03 -8.370433e-03 -1.106478e-02 -1.462621e-02
## PutOuts       1.768232e-05  2.337385e-05  3.089686e-05  4.084036e-05
## Assists       2.888099e-06  3.817685e-06  5.046383e-06  6.670373e-06
## Errors       -1.347401e-05 -1.781420e-05 -2.355343e-05 -3.114342e-05
## NewLeagueN   -9.298190e-05 -1.227106e-04 -1.618562e-04 -2.133355e-04
##
## (Intercept)  5.354590e+02  5.353088e+02  5.351104e+02  5.348483e+02
## AtBat         1.347543e-04  1.781013e-04  2.353767e-04  3.110444e-04
## Hits          4.888348e-04  6.460892e-04  8.538795e-04  1.128408e-03
## HmRun         1.969454e-03  2.602891e-03  3.439801e-03  4.545349e-03
## Runs          8.266006e-04  1.092488e-03  1.443804e-03  1.907924e-03
## RBI           8.731052e-04  1.153932e-03  1.524974e-03  2.015129e-03
## Walks         1.027654e-03  1.358217e-03  1.794992e-03  2.372016e-03
## Years         4.202270e-03  5.553840e-03  7.339554e-03  9.698448e-03
## CAtBat        1.156897e-05  1.528998e-05  2.020632e-05  2.670086e-05
## CHits         4.257704e-05  5.627140e-05  7.436488e-05  9.826652e-05
## CHmRun        3.210785e-04  4.243445e-04  5.607797e-04  7.410056e-04
## CRuns         8.541496e-05  1.128858e-04  1.491801e-04  1.971228e-04
## CRBI          8.814785e-05  1.164967e-04  1.539502e-04  2.034230e-04
## CWalks        9.325228e-05  1.232396e-04  1.628554e-04  2.151803e-04
## LeagueN      -1.430291e-03 -1.888006e-03 -2.491020e-03 -3.284581e-03
## DivisionW    -1.933364e-02 -2.555557e-02 -3.377884e-02 -4.464643e-02
## PutOuts       5.398248e-05  7.135106e-05  9.430339e-05  1.246312e-04
## Assists       8.816708e-06  1.165319e-05  1.540137e-05  2.035366e-05
## Errors       -4.118231e-05 -5.446250e-05 -7.203451e-05 -9.529233e-05
## NewLeagueN   -2.809184e-04 -3.694389e-04 -4.850258e-04 -6.353256e-04
##
## (Intercept)  5.345021e+02  5.340450e+02  5.334417e+02  5.326458e+02
## AtBat         4.109909e-04  5.429714e-04  7.171926e-04  9.470681e-04
## Hits          1.491040e-03  1.969937e-03  2.602166e-03  3.436467e-03
## HmRun         6.005426e-03  7.933134e-03  1.047721e-02  1.383295e-02
## Runs          2.520942e-03  3.330403e-03  4.398874e-03  5.808559e-03
## RBI           2.662489e-03  3.517224e-03  4.645322e-03  6.133445e-03
## Walks         3.134169e-03  4.140575e-03  5.469037e-03  7.221793e-03
## Years         1.281378e-02  1.692684e-02  2.235495e-02  2.951473e-02
## CAtBat        3.527827e-05  4.660317e-05  6.154969e-05  8.126573e-05
## CHits         1.298336e-04  1.715121e-04  2.265190e-04  2.990787e-04
## CHmRun        9.790208e-04  1.293257e-03  1.707949e-03  2.254914e-03
## CRuns         2.604372e-04  3.440252e-04  4.543318e-04  5.998166e-04
```

```
## CRBI          2.687559e-04  3.550048e-04  4.688164e-04  6.189122e-04
## CWalks        2.842724e-04  3.754715e-04  4.957933e-04  6.544367e-04
## LeagueN      -4.327356e-03 -5.694916e-03 -7.483703e-03 -9.815198e-03
## DivisionW    -5.900738e-02 -7.798233e-02 -1.030497e-01 -1.361588e-01
## PutOuts       1.646987e-04  2.176234e-04  2.875133e-04  3.797757e-04
## Assists       2.689578e-05  3.553620e-05  4.694455e-05  6.200169e-05
## Errors       -1.260879e-04 -1.668854e-04 -2.209705e-04 -2.927359e-04
## NewLeagueN   -8.296525e-04 -1.078937e-03 -1.395226e-03 -1.790270e-03
##
## (Intercept)  5.315966e+02  5.302145e+02  5.283962e+02  5.260283e+02
## AtBat         1.250193e-03  1.649587e-03  2.175269e-03  2.856183e-03
## Hits          4.536802e-03  5.986922e-03  7.896145e-03  1.038009e-02
## HmRun         1.825616e-02  2.408100e-02  3.174215e-02  4.166863e-02
## Runs          7.667251e-03  1.011593e-02  1.333834e-02  1.753936e-02
## RBI           8.095158e-03  1.067886e-02  1.407774e-02  1.850770e-02
## Walks         9.532922e-03  1.257781e-02  1.658511e-02  2.181794e-02
## Years         3.895188e-02  5.137912e-02  6.772357e-02  8.883504e-02
## CAtBat        1.072554e-04  1.414837e-04  1.865084e-04  2.449690e-04
## CHits         3.947263e-04  5.206935e-04  6.863929e-04  9.021725e-04
## CHmRun        2.975818e-03  3.925071e-03  5.173432e-03  6.802012e-03
## CRuns         7.915570e-04  1.044015e-03  1.375992e-03  1.809966e-03
## CRBI          8.167098e-04  1.077108e-03  1.419466e-03  1.867968e-03
## CWalks        8.634316e-04  1.138455e-03  1.499841e-03  1.973795e-03
## LeagueN      -1.283957e-02 -1.673732e-02 -2.171599e-02 -2.801802e-02
## DivisionW    -1.798773e-01 -2.375840e-01 -3.137182e-01 -4.140945e-01
## PutOuts       5.015182e-04  6.620666e-04  8.736282e-04  1.152153e-03
## Assists       8.186440e-05  1.080486e-04  1.425350e-04  1.879291e-04
## Errors       -3.880746e-04 -5.149282e-04 -6.840601e-04 -9.099844e-04
## NewLeagueN   -2.272378e-03 -2.840043e-03 -3.469786e-03 -4.098152e-03
##
## (Intercept)  5.229117e+02  5.188425e+02  5.135499e+02  5.067007e+02
## AtBat         3.755370e-03  4.929271e-03  6.455825e-03  8.430885e-03
## Hits          1.365619e-02  1.793929e-02  2.351966e-02  3.075783e-02
## HmRun         5.475351e-02  7.181148e-02  9.395171e-02  1.225246e-01
## Runs          2.306905e-02  3.029402e-02  3.969965e-02  5.188629e-02
## RBI           2.433453e-02  3.194175e-02  4.183469e-02  5.463507e-02
## Walks         2.870196e-02  3.770049e-02  4.942200e-02  6.462139e-02
## Years         1.167003e-01  1.530045e-01  2.000875e-01  2.607876e-01
## CAtBat        3.219824e-04  4.224467e-04  5.529605e-04  7.216005e-04
## CHits         1.186058e-03  1.556582e-03  2.038266e-03  2.661237e-03
## CHmRun        8.941711e-03  1.173391e-02  1.536291e-02  2.005485e-02
## CRuns         2.379509e-03  3.122870e-03  4.089247e-03  5.339086e-03
## CRBI          2.455780e-03  3.223000e-03  4.220419e-03  5.510445e-03
## CWalks        2.593852e-03  3.402373e-03  4.452130e-03  5.807510e-03
## LeagueN      -3.582186e-02 -4.526080e-02 -5.624560e-02 -6.824750e-02
## DivisionW    -5.463386e-01 -7.203748e-01 -9.490942e-01 -1.249143e+00
## PutOuts       1.518320e-03  1.998905e-03  2.628266e-03  3.450114e-03
## Assists       2.475408e-04  3.256905e-04  4.278733e-04  5.610195e-04
```

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## Errors      -1.213083e-03 -1.621325e-03 -2.174183e-03 -2.928000e-03
