INDENG142 Predicting NBA MVP

CASEY LI

12/17/2019

Data loading and cleaning and splitting

```
# loading data
set.seed(679)

# we cleaned this csv already
nba_csv <- read.csv("NBAStats (1).csv")
summary(nba_csv)
```

```
##        X            fga             fg3a            fta       
##  Min.   :  0   Min.   : 3.70   Min.   : 0.000   Min.   : 1.300  
##  1st Qu.:162   1st Qu.:13.90   1st Qu.: 0.100   1st Qu.: 4.800  
##  Median :324   Median :16.80   Median : 1.100   Median : 6.300  
##  Mean   :324   Mean   :16.53   Mean   : 2.069   Mean   : 6.446  
##  3rd Qu.:486   3rd Qu.:19.20   3rd Qu.: 3.700   3rd Qu.: 7.900  
##  Max.   :648   Max.   :27.80   Max.   :13.200   Max.   :13.100  
##                                                                 
##       per            ts_pct          usg_pct           bpm        
##  Min.   :10.10   Min.   :0.4410   Min.   : 7.10   Min.   :-2.800  
##  1st Qu.:19.90   1st Qu.:0.5430   1st Qu.:23.70   1st Qu.: 2.600  
##  Median :22.60   Median :0.5680   Median :26.70   Median : 4.500  
##  Mean   :22.51   Mean   :0.5687   Mean   :26.53   Mean   : 4.601  
##  3rd Qu.:24.80   3rd Qu.:0.5960   3rd Qu.:29.90   3rd Qu.: 6.100  
##  Max.   :31.70   Max.   :0.6990   Max.   :41.70   Max.   :15.600  
##                                                                   
##       vorp            season                 player         age       
##  Min.   :-0.500   1980-81: 31   LeBron James    : 16   Min.   :19.00  
##  1st Qu.: 3.100   1981-82: 25   Tim Duncan      : 16   1st Qu.:25.00  
##  Median : 4.400   1982-83: 23   Karl Malone     : 15   Median :27.00  
##  Mean   : 4.587   1984-85: 23   Shaquille O'Neal: 14   Mean   :27.47  
##  3rd Qu.: 5.800   1998-99: 21   Hakeem Olajuwon : 13   3rd Qu.:30.00  
##  Max.   :12.400   1990-91: 20   Kobe Bryant     : 13   Max.   :38.00  
##                   (Other):506   (Other)         :562                  
##     win_pct        votes_first        points_won       points_max    
##  Min.   :0.2195   Min.   :  0.000   Min.   :   1.0   Min.   : 690  
##  1st Qu.:0.5610   1st Qu.:  0.000   1st Qu.:   3.0   1st Qu.: 800  
##  Median :0.6463   Median :  0.000   Median :  23.0   Median :1130  
##  Mean   :0.6310   Mean   :  6.401   Mean   : 166.4   Mean   :1039  
##  3rd Qu.:0.7000   3rd Qu.:  1.000   3rd Qu.: 184.0   3rd Qu.:1230  
##  Max.   :0.8902   Max.   :131.000   Max.   :1310.0   Max.   :1310  
##                                                                    
##   award_share           g          mp_per_g       pts_per_g     
##  Min.   :0.0010   Min.   :17   Min.   :23.60   Min.   : 4.7  
##  1st Qu.:0.0040   1st Qu.:73   1st Qu.:34.60   1st Qu.:18.8  
##  Median :0.0210   Median :79   Median :36.70   Median :22.0  
##  Mean   :0.1562   Mean   :75   Mean   :36.33   Mean   :22.0  
##  3rd Qu.:0.1770   3rd Qu.:81   3rd Qu.:38.30   3rd Qu.:25.7  
##  Max.   :1.0000   Max.   :82   Max.   :43.70   Max.   :37.1  
##                                                             
##    trb_per_g        ast_per_g        stl_per_g       blk_per_g     
##  Min.   : 1.900   Min.   : 0.800   Min.   :0.200   Min.   :0.0000  
##  1st Qu.: 4.800   1st Qu.: 2.800   1st Qu.:1.000   1st Qu.:0.3000  
##  Median : 6.900   Median : 4.300   Median :1.400   Median :0.6000  
##  Mean   : 7.459   Mean   : 5.002   Mean   :1.428   Mean   :0.9817  
##  3rd Qu.:10.400   3rd Qu.: 6.700   3rd Qu.:1.800   3rd Qu.:1.4000  
##  Max.   :18.700   Max.   :14.500   Max.   :3.700   Max.   :5.6000  
##                                                                    
##      fg_pct           fg3_pct           ft_pct             ws       
##  Min.   :0.3840   Min.   :0.0000   Min.   :0.4220   Min.   : 2.3  
##  1st Qu.:0.4630   1st Qu.:0.1670   1st Qu.:0.7370   1st Qu.: 8.5  
##  Median :0.4920   Median :0.3020   Median :0.7900   Median :10.6  
##  Mean   :0.4944   Mean   :0.2576   Mean   :0.7802   Mean   :10.7  
```

```
##  3rd Qu.:0.5230   3rd Qu.:0.3650   3rd Qu.:0.8430   3rd Qu.:12.9
##  Max.   :0.6700   Max.   :1.0000   Max.   :0.9480   Max.   :21.2
##
##    ws_per_48
##  Min.   :0.0460
##  1st Qu.:0.1550
##  Median :0.1870
##  Mean   :0.1877
##  3rd Qu.:0.2180
##  Max.   :0.3220
##
```

```
#variable selection
nba_csv <- select(nba_csv, fg_pct, fg3_pct, ft_pct,
                  trb_per_g, ast_per_g, stl_per_g, blk_per_g,
                  per, ts_pct, usg_pct, ws, bpm, vorp, season,
                  age, award_share, win_pct, pts_per_g)

#separate to training vs. testing set
nba_csv.train <- filter(nba_csv, season != "2018-19")
nba_csv.test <- filter(nba_csv, season == "2018-19")

nba_csv.train <- select(nba_csv.train, -season)
nba_csv.test <- select(nba_csv.test, -season)
```

Baseline linear model

```