## NewLeagueN  -4.569680e-03 -4.583337e-03 -3.566264e-03 -4.803376e-04
##
## (Intercept)  4.978943e+02  4.866654e+02 472.498378438 454.861260147
## AtBat        1.096941e-02  1.420455e-02   0.018282926   0.023354159
## Hits         4.009239e-02  5.204227e-02   0.067198374   0.086198517
## HmRun        1.591261e-01  2.055639e-01   0.263758081   0.335543956
## Runs         6.757994e-02  8.763193e-02   0.112998450   0.144688328
## RBI          7.108903e-02  9.206175e-02   0.118508172   0.151407046
## Walks        8.421579e-02  1.092880e-01   0.141067207   0.180873783
## Years        3.384406e-01  4.367954e-01   0.559787485   0.711104743
## CAtBat       9.379908e-04  1.213177e-03   0.001559167   0.001987971
## CHits        3.461590e-03  4.481097e-03   0.005765777   0.007362758
## CHmRun       2.608015e-02  3.375084e-02   0.043409092   0.055402473
## CRuns        6.944803e-03  8.990204e-03   0.011567613   0.014771580
## CRBI         7.167866e-03  9.279254e-03   0.011940038   0.015248039
## CWalks       7.544879e-03  9.751250e-03   0.012520080   0.015942789
## LeagueN     -7.990807e-02 -8.840291e-02  -0.088455415  -0.070900107
## DivisionW   -1.641870e+00 -2.154416e+00  -2.820910377  -3.683711643
## PutOuts      4.519410e-03  5.904237e-03   0.007687359   0.009967040
## Assists      7.337315e-04  9.564578e-04   0.001241514   0.001602813
## Errors      -3.964426e-03 -5.403699e-03  -0.007425602  -0.010302495
## NewLeagueN   6.493568e-03  2.044812e-02   0.046482957   0.092729187
##
## (Intercept) 433.268258847 407.356050200 377.006569878 342.451468563
## AtBat         0.029547561   0.036957182   0.045589732   0.055334078
## Hits          0.109670011   0.138180344   0.172108858   0.211562795
## HmRun         0.422312721   0.524629976   0.641536830   0.770008226
## Runs          0.183661626   0.230701523   0.286205186   0.349995677
## RBI           0.191641949   0.239841459   0.296149046   0.360005443
## Walks         0.230012478   0.289618741   0.360442195   0.442631974
## Years         0.893457806   1.107702929   1.351567446   1.618621004
## CAtBat        0.002510003   0.003131815   0.003853349   0.004665333
## CHits         0.009315050   0.011653637   0.014388616   0.017500399
## CHmRun        0.070043092   0.087545670   0.107958732   0.131095646
## CRuns         0.018688316   0.023379882   0.028866249   0.035107564
## CRBI          0.019292543   0.024138320   0.029806970   0.036259050
## CWalks        0.020094771   0.025015421   0.030684082   0.036996310
## LeagueN      -0.020774094   0.085028114   0.279935865   0.609056931
## DivisionW    -4.794557569  -6.215440973  -8.019029703 -10.288260695
## PutOuts       0.012856678   0.016482577   0.020980083   0.026487849
## Assists       0.002055224   0.002612988   0.003287919   0.004086750
## Errors       -0.014448993  -0.020502690  -0.029430225  -0.042676252
## NewLeagueN    0.171640916   0.301433531   0.507144682   0.820616108
##
## (Intercept) 304.362859755 263.846654562 222.378308850 181.620664049
## AtBat         0.065923408   0.076920260   0.087729087   0.097638894
## Hits          0.256282366   0.305662723   0.358810274   0.414754289
```

```
## HmRun          0.904400960   1.036563350   1.156053269   1.251219457
## Runs           0.421140434   0.497957970   0.578075376   0.658733133
## RBI            0.429956940   0.503674263   0.578045670   0.649543482
## Walks          0.535550765   0.637775987   0.747176013   0.861217216
## Years          1.897347931   2.171953758   2.422771139   2.628463155
## CAtBat         0.005547517   0.006469871   0.007394731   0.008281797
## CHits          0.020935119   0.024607480   0.028411896   0.032240307
## CHmRun         0.156501331   0.183465343   0.211118747   0.238574367
## CRuns          0.041995605   0.049356315   0.056975328   0.064634579
## CRBI           0.043385257   0.051010253   0.058919707   0.066901470
## CWalks         0.043748453   0.050636327   0.057275955   0.063239487
## LeagueN        1.128214010   1.899723621   2.983666664   4.426228883
## DivisionW   -13.114735551 -16.595066317 -20.824312663 -25.884977165
## PutOuts        0.033141498   0.041066380   0.050370740   0.061135827
## Assists        0.005009084   0.006047853   0.007193656   0.008446062
## Errors        -0.062329257  -0.091286854  -0.133333823  -0.193078245
## NewLeagueN     1.278131419   1.914781859   2.754632704   3.798020915
##
## (Intercept) 143.22090840 108.600710701  78.77602181  54.32519950  35.46327353
## AtBat          0.10588318   0.111518137   0.11395508   0.11211115   0.10525447
## Hits           0.47267953   0.531865951   0.59291566   0.65622409   0.72363621
## HmRun          1.31032995   1.322352070   1.28051133   1.17980910   1.02015692
## Runs           0.73710234   0.810793514   0.87789776   0.93769713   0.98970202
## RBI            0.71462053   0.770509613   0.81479615   0.84718546   0.86759746
## Walks          0.97728746   1.093441793   1.20767181   1.31987948   1.42983156
## Years          2.76720712   2.819771505   2.76690445   2.59640425   2.29065223
## CAtBat         0.00909199   0.009804177   0.01038110   0.01083413   0.01114257
## CHits          0.03600111   0.039679409   0.04321928   0.04674557   0.05031617
## CHmRun         0.26510274   0.290492253   0.31447125   0.33777318   0.36098753
## CRuns          0.07216192   0.079473240   0.08657406   0.09355528   0.10064120
## CRBI           0.07480059   0.082525948   0.09017050   0.09780402   0.10572793
## CWalks         0.06810015   0.071404369   0.07283526   0.07189612   0.06823214
## LeagueN        6.24738811   8.430972127  10.93317978  13.68370191  16.61465820
## DivisionW   -31.83095172 -38.667124195 -46.32700244 -54.65877750 -63.42474502
## PutOuts        0.07340191   0.087151439   0.10226556   0.11852289   0.13556792
## Assists        0.00983132   0.011450440   0.01343260   0.01606037   0.01962612
## Errors        -0.27563868  -0.385605214  -0.52765966  -0.70358655  -0.91405980
## NewLeagueN     5.00844788   6.303489418   7.55776896   8.61181213   9.29582644
##
## (Intercept)  22.07163454  13.69965470  10.08979010  10.368086610  1.426003e+01
## AtBat          0.09238344   0.07214526   0.04333856   0.003859899 -4.801371e-02
## Hits           0.79744297   0.88059238   0.97661396   1.090128700  1.225743e+00
## HmRun          0.80505438   0.54367980   0.24336135  -0.074578917 -3.984466e-01
## Runs           1.03411394   1.07217873   1.10318741   1.129710071  1.150128e+00
## RBI            0.87728221   0.87912033   0.87391232   0.866429174  8.566772e-01
## Walks          1.53862798   1.64903804   1.76354869   1.887887126  2.026831e+00
## Years          1.83395501   1.22528239   0.42870209  -0.509625577 -1.612638e+00
## CAtBat         0.01129748   0.01132160   0.01113273   0.010812515  1.025023e-02
```

```