# baseline model ------------------------------------------------------------
baseline <- mean(nba_csv.train$award_share)
pred.base <- rep(baseline, nrow(nba_csv.test))

# OSR2
SSE <-  sum((nba_csv.test$award_share - pred.base)^2)
SST = sum((nba_csv.test$award_share - mean(nba_csv.train$award_share))^2)
OSR2 = 1 - SSE/SST
OSR2 #0 as expected! since sse = sst
```

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

Naive linear regression

```
##linear regression model
testlm <- lm(award_share ~ ., data = nba_csv.train)
summary(testlm)
```

```
##
## Call:
## lm(formula = award_share ~ ., data = nba_csv.train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.40274 -0.11786 -0.03753  0.09231  0.69770
##
## Coefficients:
##               Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.6529754  0.2288151  -2.854 0.004465 **
## fg_pct       0.5290393  0.3817452   1.386 0.166293
## fg3_pct     -0.0667063  0.0596292  -1.119 0.263708
## ft_pct       0.1576860  0.1352366   1.166 0.244062
## trb_per_g    0.0071437  0.0039831   1.793 0.073381 .
## ast_per_g    0.0163803  0.0046416   3.529 0.000448 ***
## stl_per_g   -0.0447344  0.0186352  -2.401 0.016665 *
## blk_per_g    0.0045502  0.0122848   0.370 0.711213
## per          0.0005473  0.0092639   0.059 0.952907
## ts_pct      -1.3495734  0.4553094  -2.964 0.003152 **
## usg_pct      0.0038880  0.0058959   0.659 0.509854
## ws           0.0237721  0.0097291   2.443 0.014828 *
## bpm          0.0140661  0.0164185   0.857 0.391929
## vorp         0.0085559  0.0244173   0.350 0.726154
## age          0.0018868  0.0020919   0.902 0.367426
## win_pct      0.6003816  0.0898235   6.684 5.19e-11 ***
## pts_per_g    0.0104445  0.0044217   2.362 0.018479 *
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.1783 on 620 degrees of freedom
## Multiple R-squared:  0.5303, Adjusted R-squared:  0.5181
## F-statistic: 43.74 on 16 and 620 DF,  p-value: < 2.2e-16
```

```
testlm$coefficients
```

```
##   (Intercept)        fg_pct       fg3_pct        ft_pct     trb_per_g
## -0.6529753819  0.5290393304 -0.0667062644  0.1576860037  0.0071437321
##     ast_per_g     stl_per_g     blk_per_g           per        ts_pct
##  0.0163803226 -0.0447344375  0.0045502399  0.0005473181 -1.3495734159
##       usg_pct            ws           bpm          vorp           age
##  0.0038880487  0.0237721109  0.0140660859  0.0085559299  0.0018868444
##       win_pct     pts_per_g
##  0.6003815569  0.0104444661
```

```
testlm$fitted.values
```

```
##             1             2             3             4             5
##  0.3972906118  0.2916581793  0.3594884314  0.1993401127  0.1624579346
##             6             7             8             9            10
##  0.2147955046  0.2154722659  0.0350259089 -0.0589241505  0.0297343558
##            11            12            13            14            15
##  0.0885785342  0.0922945096 -0.2112985691 -0.0617071877 -0.2187128273
##            16            17            18            19            20
## -0.0637384935 -0.0691877979 -0.0106819405  0.0264315739 -0.0688684067
##            21            22            23            24            25
## -0.0610597527  0.0219044207 -0.0774595865 -0.2117189962 -0.0560655893
##            26            27            28            29            30
## -0.2113985352  0.0414616602 -0.2139183151 -0.0582458470 -0.1094189856
##            31            32            33            34            35
## -0.1195729109  0.3798380306  0.3958375379  0.3154756571  0.2087001326
##            36            37            38            39            40
##  0.1747815062  0.1971712924  0.1797696935  0.2800780058  0.1998916974
##            41            42            43            44            45
##  0.2261494109 -0.0338753795 -0.1361760292  0.1479482157 -0.0056570763
##            46            47            48            49            50
##  0.0354081373  0.0028759112 -0.1874816730 -0.0294870068 -0.0377728547
##            51            52            53            54            55
## -0.2869335512 -0.0299859784  0.0449853754 -0.2319481805 -0.0200816963
##            56            57            58            59            60
## -0.1276560415  0.3810857245  0.3798848301  0.2773002294  0.1782551794
##            61            62            63            64            65
##  0.2660436783  0.2175688987  0.0121898546  0.0634733313  0.1016404280
##            66            67            68            69            70
##  0.1816038097  0.0680002057  0.0099041576 -0.1061899541 -0.0208888189
##            71            72            73            74            75
## -0.2615872467 -0.0231199347 -0.0724331019 -0.0484033035  0.0598843630
##            76            77            78            79            80
##  