## CHits         0.05406625   0.05819360   0.06284902   0.068237280  7.456047e-02
## CHmRun        0.38509943   0.41084586   0.43960243   0.470146993  5.032874e-01
## CRuns         0.10815217   0.11626187   0.12587087   0.136628201  1.496673e-01
## CRBI          0.11427651   0.12363705   0.13443111   0.146475511  1.602009e-01
## CWalks        0.06137171   0.05071118   0.03567477   0.015680017 -9.949162e-03
## LeagueN      19.67455371  22.84517646  26.12460529  29.543809988  3.309897e+01
## DivisionW   -72.32155123 -81.01744688 -89.20563810 -96.632937860 -1.031412e+02
## PutOuts       0.15293830   0.17009772   0.18653652   0.201768977  2.154919e-01
## Assists       0.02448004   0.03096459   0.03934585   0.049763941  6.229233e-02
## Errors       -1.15688766  -1.42769526  -1.71914339  -2.024038348 -2.331384e+00
## NewLeagueN    9.45368575   8.96604057   7.76059860   5.827331162  3.208871e+00
##
## (Intercept)  2.124749e+01  3.069348e+01  4.208552e+01   54.97384215
## AtBat       -1.143526e-01 -1.969965e-01 -2.970743e-01   -0.41480601
## Hits         1.388857e+00  1.585886e+00  1.823059e+00    2.10530493
## HmRun       -7.097177e-01 -9.847328e-01 -1.202878e+00   -1.34828331
## Runs         1.163539e+00  1.168232e+00  1.159967e+00    1.13281252
## RBI          8.455760e-01  8.329787e-01  8.163507e-01    0.79219405
## Walks        2.186674e+00  2.372658e+00  2.588231e+00    2.83508432
## Years       -2.856051e+00 -4.179625e+00 -5.529761e+00   -6.85814163
## CAtBat       9.398768e-03  8.218857e-03  6.595689e-03    0.00438123
## CHits        8.205608e-02  9.077258e-02  1.006909e-01    0.11187771
## CHmRun       5.385468e-01  5.737733e-01  6.075669e-01    0.64020753
## CRuns        1.655780e-01  1.845664e-01  2.073068e-01    0.23468562
## CRBI         1.754472e-01  1.919658e-01  2.094897e-01    0.22724180
## CWalks      -4.182522e-02 -7.997127e-02 -1.241631e-01   -0.17405551
## LeagueN      3.676542e+01  4.047940e+01  4.413201e+01   47.59278798
## DivisionW   -1.086578e+02 -1.131837e+02 -1.167759e+02 -119.52546741
## PutOuts      2.275307e-01  2.378412e-01  2.465061e-01    0.25369445
## Assists      7.689081e-02  9.336288e-02  1.114676e-01    0.13095051
## Errors      -2.630586e+00 -2.911822e+00 -3.165503e+00   -3.38369142
## NewLeagueN   6.796074e-03 -3.622802e+00 -7.484213e+00  -11.36670636
##
## (Intercept)  6.868725e+01   82.61640119  9.634055e+01  109.2829120
## AtBat       -5.489118e-01   -0.69643604 -8.532130e-01   -1.0135354
## Hits         2.436428e+00    2.81639310  3.239094e+00    3.6940734
## HmRun       -1.402807e+00   -1.35623466 -1.213468e+00   -0.9796829
## Runs         1.080074e+00    0.99436103  8.703921e-01    0.7058863
## RBI          7.564450e-01    0.70498494  6.365634e-01    0.5510051
## Walks        3.110297e+00    3.40763211  3.720043e+00    4.0365649
## Years       -8.081607e+00   -9.13200536 -9.981034e+00  -10.5807895
## CAtBat       1.429316e-03   -0.00246579 -7.484979e-03   -0.0138037
## CHits        1.239214e-01    0.13627298  1.489150e-01    0.1611629
## CHmRun       6.696065e-01    0.69422247  7.163550e-01    0.7336816
## CRuns        2.670863e-01    0.30531691  3.502007e-01    0.4022177
## CRBI         2.449054e-01    0.26240070  2.785703e-01    0.2939173
## CWalks      -2.281680e-01   -0.28476947 -3.426212e-01   -0.3996671
## LeagueN      5.073609e+01   53.46198878  5.572351e+01   57.5193908
```

```
## DivisionW   -1.215340e+02 -122.90545105 -1.237435e+02 -124.1385803
## PutOuts      2.595876e-01    0.26438094  2.682829e-01    0.2714489
## Assists      1.513785e-01    0.17229172  1.933099e-01    0.2139257
## Errors      -3.561257e+00   -3.69538139 -3.786560e+00   -3.8379446
## NewLeagueN  -1.505814e+01  -18.37823712 -2.121581e+01  -23.5048569
##
## (Intercept)  121.03941275  131.33838708  140.02704637  147.04391493
## AtBat         -1.17121685   -1.32030389   -1.45573912   -1.57376850
## Hits           4.16555335    4.63484240    5.08339645    5.49588051
## HmRun         -0.67027625   -0.30595152    0.09220561    0.50844339
## Runs           0.50301494    0.26863955    0.01299834   -0.25290444
## RBI            0.45074152    0.34002475    0.22342867    0.10391638
## Walks          4.34665150    4.64078480    4.91107921    5.15159621
## Years        -10.91561927  -10.99172107  -10.83039120  -10.45832707
## CAtBat        -0.02154818   -0.03075212   -0.04134818   -0.05320617
## CHits          0.17263636    0.18316647    0.19264851    0.20071017
## CHmRun         0.74497092    0.74904806    0.74413317    0.72663492
## CRuns          0.46162220    0.52800749    0.60028727    0.67720829
## CRBI           0.30888439    0.32407517    0.34048110    0.35998074
## CWalks        -0.45438108   -0.50560059   -0.55244389   -0.59425701
## LeagueN       58.89440480   59.92234667   60.68538788   61.25500340
## DivisionW   -124.17545130 -123.93295657 -123.48410695 -122.89334868
## PutOuts        0.27401855    0.27610457    0.27779012    0.27912746
## Assists        0.23373456    0.25241905    0.26974580    0.28556055
## Errors        -3.85516497   -3.84557127   -3.81706080   -3.77676062
## NewLeagueN   -25.24429108  -26.48195710  -27.29307376  -27.75530367
##
## (Intercept)  152.52893912  156.6073700  159.61609669  161.6138012  162.9350244
## AtBat         -1.67284639   -1.7526436   -1.81534382   -1.8619922   -1.8962304
## Hits           5.86106113    6.1739859    6.43375910    6.6446724    6.8126375
## HmRun          0.92327754    1.3285278    1.70384607    2.0577112    2.3769197
## Runs          -0.51634440   -0.7689372   -0.99932117   -1.2091093   -1.3918382
## RBI           -0.01416825   -0.1297830   -0.23728335   -0.3401913   -0.4343568
## Walks          5.36007853    5.5357165    5.68122455    5.7981554    5.8910979
## Years         -9.93306467   -9.2923000   -8.62010707   -7.9083648   -7.2326931
## CAtBat        -0.06593201   -0.0792321   -0.09229393   -0.1052349   -0.1171587
## CHits          0.20771259    0.2132942    0.21835910    0.2218419    0.2240931
## CHmRun         0.69782050    0.6557328    0.60822654    0.5497279    0.4880357
## CRuns          0.75594735    0.8349167    0.90947226    0.9811532    1.0459801
## CRBI           0.38243059    0.4090719    0.43673572    0.4682186    0.5001625
## CWalks        -0.63089682   -0.6623253   -0.68886022   -0.7108440   -0.7287648
## LeagueN       61.69452203   62.0427219   62.33171359   62.5718652   62.7667495
## DivisionW   -122.22631375 -121.5286522 -120.85795621 -120.2162304 -119.6449720
## PutOuts        0.28016906    0.2809457    0.28151350    0.2818872    0.2821155
## Assists        0.29979472    0.3124435    0.32347690    0.3330665    0.3411651
## Errors        -3.73139449   -3.6852362   -3.64257293   -3.6035362   -3.5697725
## NewLeagueN   -27.96471550  -27.9849755  -27.90761820  -27.7384286  -27.5366134
##
```

```