0.0001164818  0.1760449005 -0.0945440380  0.0422575085  0.4607651897
##            81            82            83            84            85
##  0.1277977964  0.1692539986  0.0933294478  0.1330411785  0.1622708841
##            86            87            88            89            90
##  0.2235146215  0.1337276646 -0.0199162344  0.0740147508  0.1296931373
##            91            92            93            94            95
##  0.0497300998 -0.1157686670 -0.2275910100  0.0754248231  0.5651062663
##            96            97            98            99           100
##  0.2964140129  0.2152980481  0.2495141359  0.2393991395  0.2414150315
##           101           102           103           104           105
## -0.0218312096  0.1908948211  0.2385215484 -0.0028557656  0.0988968475
##           106           107           108           109           110
##  0.1689760146  0.0692480212  0.0512158342 -0.1016887179 -0.1684487839
##           111           112           113           114           115
##  0.0833802641 -0.0704482056 -0.0474338351 -0.1014580300 -0.2061901511
##           116           117           118           119           120
## -0.0467824444  0.0588340294  0.5485016823  0.2255040542  0.3133382257
##           121           122           123           124           125
##  0.1269333208  0.2673610796  0.1467539149  0.1221774615  0.1766752978
##           126           127           128           129           130
##  0.0760933393  0.0616564975  0.0539584230  0.1066611894  0.2511496383
##           131           132           133           134           135
```

```
##  0.0830623377 -0.1425847923  0.1916543275 -0.1859185553  0.0629914075
##           136           137           138           139           140
##  0.5505936853  0.4431377734  0.4963458117  0.3543969927  0.3164025261
##           141           142           143           144           145
##  0.1851487704  0.1425950248  0.1045610563  0.0627110386  0.0749202261
##           146           147           148           149           150
## -0.2070096665 -0.0476501164  0.0902816348  0.0450707472  0.1280898977
##           151           152           153           154           155
## -0.0058145069 -0.1013492495  0.6435355211  0.4909543444  0.3038973946
##           156           157           158           159           160
##  0.2664241078  0.3199673969  0.2150042519  0.1241270757  0.1435291862
##           161           162           163           164           165
##  0.2010242045  0.0534988670  0.1527539107  0.0779074322 -0.0970659812
##           166           167           168           169           170
## -0.1393687167  0.1538468443 -0.0045354729 -0.3759730112  0.4824391599
##           171           172           173           174           175
##  0.6038916276  0.3256121344  0.1378877341  0.1852858100  0.3272939319
##           176           177           178           179           180
##  0.1846989439  0.2253351013  0.1340769873  0.0928675085  0.0644146218
##           181           182           183           184           185
##  0.0382743230 -0.1410676510  0.0811748639  0.0874044658  0.1056544324
##           186           187           188           189           190
##  0.0339469554 -0.0037865435  0.1074438670  0.4979090700  0.3760578386
##           191           192           193           194           195
##  0.5844865604  0.4009488401  0.2607127947  0.3299225644  0.1882687979
##           196           197           198           199           200
##  0.1648916237  0.2037271630  0.2957021013 -0.0459284286  0.3085042573
##           201           202           203           204           205
##  0.0431050342  0.1212627625  0.6359032968  0.4140381274  0.4313950629
##           206           207           208           209           210
##  0.2695938546  0.4029921390  0.3203995910  0.2290042195  0.1570796380
##           211           212           213           214           215
##  0.1244123724  0.1554239678  0.1603209640  0.1928117616 -0.0806575671
##           216           217           218           219           220
## -0.0144751477  0.0526305755 -0.1117966994 -0.0630058446  0.1470418841
##           221           222           223           224           225
##  0.0808047232  0.0105841321  0.6091494637  0.3648177724  0.2684030535
##           226           227           228           229           230
##  0.3626741179  0.2475786360  0.1182449365  0.0379832498  0.1550542683
##           231           232           233           234           235
##  0.3797606469  0.0515001160  0.2042012694  0.0926412763  0.1744586967
##           236           237           238           239           240
##  0.1097527419  0.1308838425  0.0474664250 -0.0565397787  0.4397763005
##           241           242           243           244           245
##  0.4851069388  0.5549538297  0.2523358110  0.1472741115  0.2774255022
##           246           247           248           249           250
##  0.1013358223  0.3397837546  0.0501789429  0.1697483450  0.0582189030
##           251           252           253           254           255
## -0.0532288389  0.0597979040  0.0058044398  0.4376235050  0.6531149024
##           256           257           258           259           260
##  0.2310999456  0.4367468762  0.3248808135  0.0638498489  0.1999928553
##           261           262           263           264           265
##  0.3433020874  0.0330149448  0.1642114058  0.1435191340  0.0545589017
##           266           267           268           269           270
```

```
## -0.0724093291 -0.0560118081  0.1413972241  0.0131052507  0.1031591960
##           271           272           273           274           275
##  0.5127593147  0.4017993440  0.3695351133  0.1846791855  0.2434262271
##           276           277           278           279           280
##  0.2427020446  0.1452753090  0.1630967564  0.1498564072  0.1166625696
##           281           282           283           284           285
## -0.0244534565 -0.0783888995 -0.2711467691  0.0844513004 -0.1519106289
##           286           287           288           289           290
##  0.6754691688  0.5265069310  0.2726951859  0.2123914072  0.3346789889
##           291           292           293           294           295
##  0.1839569039  0.3854044001  0.1421588108  0.2027522146  0.1720069621
##           296           297           298           299           300
##  0.0964786602  0.1018918351 -0.1529203937  0.0557838077  0.0356600415
##           301           302           303           304           305
##  0.1298851865 -0.1073350671  0.5759807021  0.5925164560  0.3723969641
##           306           307           308           309           310
##  0.2886361909  0.0527791256  0.2488176198  0.1721828614  0.1725231196
##           311           312           313           314           315
##  0.1416229339  0.2583806222  0.3367462913  0.0996400901  0.0734099288
##           316           317           318           319           320
## -0.0115412307  0.1420356117  0.1726953571 -0.0631088225 -0.2676841750
##           321           322           323           324           325
##  0.0075989455  0.0310160099  0.4547717182  0.4937551757  0.2388624895
##           326           327           328           329           330
##  0.3182775521  0.2889096306  0.2026247901  0.3406526970  0.1043198074
##           331           332           333           334           335
##  0.0946830229  0.1073807719 -0.0242678095 -0.1425502496  0.0218473476
##           336           337           338           339           340
## -0.0454342904 -0.1795787294  0.0589440775  0.0112058018 -0.2012647130
##           341           342           343           344           345
##  0.0473286205  0.2827174908  0.1104186216  0.2056320401  0.0488571816
##           346           347           348           349           350
##  0.0426866942  0.2113561972 -0.0543326756  0.1021685191  0.0312985168
##           351           352           353           354           355
##  0.0116338360 -0.1305942693  0.1261982554 -0.0400401604 -0.0381475952
##           356           357           358           359           360
## -0.0809917541 -0.1838096964 -0.0638212588 -0.1662626945 -0.1539933938
##           361           362           363           364           365
## -0.0992972190 -0.2000240707  0.7518793147  0.2629045110  0.2310265738
##           366           367           368           369           370
##  0.4207412507  0.3261598385  0.3123144386  0.0748923396  0.1398683916
##           371           372           373           374           375
##  0.2089471384  0.1706762766  0.0978933305  0.2717219537 -0.0849083885
##           376           377           378           379           380
##  0.0120082629 -0.0231967310 -0.0044980131  0.2955677828  0.3409694031
##           381           382           383           384           385
##  0.5101685406  0.3543101636  0.2438922165  0.2347969567  0.2986949701
##           386           387           388           389           390
##  0.1347352462  0.2640186099  0.1663920229  0.1560350422  0.2552806599
##           391           392           393           394           395
## -0.0268584633  0.0771730730  0.0701336769  0.0840772540 -0.0198988233
##           396           397           398           399           400
##  0.5541818708  0.1434521102  0.4151199967  0.2114993287  0.3078507897
##           401           402           403           404           405
```

```