## (Intercept)  163.6938252  164.1218504  164.3266996  164.4197999  164.4398691
## AtBat         -1.9201291   -1.9368385   -1.9482895   -1.9562902   -1.9617909
## Hits           6.9445433    7.0473614    7.1270344    7.1885531    7.2358004
## HmRun          2.6655164    2.9163590    3.1305427    3.3073722    3.4514572
## Runs          -1.5508817   -1.6845635   -1.7957415   -1.8857654   -1.9581687
## RBI           -0.5209687   -0.5973026   -0.6632374   -0.7181371   -0.7631803
## Walks          5.9635746    6.0198809    6.0633585    6.0969219    6.1227027
## Years         -6.5911716   -6.0267066   -5.5402066   -5.1408332   -4.8158407
## CAtBat        -0.1281349   -0.1376330   -0.1457004   -0.1522684   -0.1575691
## CHits          0.2249102    0.2246134    0.2235170    0.2220310    0.2204008
## CHmRun         0.4229826    0.3606605    0.3031789    0.2534178    0.2112503
## CRuns          1.1050245    1.1561900    1.1999368    1.2359524    1.2653447
## CRBI           0.5328591    0.5636380    0.5916780    0.6157602    0.6360441
## CWalks        -0.7432658   -0.7548744   -0.7641437   -0.7714778   -0.7772588
## LeagueN       62.9243098   63.0452251   63.1373131   63.2057962   63.2575558
## DivisionW   -119.1364270 -118.7075259 -118.3500743 -118.0629294 -117.8335298
## PutOuts        0.2822293    0.2822701    0.2822670    0.2822434    0.2822110
## Assists        0.3479857    0.3535606    0.3580724    0.3616388    0.3644399
## Errors        -3.5405968   -3.5162140   -3.4960213   -3.4797333   -3.4667021
## NewLeagueN   -27.3084624  -27.0860778  -26.8783484  -26.6986394  -26.5464725
##
## (Intercept)  164.4099707  164.3701706  164.3247947  164.2813513  164.24579777
## AtBat         -1.9654629   -1.9680069   -1.9697620   -1.9709892   -1.97188034
## Hits           7.2719325    7.2992751    7.3199359    7.3354142    7.34690332
## HmRun          3.5681841    3.6592305    3.7298870    3.7837313    3.82384224
## Runs          -2.0162146   -2.0612924   -2.0963217   -2.1230968   -2.14312621
## RBI           -0.7998993   -0.8286657   -0.8509939   -0.8679825   -0.88059559
## Walks          6.1423731    6.1573465    6.1687194    6.1772886    6.18368672
## Years         -4.5519898   -4.3482824   -4.1890140   -4.0665970   -3.97487170
## CAtBat        -0.1618281   -0.1650985   -0.1676366   -0.1695734   -0.17101797
## CHits          0.2187198    0.2171948    0.2158740    0.2147859    0.21394264
## CHmRun         0.1757281    0.1474317    0.1249304    0.1074412    0.09427054
## CRuns          1.2892569    1.3078710    1.3224611    1.3336811    1.34209282
## CRBI           0.6530380    0.6665221    0.6772129    0.6855008    0.69172894
## CWalks        -0.7817956   -0.7852905   -0.7879917   -0.7900513   -0.79159563
## LeagueN       63.2964248   63.3255869   63.3472509   63.3633925   63.37560871
## DivisionW   -117.6506258 -117.5114900 -117.4034212 -117.3208022 -117.25903013
## PutOuts        0.2821751    0.2821416    0.2821135    0.2820910    0.28207400
## Assists        0.3666284    0.3682837    0.3695495    0.3705051    0.37121516
## Errors        -3.4562924   -3.4482994   -3.4420970   -3.4373720   -3.43386922
## NewLeagueN   -26.4181820  -26.3183182  -26.2388921  -26.1774491  -26.13171275
##
## (Intercept)  164.21355478  164.18691905  164.1646430  164.14609109
## AtBat         -1.97252617   -1.97296226   -1.9732951   -1.97350969
## Hits           7.35592221    7.36231243    7.3675688    7.37129548
## HmRun          3.85617498    3.87915104    3.8985402    3.91244619
## Runs          -2.15909296   -2.17053393   -2.1800496   -2.18687966
## RBI           -0.89079180   -0.89800448   -0.9041437   -0.90854849
```

```
## Walks          6.18861189    6.19212067    6.1949605    6.19694978
## Years         -3.90063638   -3.84722737   -3.8025868   -3.77022451
## CAtBat        -0.17218527   -0.17301959   -0.1737195   -0.17422443
## CHits          0.21323289    0.21271057    0.2122596    0.21192408
## CHmRun         0.08355577    0.07582075    0.0693103    0.06456861
## CRuns          1.34891010    1.35379920    1.3579095    1.36088218
## CRBI           0.69679541    0.70044102    0.7035171    0.70575245
## CWalks        -0.79281715   -0.79369129   -0.7944134   -0.79492845
## LeagueN       63.38437947   63.39124155   63.3960204   63.39948921
## DivisionW   -117.20858143 -117.17256651 -117.1422225 -117.12031613
## PutOuts        0.28206056    0.28205062    0.2820423    0.28203613
## Assists        0.37178554    0.37218979    0.3725280    0.37276925
## Errors        -3.43101228   -3.42903160   -3.4273134   -3.42611017
## NewLeagueN   -26.09240802  -26.06493579  -26.0403673  -26.02245608
##
## (Intercept)  164.13195608  164.12045829  164.11321606
## AtBat         -1.97366600   -1.97379021   -1.97386151
## Hits           7.37407245    7.37635206    7.37772270
## HmRun          3.92282514    3.93147277    3.93660219
## Runs          -2.19198567   -2.19620708   -2.19873625
## RBI           -0.91183999   -0.91458802   -0.91623008
## Walks          6.19843547    6.19965258    6.20037718
## Years         -3.74605080   -3.72601133   -3.71403424
## CAtBat        -0.17460121   -0.17491365   -0.17510063
## CHits          0.21167038    0.21145637    0.21132772
## CHmRun         0.06101687    0.05806358    0.05629004
## CRuns          1.36310421    1.36494921    1.36605490
## CRBI           0.70742622    0.70881996    0.70965516
## CWalks        -0.79531368   -0.79563082   -0.79582173
## LeagueN       63.40200575   63.40387275   63.40493257
## DivisionW   -117.10400639 -117.09042529 -117.08243713
## PutOuts        0.28203146    0.28202761    0.28202541
## Assists        0.37294853    0.37309736    0.37318482
## Errors        -3.42521149   -3.42443980   -3.42400281
## NewLeagueN   -26.00905121  -25.99761906  -25.99081928
```

```
# Let's look at a random lambda
ridge.mod$lambda[50]
```

```
## [1] 11497.57
```

```
# okay, so what do the coefficients look like for a lambda of 11497.57?

coef(ridge.mod)[, 50]
```

```
##   (Intercept)         AtBat          Hits         HmRun          Runs
```

```
## 407.356050200   0.036957182   0.138180344   0.524629976   0.230701523
##           RBI         Walks         Years        CAtBat         CHits
##   0.239841459   0.289618741   1.107702929   0.003131815   0.011653637
##        CHmRun         CRuns          CRBI        CWalks       LeagueN
##   0.087545670   0.023379882   0.024138320   0.025015421   0.085028114
##     DivisionW       PutOuts       Assists        Errors    NewLeagueN
##  -6.215440973   0.016482577   0.002612988  -0.020502690   0.301433531
```

```
# What do you think you will see with a significantly smaller value of lambda?

ridge.mod$lambda[60]
```

```
## [1] 705.4802
```

```
coef(ridge.mod)[, 60]
```

```
##  (Intercept)        AtBat         Hits        HmRun         Runs          RBI
##  54.32519950   0.11211115   0.65622409   1.17980910   0.93769713   0.84718546
##        Walks        Years       CAtBat        CHits       CHmRun        CRuns
##   1.31987948   2.59640425   0.01083413   0.04674557   0.33777318   0.09355528
##         CRBI       CWalks      LeagueN    DivisionW      PutOuts      Assists
##   0.09780402   0.07189612  13.68370191 -54.65877750   0.11852289   0.01606037
##       Errors   NewLeagueN
##  -0.70358655   8.61181213
```

```
# Note the much larger l2 norm of the coefficients associated with this
# significantlly smaller value of lambda.
```

```
# Now, let's get to actually seeing how this can work for predictive purposes!

# Set your seed to make this common between all of us.
set.seed(1)

# Moving forward, you'll often need to set a "Training" and "testing" group from your data
# In order to calculate various kinds of predictive accuracy metrics. This is a great way to d
# below.

train <- sample(1:nrow(x), nrow(x) / 2)
test <- (-train)
y.test <- y[test]

# Next we fit a ridge regression model on the training set, and evaluate
# its MSE on the test set, using a lambda = 4. Note the use of the predict()
# function This time we get predictions for a test set, by replacing
# type="coefficients" with the newx argument.
```

```r
# Run ridge regression on TRAINING data
ridge.mod <- glmnet(x[train, ], y[train], alpha = 0,
                    lambda = grid, thresh = 1e-12)

# PREDICT outputs of the ridge regression using the TEST data
ridge.pred <- predict(ridge.mod, s = 4, newx = x[test, ])
ridge.pred
```

```
##                            s1
## -Alvin Davis         735.69903
## -Andre Dawson       1184.60880
## -Andres Galarraga    525.51624
## -Alfredo Griffin     379.52867
## -Al Newman           338.10775
## -Argenis Salazar      76.26170
## -Andres Thomas       174.02662
## -Andre Thornton     1094.30242
## -Alan Trammell      1004.68669
## -Alex Trevino        229.07934
## -Andy VanSlyke       577.84081
## -Buddy Bell         1377.94274
## -Buddy Biancalana     41.99658
## -Bruce Bochy         153.09866
## -Barry Bonds         547.46399
## -Bobby Bonilla       269.44666
## -Bill Buckner       1390.58153
## -Billy Hatcher       114.33101
## -Bill Madlock        944.16069
## -BillyJo Robidoux    347.38515
## -Chris Brown         326.62497
## -Carmen Castillo     251.93458
## -Carlton Fisk        861.98759
## -Chet Lemon          901.87322
## -Cory Snyder         396.86931
## -Chris Speier        757.85995
## -Darnell Coles       435.25349
## -Dave Concepcion     904.48054
## -Doug DeCinces       926.10588
## -Darrell Evans      1639.98865
## -Dwight Evans       1435.92336
## -Damaso Garcia       529.96432
## -Dan Gladden         324.87573
## -Dave Henderson      405.05659
## -Don Mattingly      1167.05634
## -Dale Murphy        1169.82320
## -Dave Parker        1345.95415
## -Dan Pasqua          524.02973
```

```
## -Darrell Porter     691.79273
## -Dick Schofield     383.99392
## -Don Slaught        299.46889
## -Danny Tartabull    366.38451
## -Eddie Milner       329.86657
## -Eddie Murray      1689.61073
## -George Bell        706.38565
## -Glenn Braggs       201.72902
## -George Brett      1445.65254
## -George Hendrick   1045.95845
## -Gary Matthews     1377.17322
## -Graig Nettles     1228.11489
## -Gary Pettis        270.08917
## -Gary Redus         533.97357
## -Garry Templeton    674.02583
## -Greg Walker        518.38807
## -Gary Ward          513.40097
## -Glenn Wilson       636.41837
## -Hubie Brooks       773.04070
## -Howard Johnson     463.91094
## -Jose Canseco       403.18758
## -Jose Cruz         1112.81352
## -Jim Dwyer          292.95195
## -Johnny Grubb       633.91934
## -Jeffrey Leonard    386.87179
## -Jerry Mumphrey     718.04414
## -Jim Presley        441.78236
## -Johnny Ray         958.11863
## -Jim Rice          1731.24435
## -Jerry Royster      347.42020
## -John Shelby        220.36249
## -Joel Skinner        34.40803
## -Jim Sundberg       654.86225
## -Kevin Bass         420.22917
## -Kal Daniels        248.21362
## -Ken Griffey       1000.43601
## -Keith Hernandez   1652.55681
## -Ken Landreaux      472.16469
## -Kevin Mitchell     430.15790
## -Ken Phelps         491.45027
## -Len Dykstra        533.00771
## -Lee Lacy           576.46822
## -Len Matuszek       230.93722
## -Lloyd Moseby       811.36208
## -Larry Parrish      977.80489
## -Larry Sheets       382.69699
## -Lou Whitaker      1062.39023
## -Marty Barrett      628.26579
```

```
## -Mike Davis         331.66827
## -Mariano Duncan     272.47281
## -Mike Kingery        87.33177
## -Mike Marshall      437.92576
## -Mike Pagliarulo    630.94759
## -Mickey Tettleton   279.38060
## -Mitch Webster      439.35544
## -Mike Young         453.28656
## -Oddibe McDowell    385.16120
## -Ozzie Smith        889.61737
## -Ozzie Virgil       522.68413
## -Phil Bradley       540.46405
## -Phil Garner        674.87260
## -Paul Molitor       720.26564
## -Pete Rose         1679.13371
## -Pat Tabler         584.75436
## -Rafael Belliard    280.79702
## -Rob Deer           625.52921
## -Ron Hassey         600.59720
## -Rickey Henderson  1028.17179
## -Reggie Jackson    1819.72445
## -Ray Knight         782.28416
## -Rick Leach         218.98396
## -Ronn Reynolds      202.63025
## -Ryne Sandberg      970.82707
## -Rick Schu          366.63482
## -Roy Smalley        803.19981
## -Rob Wilfong        218.81255
## -Steve Balboni      575.88569
## -Scott Bradley      129.66473
## -Shawon Dunston     464.23418
## -Steve Garvey      1495.33695
## -Steve Jeltz        478.71472
## -Steve Lombardozzi  388.44362
## -Tony Gwynn         584.52956
## -Terry Kennedy      284.78304
## -Tim Laudner        226.99085
## -Ted Simmons       1246.92427
## -Tim Teufel         504.28342
## -Vince Coleman      335.12788
## -Wally Backman      484.17920
## -Wally Joyner       585.38889
## -Willie McGee       625.58347
## -Willie Randolph   1019.88821
## -Wayne Tolleson     179.88403
## -Willie Wilson      431.05643
```

```r
# Calculate MSE!
mean((ridge.pred - y.test)^2)
```

```
## [1] 142199.2
```

```r
# Let's compare that to the predictions of an LM model!

lm.model <- lm(y~x, subset = train)
lm.pred <- predict(lm.model, newx = x[test,], type = "response")

# Calculate MSE!
mean((lm.pred - y.test)^2)
```

```
## Warning in lm.pred - y.test: longer object length is not a multiple of shorter
## object length
```

```
## [1] 326493.9
```

```r
# Ridge is waaaaay better.