##  0.2525881053  0.2716862758  0.2075810494  0.1058123254  0.0024866901
##           406           407           408           409           410
##  0.1606126894  0.3097576893 -0.0216198066  0.0712699715 -0.0117237312
##           411           412           413           414           415
## -0.0786940550  0.1141863768  0.0598296074  0.5055873820  0.4545650523
##           416           417           418           419           420
##  0.3738324722  0.4242792031  0.3417190884  0.1192522821  0.3656799833
##           421           422           423           424           425
##  0.0009865580  0.2044291653  0.2205610144  0.0971571942  0.1655458362
##           426           427           428           429           430
##  0.1252376917  0.6222301662  0.3821802498  0.2055959013  0.1208260350
##           431           432           433           434           435
##  0.2049859192  0.2311936860  0.0726137876  0.0600129005 -0.1193174654
##           436           437           438           439           440
##  0.2388294366  0.0393077360  0.1275300220  0.0395334939 -0.1248931990
##           441           442           443           444           445
##  0.0299705095 -0.0375466543  0.1412967430  0.3028676155  0.3671230655
##           446           447           448           449           450
##  0.2885955517  0.1717485048  0.3103513373  0.2939121416  0.2499642446
##           451           452           453           454           455
##  0.2853173546  0.1313096556  0.4147423914  0.0875501986  0.0876352596
##           456           457           458           459           460
## -0.3260388892 -0.0826642721  0.2002130318  0.1826344976  0.4978785172
##           461           462           463           464           465
##  0.4568226373  0.3912972646  0.2858952458  0.3706454185  0.2931539653
##           466           467           468           469           470
##  0.2609887046  0.1242843550  0.1879032142  0.2104383710  0.4650738959
##           471           472           473           474           475
##  0.2266249078  0.2477688589  0.3297937109  0.3418850003  0.2313973623
##           476           477           478           479           480
##  0.0572553288  0.1131500422  0.1440386829  0.1057884734  0.0664411684
##           481           482           483           484           485
## -0.1766805599  0.1746594614  0.0880567587  0.0545105124 -0.0569501919
##           486           487           488           489           490
##  0.0858021939  0.3343997339  0.4482708251  0.3385180182  0.4643158179
##           491           492           493           494           495
##  0.1245032474  0.2273514190  0.2536885914  0.0945787154  0.0689771121
##           496           497           498           499           500
##  0.1394859743  0.2397800795  0.1199733949  0.0403149811  0.1384325136
##           501           502           503           504           505
## -0.0455375356  0.1996603580 -0.0186272146  0.7479513246  0.3592312891
##           506           507           508           509           510
##  0.4192197380  0.2587521795  0.4537657841 -0.0977996549  0.1078486447
##           511           512           513           514           515
##  0.1492435669  0.2493614994  0.1430246011  0.2232322124  0.0470581456
##           516           517           518           519           520
##  0.6828542433  0.3022433780  0.2171480860  0.2219942794  0.3411190131
##           521           522           523           524           525
##  0.1017282697  0.2068840203  0.1041113051  0.1226431847  0.0581861609
##           526           527           528           529           530
##  0.0194981166 -0.0037236448  0.0173314272 -0.1620522282  0.0644666630
##           531           532           533           534           535
##  0.4071098911  0.2350743535  0.4642265111  0.2401642703  0.1832273014
##           536           537           538           539           540
```

```
##  0.1713661222  0.3041568912  0.0994611354 -0.0110512405  0.0099821954
##           541           542           543           544           545
## -0.0298439333  0.0596330567  0.1250847756  0.4436245018  0.2597127397
##           546           547           548           549           550
##  0.1784332673  0.1156220949  0.1152796829  0.0206909056  0.0145201226
##           551           552           553           554           555
## -0.0789239465 -0.2026512648  0.1446220773  0.1722155800 -0.0369104644
##           556           557           558           559           560
##  0.1352739503  0.0630749572 -0.0768576577  0.6351406025  0.4657458941
##           561           562           563           564           565
##  0.1762673642  0.2195649413  0.1946656498  0.1448003329  0.1529103111
##           566           