# A neat trick to remember: a least squares  estimate is simply
# a ridge regression with the lambda set to 0. For this part, we'll set our predictions to outp
# coefficient estimates vs. raw dependent predictions. This way we'll see how a ridge regressi
# lambda of 0 is basically equivalent to an LM model.

lm(y~x, subset = train)
```

```
##
## Call:
## lm(formula = y ~ x, subset = train)
##
## Coefficients:
## (Intercept)       xAtBat        xHits       xHmRun        xRuns         xRBI
##    274.0145      -0.3521      -1.6377       5.8145       1.5424       1.1243
##      xWalks       xYears      xCAtBat       xCHits      xCHmRun       xCRuns
##      3.7287     -16.3773      -0.6412       3.1632       3.4008      -0.9739
##       xCRBI      xCWalks     xLeagueN   xDivisionW     xPutOuts     xAssists
##     -0.6005       0.3379     119.1486    -144.0831       0.1976       0.6804
##     xErrors  xNewLeagueN
##     -4.7128     -71.0951
```

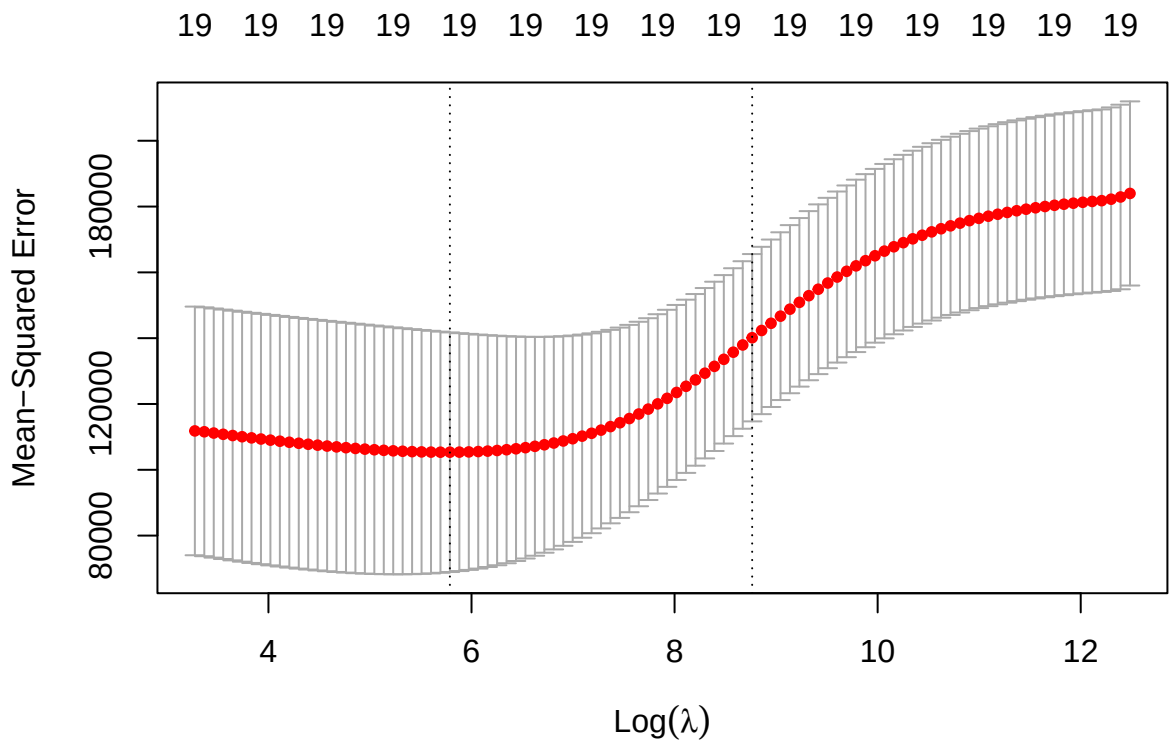
```r
predict(ridge.mod, s=0, type="coefficients")[1:20,]
```

```
##  (Intercept)        AtBat         Hits        HmRun         Runs          RBI
```

```
##  274.2089049   -0.3699455   -1.5370022    5.9129307    1.4811980    1.0772844
##        Walks        Years       CAtBat        CHits       CHmRun        CRuns
##    3.7577989  -16.5600387   -0.6313336    3.1115575    3.3297885   -0.9496641
##         CRBI       CWalks      LeagueN    DivisionW      PutOuts      Assists
##   -0.5694414    0.3300136  118.4000592 -144.2867510    0.1971770    0.6775088
##       Errors   NewLeagueN
##   -4.6833775  -70.1616132
```

```
# Pretty darn close!
```

```
# But what if we wanted to have this done automatically for us, this whole "choose lambda" non
# We can use the power of cross-validation!
# Don't know what that is? That's okay! We're gonna talk about it in Week 5, but I wanted you
# at it now to get an idea of how it works.

set.seed(1)
cv.out<-cv.glmnet(x[train, ], y[train], alpha=0)

plot(cv.out)
```




```
# Let's extract that best lambda value
bestlam<-cv.out$lambda.min

# And plug it in to our previous MSE calculator:
ridge.pred.2 <- predict(ridge.mod, s=bestlam, newx=x[test,])
mean((ridge.pred.2-y.test)^2)
```

```
## [1] 139856.6
```

```
# Is this better than our previous one?
mean((ridge.pred - y.test)^2)
```

```
## [1] 142199.2
```

```
# # ------------------------------------------------------------------
#
# Lasso Regression
#
# # ------------------------------------------------------------------

# This will look pretty familiar, just change alpha = 1!

lasso.mod <- glmnet(x[train, ], y[train], alpha = 1,
                    lambda = grid)

# Let's see how close the MSE values are between Lasso and Ridge

set.seed(1)
cv.out <- cv.glmnet(x[train, ], y[train], alpha = 1)
bestlam_lasso <- cv.out$lambda.min
lasso.pred <- predict(lasso.mod, s = bestlam_lasso,
                      newx = x[test, ])
mean((lasso.pred - y.test)^2)
```

```
## [1] 143673.6
```

```
mean((ridge.pred - y.test)^2)
```

```
## [1] 142199.2
```

```
# Basically the same, although the ridge regression one is slightly lower (but not meaningfuly

# The real power here is comparing the model interpretability!
# Let's look at the coefficient estimates for the lasso model.

out_lasso <- glmnet(x, y, alpha = 1, lambda = grid)
lasso.coef <- predict(out_lasso, type = "coefficients",
                      s = bestlam_lasso)[1:20, ]
lasso.coef
```

```
##   (Intercept)         AtBat          Hits         HmRun          Runs
##    1.27479059   -0.05497143    2.18034583    0.00000000    0.00000000
```

```
##           RBI         Walks         Years        CAtBat         CHits
##    0.00000000    2.29192406   -0.33806109    0.00000000    0.00000000
##        CHmRun         CRuns          CRBI        CWalks       LeagueN
##    0.02825013    0.21628385    0.41712537    0.00000000   20.28615023
##     DivisionW       PutOuts       Assists        Errors    NewLeagueN
## -116.16755870    0.23752385    0.00000000   -0.85629148    0.00000000
```