567           568           569           570
##  0.1295497713  0.3018088651  0.1910605142  0.1063599355 -0.1565167091
##           571           572           573           574           575
##  0.1705731941 -0.0396804970  0.0655790197 -0.0342479090  0.5666388623
##           576           577           578           579           580
##  0.3876921964  0.2508491256  0.1510339862  0.1876706611  0.2579452923
##           581           582           583           584           585
##  0.2307947276  0.0258071992  0.1224271653  0.1211974817  0.2833279841
##           586           587           588           589           590
##  0.1357306606 -0.0068033097  0.0667963046  0.0861510717  0.0052273728
##           591           592           593           594           595
## -0.0208128934  0.4224504356  0.4031673460  0.2609821527  0.3697239643
##           596           597           598           599           600
##  0.2391993075  0.3483503599  0.0877582441  0.1518206918  0.1714648424
##           601           602           603           604           605
##  0.1069709819 -0.0232385474  0.0816534859  0.6079772493  0.2741201940
##           606           607           608           609           610
##  0.4211225832  0.4673510961  0.3687107001  0.2637359703  0.2303198017
##           611           612           613           614           615
##  0.0986823029  0.2387959324  0.1662542860  0.6544219717  0.5206176929
##           616           617           618           619           620
##  0.2988363183  0.3648256025  0.2448380467  0.3206963365  0.1791531761
##           621           622           623           624           625
##  0.1629478848  0.0819950458  0.3325198717  0.1157292559  0.5587262244
##           626           627           628           629           630
##  0.4365125411  0.2365969130  0.2585384265  0.3725967368  0.2019674734
##           631           632           633           634           635
##  0.2344634968  0.1412535188  0.1384792308 -0.0036472864  0.1466540818
##           636           637
##  0.0507897436 -0.0023127817
```

```
## testing multicollinearity
vif(testlm)
```

```
##    fg_pct   fg3_pct    ft_pct trb_per_g ast_per_g stl_per_g blk_per_g
##  5.920908  1.690224  2.797433  3.440902  3.472220  2.389805  2.630610
##       per    ts_pct   usg_pct        ws       bpm      vorp       age
## 23.899302  6.350981 16.487403 21.594223 39.249989 53.801023  1.215793
##   win_pct pts_per_g
##  1.884890 10.375766
```

```
## predicting
predictions_testlm <- predict(testlm, newdata=nba_csv.test)
predictions_testlm
```

```
##         1         2         3         4         5         6         7
## 0.4918244 0.5519403 0.1647240 0.3149604 0.1654079 0.2545112 0.1870386
##         8         9        10        11        12
## 0.2452853 0.1413281 0.2404894 0.1355675 0.1319142
```

```
nba_csv.test
```

```
##    fg_pct fg3_pct ft_pct trb_per_g ast_per_g stl_per_g blk_per_g  per
## 1   0.578   0.256  0.729      12.5       5.9       1.3       1.5 30.9
## 2   0.442   0.368  0.879       6.6       7.5       2.0       0.7 30.6
## 3   0.438   0.386  0.839       8.2       4.1       2.2       0.4 23.3
## 4   0.511   0.307  0.821      10.8       7.3       1.4       0.7 26.3
## 5   0.472   0.437  0.916       5.3       5.2       1.3       0.4 24.4
## 6   0.444   0.369  0.912       4.6       6.9       1.1       0.4 23.7
## 7   0.484   0.300  0.804      13.6       3.7       0.7       1.9 26.1
## 8   0.521   0.353  0.885       6.4       5.9       0.7       1.1 24.2
## 9   0.496   0.371  0.854       7.3       3.3       1.8       0.4 25.8
## 10  0.428   0.290  0.656      11.1      10.7       1.9       0.5 21.1
## 11  0.669   0.000  0.636      12.9       2.0       0.8       2.3 24.6
## 12  0.510   0.339  0.665       8.5       8.3       1.3       0.6 25.6
##    ts_pct usg_pct   ws  bpm vorp age award_share   win_pct pts_per_g
## 1   0.644    32.3 14.4 10.8  7.6  24       0.932 0.7317073      27.7
## 2   0.616    40.5 15.2 11.7  9.9  29       0.768 0.6463415      36.1
## 3   0.583    29.5 11.9  5.5  5.3  28       0.352 0.5975610      28.0
## 4   0.589    27.4 11.8  9.5  7.3  23       0.210 0.6585366      20.1
## 5   0.641    30.4  9.7  6.3  4.9  30       0.173 0.6951220      27.3
## 6   0.588    29.3 12.1  5.5  5.4  28       0.068 0.6463415      25.8
## 7   0.593    33.3  8.7  4.1  3.3  24       0.049 0.6219512      27.5
## 8   0.631    29.0 11.5  4.3  4.3  30       0.025 0.6951220      26.0
## 9   0.606    30.3  9.5  5.0  3.6  27       0.013 0.7073171      26.6
## 10  0.501    30.9  6.8  6.5  5.6  30       0.008 0.5975610      22.9
## 11  0.682    17.8 14.4  7.0  5.9  26       0.001 0.6097561      15.9
## 12  0.588    31.6  7.2  8.1  4.9  34       0.001 0.4512195      27.4
```