```
# Compare this to the Ridge model.
out_ridge <- glmnet(x, y, alpha = 0, lambda = grid)
ridge.coef <- predict(out_ridge, type = "coefficients", s = bestlam)[1:20,]

ridge.coef
```

```
##  (Intercept)        AtBat         Hits        HmRun         Runs          RBI
##  15.46209956   0.07640574   0.86308801   0.59870361   1.06416544   0.87873337
##        Walks        Years       CAtBat        CHits       CHmRun        CRuns
##   1.62579484   1.35341838   0.01131653   0.05732472   0.40542580   0.11455464
##         CRBI       CWalks      LeagueN    DivisionW      PutOuts      Assists
##   0.12166650   0.05295541  22.17770617 -79.18681219   0.16648537   0.02959948
##       Errors   NewLeagueN
##  -1.37068563   9.06869821
```

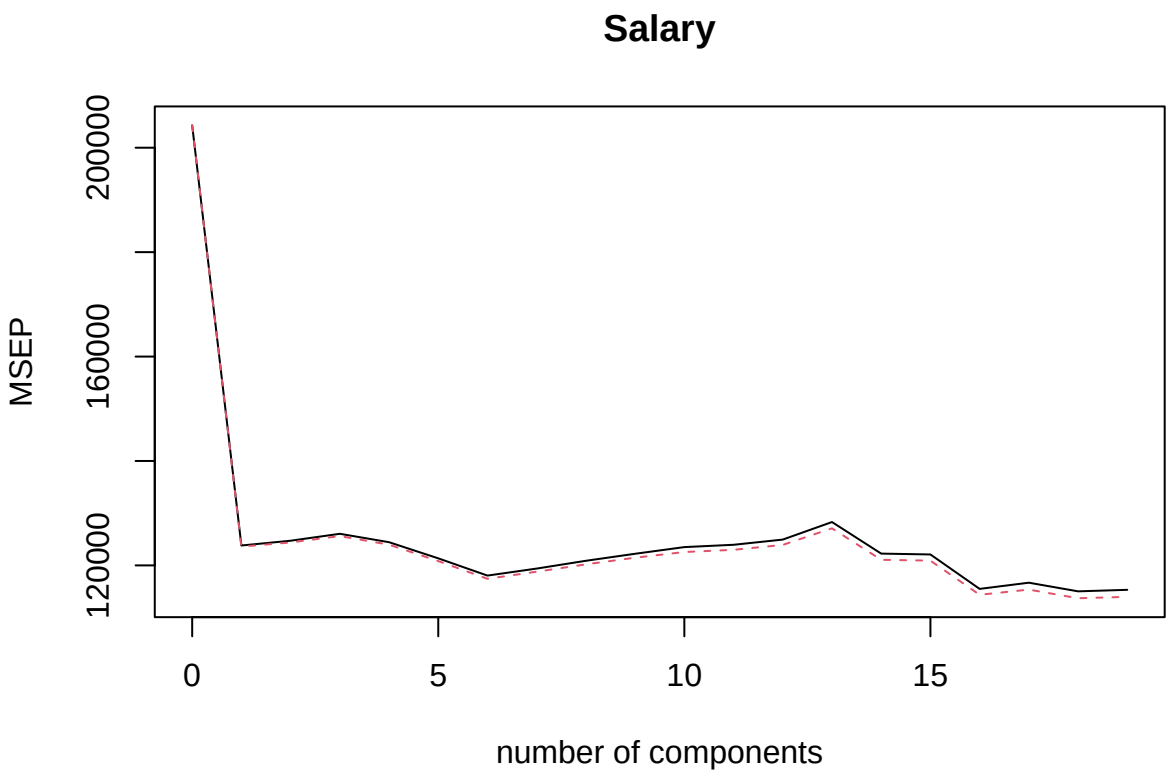
```
# # ------------------------------------------------------------
#
# STOP! Your turn!
#
# Use the credit data to run a Ridge model. Use Rating as your dependent
# variable again. Calculate the test MSE.
#
#
# # ------------------------------------------------------------
```

```
# # ------------------------------------------------------------
#
# PCR Regression!
#
# # ------------------------------------------------------------

# Principal components regression (PCR) can be performed using the pcr() pcr() function,
# which is part of the pls library. We now apply PCR to the Hitters
# data, in order to predict Salary.

set.seed(2)
# The syntax for the pcr() function is similar to that for lm(), with a few
# additional options. Setting scale = TRUE has the effect of standardizing each
# predictor,  prior to generating the principal components, so that
# the scale on which each variable is measured will not have an effect. Setting
```

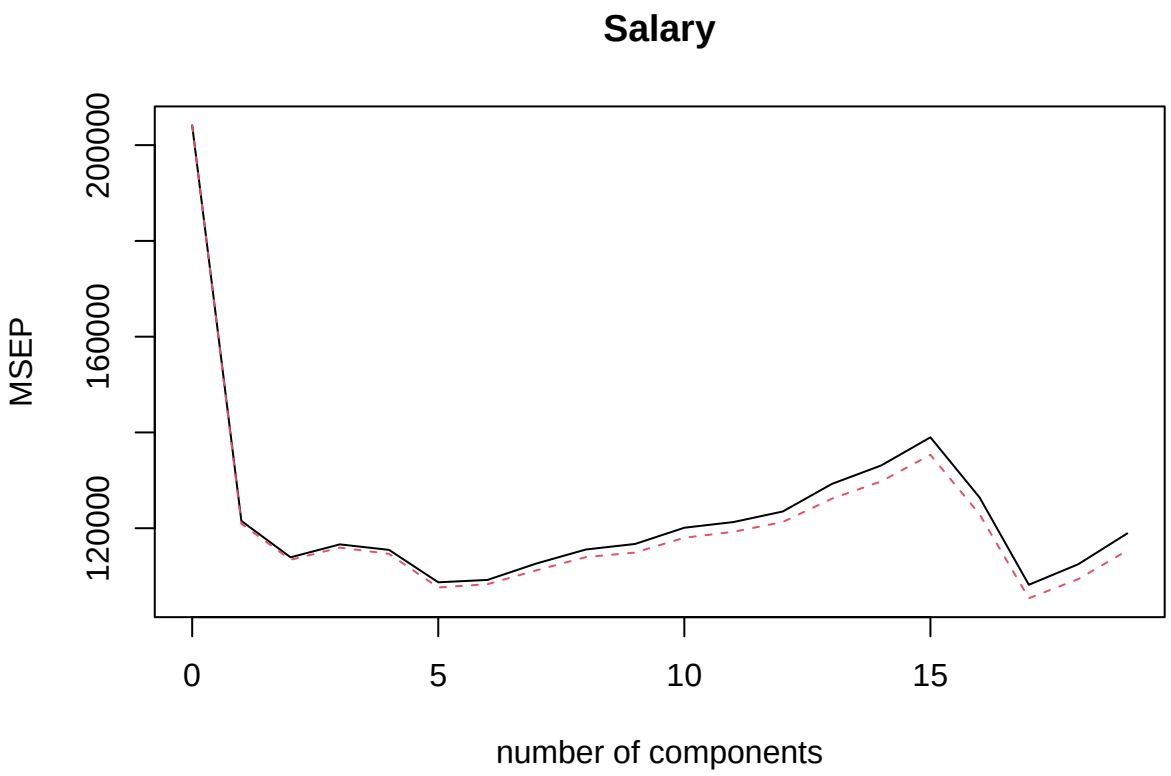
```r
# validation = "CV" causes pcr() to compute the ten-fold cross-validation
# error for each possible value of M, the number of principal components
# used. AGain, don't worry if that makes no sense yet - we'll talk about that soon!
# The resulting fit can be examined using summary().
pcr.fit <- pcr(Salary ~ ., data = Hitters_dropNA, scale = TRUE,
               validation = "CV")

summary(pcr.fit)
```