```
SSE <-  sum((nba_csv.test$award_share - predictions_testlm)^2)
SST = sum((nba_csv.test$award_share - mean(nba_csv.train$award_share))^2)
OSR2 = 1 - SSE/SST
OSR2 #0.5684896
```

```
## [1] 0.5684896
```

Backwards stepwise linear regression

```
# backwards stepwise regression ----------------------------------------
set.seed(679)

# training model
step.model <- train(award_share ~., data = nba_csv.train,
                    method = "leapBackward",
                    tuneGrid = data.frame(nvmax = 1:17),
                    trControl = trainControl(method = "cv", number = 5)
)
step.model$results
```

```
##    nvmax      RMSE  Rsquared       MAE      RMSESD RsquaredSD       MAESD
## 1      1 0.2031545 0.3777678 0.1494879 0.013038205 0.06766914 0.009339134
## 2      2 0.1980863 0.4130157 0.1495969 0.009385366 0.06155075 0.008390312
## 3      3 0.1889702 0.4656558 0.1435723 0.009611728 0.03700280 0.008884902
## 4      4 0.1882616 0.4697285 0.1436825 0.009994344 0.03384342 0.008142159
## 5      5 0.1841933 0.4921710 0.1417201 0.011991674 0.04868312 0.009469273
## 6      6 0.1836906 0.4947454 0.1412724 0.011580542 0.05086569 0.008098952
## 7      7 0.1819367 0.5038802 0.1405544 0.011323619 0.04721548 0.008132983
## 8      8 0.1815373 0.5057130 0.1394399 0.010978828 0.04708293 0.007602473
## 9      9 0.1807420 0.5093612 0.1390457 0.010185091 0.04485822 0.006754325
## 10    10 0.1807905 0.5091646 0.1393108 0.010052605 0.04357026 0.006941399
## 11    11 0.1808864 0.5086471 0.1394837 0.009905718 0.04480604 0.006538665
## 12    12 0.1812204 0.5069891 0.1397146 0.010475619 0.04806086 0.006904193
## 13    13 0.1811344 0.5073143 0.1397867 0.010223272 0.04627425 0.006816784
## 14    14 0.1808260 0.5089978 0.1395601 0.010537676 0.04727980 0.007043144
## 15    15 0.1807655 0.5094014 0.1395333 0.010362966 0.04689159 0.006909715
## 16    16 0.1808619 0.5089869 0.1396446 0.010010337 0.04627448 0.006591465
## 17    17 0.1808619 0.5089869 0.1396446 0.010010337 0.04627448 0.006591465
```

```
step.model$bestTune
```

```
##   nvmax
## 9     9
```

```
summary(step.model$finalModel) # tells us which variables to include
```

```
## Subset selection object
## 16 Variables  (and intercept)
##           Forced in Forced out
## fg_pct        FALSE      FALSE
## fg3_pct       FALSE      FALSE
## ft_pct        FALSE      FALSE
## trb_per_g     FALSE      FALSE
## ast_per_g     FALSE      FALSE
## stl_per_g     FALSE      FALSE
## blk_per_g     FALSE      FALSE
## per           FALSE      FALSE
## ts_pct        FALSE      FALSE
## usg_pct       FALSE      FALSE
## ws            FALSE      FALSE
## bpm           FALSE      FALSE
## vorp          FALSE      FALSE
## age           FALSE      FALSE
## win_pct       FALSE      FALSE
## pts_per_g     FALSE      FALSE
## 1 subsets of each size up to 9
## Selection Algorithm: backward
##          fg_pct fg3_pct ft_pct trb_per_g ast_per_g stl_per_g blk_per_g per
## 1  ( 1 ) " "    " "     " "    " "       " "       " "       " "       " "
## 2  ( 1 ) " "    " "     " "    " "       " "       " "       " "       " "
## 3  ( 1 ) " "    " "     " "    " "       " "       " "       " "       " "
## 4  ( 1 ) " "    " "     " "    " "       " "       " "       " "       " "
## 5  ( 1 ) " "    " "     " "    " "       " "       " "       " "       " "
## 6  ( 1 ) " "    " "     " "    " "       " "       "*"       " "       " "
## 7  ( 1 ) " "    " "     " "    " "       "*"       "*"       " "       " "
## 8  ( 1 ) " "    " "     " "    "*"       "*"       "*"       " "       " "
## 9  ( 1 ) "*"    " "     " "    "*"       "*"       "*"       " "       " "
##          ts_pct usg_pct ws  bpm vorp age win_pct pts_per_g
## 1  ( 1 ) " "    " "     " " "*" " "  " " " "     " "
## 2  ( 1 ) " "    " "     " " "*" " "  " " "*"     " "
## 3  ( 1 ) " "    " "     " " "*" " "  " " "*"     "*"
## 4  ( 1 ) " "    " "     "*" "*" " "  " " "*"     "*"
## 5  ( 1 ) "*"    " "     "*" "*" " "  " " "*"     "*"
## 6  ( 1 ) "*"    " "     "*" "*" " "  " " "*"     "*"
## 7  ( 1 ) "*"    " "     "*" "*" " "  " " "*"     "*"
## 8  ( 1 ) "*"    " "     "*" "*" " "  " " "*"     "*"
## 9  ( 1 ) "*"    " "     "*" "*" " "  " " "*"     "*"
```

```
coef(step.model$finalModel, id = 9)
```

```
##  (Intercept)       fg_pct    trb_per_g    ast_per_g    stl_per_g
## -0.387387572  0.425193698  0.006473243  0.016045291 -0.054028684
##       ts_pct           ws          bpm      win_pct    pts_per_g
## -1.364878622  0.025383895  0.020137578  0.613492903  0.013981895
```

```
#building final linear model
bswr.mod <- lm(award_share ~ fg_pct +  trb_per_g + ast_per_g + stl_per_g +
                 ts_pct + ws + bpm + win_pct + pts_per_g,
               data = nba_csv.train)
summary(bswr.mod)
```