```
## Data:    X dimension: 263 19
##  Y dimension: 263 1
## Fit method: svdpc
## Number of components considered: 19
##
## VALIDATION: RMSEP
## Cross-validated using 10 random segments.
##        (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## CV             452    351.9    353.2    355.0    352.8    348.4    343.6
## adjCV          452    351.6    352.7    354.4    352.1    347.6    342.7
##        7 comps  8 comps  9 comps  10 comps  11 comps  12 comps  13 comps
## CV       345.5    347.7    349.6     351.4     352.1     353.5     358.2
## adjCV    344.7    346.7    348.5     350.1     350.7     352.0     356.5
##        14 comps  15 comps  16 comps  17 comps  18 comps  19 comps
## CV        349.7     349.4     339.9     341.6     339.2     339.6
## adjCV     348.0     347.7     338.2     339.7     337.2     337.6
##
## TRAINING: % variance explained
##         1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps  8 comps
## X         38.31    60.16    70.84    79.03    84.29    88.63    92.26    94.96
## Salary    40.63    41.58    42.17    43.22    44.90    46.48    46.69    46.75
##         9 comps  10 comps  11 comps  12 comps  13 comps  14 comps  15 comps
## X         96.28     97.26     97.98     98.65     99.15     99.47     99.75
## Salary    46.86     47.76     47.82     47.85     48.10     50.40     50.55
##         16 comps  17 comps  18 comps  19 comps
## X          99.89     99.97     99.99    100.00
## Salary     53.01     53.85     54.61     54.61
```

```r
###
validationplot(pcr.fit, val.type = "MSEP")
```




```
###
set.seed(1)
pcr.fit <- pcr(Salary ~ ., data = Hitters, subset = train,
               scale = TRUE, validation = "CV")

validationplot(pcr.fit, val.type = "MSEP")
```




```
###
pcr.pred <- predict(pcr.fit, x[test, ], ncomp = 5)
mean((pcr.pred - y.test)^2)
```

```
## [1] 124738.3
```

```
###
pcr.fit <- pcr(y ~ x, scale = TRUE, ncomp = 5)
summary(pcr.fit)
```

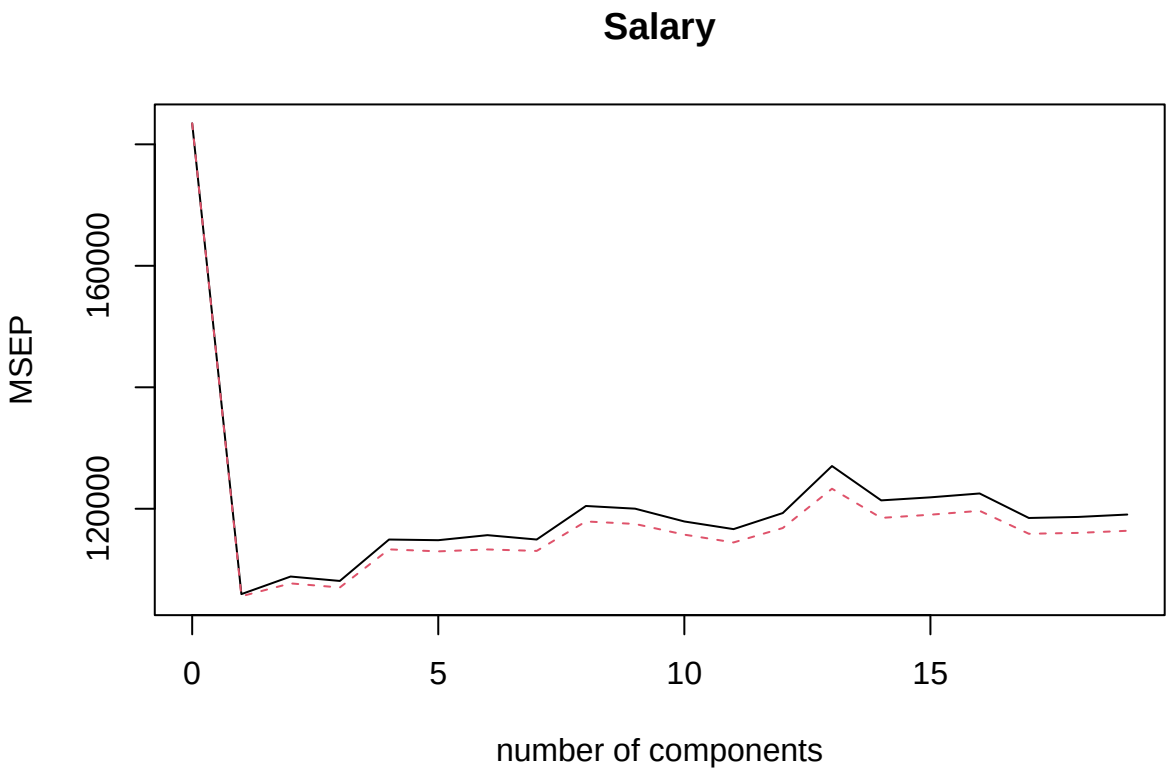
```
## Data:    X dimension: 263 19
##  Y dimension: 263 1
## Fit method: svdpc
## Number of components considered: 5
## TRAINING: % variance explained
##    1 comps  2 comps  3 comps  4 comps  5 comps
## X    38.31    60.16    70.84    79.03    84.29
## y    40.63    41.58    42.17    43.22    44.90
```

```
# # ------------------------------------------------------------------
#
# PLS Regression!
#
# # ------------------------------------------------------------------
```

```r
#We implement partial least squares (PLS) using the plsr() function, also plsr() in the pls li
# The syntax is just like that of the pcr() function
set.seed(1)
pls.fit <- plsr(Salary ~ ., data = Hitters_dropNA, subset = train, scale = TRUE, validation = "
summary(pls.fit)
```

```
## Data:    X dimension: 131 19
##  Y dimension: 131 1
## Fit method: kernelpls
## Number of components considered: 19
##
## VALIDATION: RMSEP
## Cross-validated using 10 random segments.
##        (Intercept)  1 comps  2 comps  3 comps  4 comps  5 comps  6 comps
## CV           428.3    325.5    329.9    328.8    339.0    338.9    340.1
## adjCV        428.3    325.0    328.2    327.2    336.6    336.1    336.6
##        7 comps  8 comps  9 comps  10 comps  11 comps  12 comps  13 comps
## CV       339.0    347.1    346.4     343.4     341.5     345.4     356.4
## adjCV    336.2    343.4    342.8     340.2     338.3     341.8     351.1
##        14 comps  15 comps  16 comps  17 comps  18 comps  19 comps
## CV        348.4     349.1     350.0     344.2     344.5     345.0
## adjCV     344.2     345.0     345.9     340.4     340.6     341.1
##
## TRAINING: % variance explained
##         1 comps  2 comps  3 comps  4 comps  5 comps  6 comps  7 comps  8 comps
## X         39.13    48.80    60.09    75.07    78.58    81.12    88.21    90.71
## Salary    46.36    50.72    52.23    53.03    54.07    54.77    55.05    55.66
##         9 comps  10 comps  11 comps  12 comps  13 comps  14 comps  15 comps
## X         93.17     96.05     97.08     97.61     97.97     98.70     99.12
## Salary    55.95     56.12     56.47     56.68     57.37     57.76     58.08
##         16 comps  17 comps  18 comps  19 comps
## X          99.61     99.70     99.95    100.00
## Salary     58.17     58.49     58.56     58.62
```

```r
validationplot(pls.fit, val.type = "MSEP")
```




```
# The lowest cross-validation error occurs when only M = 1 partial least
#squares directions are used. We now evaluate the corresponding test set
# MSE.


pls.pred <- predict(pls.fit, x[test, ], ncomp = 1)
mean((pls.pred - y.test)^2)
```

```
## [1] 151995.3
```

```
# The test MSE is comparable to, but slightly higher than, the test MSE
# obtained using ridge regression, the lasso, and PCR.
# Finally, we perform PLS using the full data set, using M = 1, the number
# of components identified by cross-validation.

pls.fit <- plsr(Salary ~ ., data = Hitters, scale = TRUE,
                ncomp = 1)
summary(pls.fit)
```

```
## Data:    X dimension: 263 19
##  Y dimension: 263 1
## Fit method: kernelpls
## Number of components considered: 1
## TRAINING: % variance explained
```

```
##         1 comps
## X         38.08
## Salary    43.05
```

```
# Notice that the percentage of variance in Salary that the one-component
# PLS fit explains, 43.05 %, is almost as much as that explained using the final
# five-component model PCR fit, 44.90 %. This is because PCR only attempts
# to maximize the amount of variance explained in the predictors, while PLS
# searches for directions that explain variance in both the predictors and the
# response.
```