```
##
## Call:
## lm(formula = award_share ~ fg_pct + trb_per_g + ast_per_g + stl_per_g +
##     ts_pct + ws + bpm + win_pct + pts_per_g, data = nba_csv.train)
##
## Residuals:
##      Min       1Q   Median       3Q      Max
## -0.38158 -0.11672 -0.03796  0.09170  0.69670
##
## Coefficients:
##              Estimate Std. Error t value Pr(>|t|)
## (Intercept) -0.387388   0.153987  -2.516  0.01213 *
## fg_pct       0.425194   0.260576   1.632  0.10323
## trb_per_g    0.006473   0.003485   1.858  0.06369 .
## ast_per_g    0.016045   0.003737   4.294 2.03e-05 ***
## stl_per_g   -0.054029   0.017149  -3.151  0.00171 **
## ts_pct      -1.364879   0.332031  -4.111 4.47e-05 ***
## ws           0.025384   0.003995   6.354 4.03e-10 ***
## bpm          0.020138   0.004676   4.307 1.92e-05 ***
## win_pct      0.613493   0.075165   8.162 1.81e-15 ***
## pts_per_g    0.013982   0.001792   7.803 2.53e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 0.178 on 627 degrees of freedom
## Multiple R-squared:  0.5266, Adjusted R-squared:  0.5198
## F-statistic: 77.51 on 9 and 627 DF,  p-value: < 2.2e-16
```

```
vif(bswr.mod) # acceptable vifs
```

```
##    fg_pct trb_per_g ast_per_g stl_per_g    ts_pct        ws       bpm
##  2.768500  2.642912  2.258271  2.031006  3.389390  3.653558  3.194391
##   win_pct pts_per_g
##  1.324580  1.709839
```

```
# testing for OSR2
pred.bswr <- predict(bswr.mod, newdata=nba_csv.test)
pred.bswr
```

```
##         1         2         3         4         5         6         7
## 0.5039477 0.5375057 0.1740437 0.3132550 0.1671717 0.2550683 0.1880855
##         8         9        10        11        12
## 0.2396639 0.1470319 0.2419638 0.1414766 0.1506761
```

```
nba_csv.test$award_share
```

```
##  [1] 0.932 0.768 0.352 0.210 0.173 0.068 0.049 0.025 0.013 0.008 0.001
## [12] 0.001
```

```
SSE <-  sum((nba_csv.test$award_share - pred.bswr)^2)
SST = sum((nba_csv.test$award_share - mean(nba_csv.train$award_share))^2)
OSR2 = 1 - SSE/SST
OSR2 # 0.5691312 # slight improvement!
```

```
## [1] 0.5691312
```

Random forests – basic and cross-validated

```
##basic random forest model
set.seed(144)
mod.rf <- randomForest(award_share ~ ., data = nba_csv.train, mtry = 5, nodesize = 5, ntree = 50
0)
pred.rf <- predict(mod.rf, newdata = nba_csv.test) # just to illustrate

importance(mod.rf) #most important features: ws, vorp, win_pct, bpm
```

```
##           IncNodePurity
## fg_pct        1.0813085
## fg3_pct       0.8731366
## ft_pct        1.2082597
## trb_per_g     0.9318022
## ast_per_g     1.2053944
## stl_per_g     0.5994095
## blk_per_g     0.7338723
## per           5.0909337
## ts_pct        0.9842470
## usg_pct       1.8279452
## ws            9.0585303
## bpm           3.9519190
## vorp          5.5728829
## age           0.7868769
## win_pct       4.3633348
## pts_per_g     2.2574873
```

```
#cross validation on mtry
set.seed(849)
train.rf <- train(award_share ~ .,
                  data = nba_csv.train,
                  method = "rf",
                  tuneGrid = data.frame(mtry=1:16),
                  trControl = trainControl(method="cv",
                                           number=5, verboseIter = TRUE),
                  metric = "RMSE")
```

```
## + Fold1: mtry= 1
## - Fold1: mtry= 1
## + Fold1: mtry= 2
## - Fold1: mtry= 2
## + Fold1: mtry= 3
## - Fold1: mtry= 3
## + Fold1: mtry= 4
## - Fold1: mtry= 4
## + Fold1: mtry= 5
## - Fold1: mtry= 5
## + Fold1: mtry= 6
## - Fold1: mtry= 6
## + Fold1: mtry= 7
## - Fold1: mtry= 7
## + Fold1: mtry= 8
## - Fold1: mtry= 8
## + Fold1: mtry= 9
## - Fold1: mtry= 9
## + Fold1: mtry=10
## - Fold1: mtry=10
## + Fold1: mtry=11
## - Fold1: mtry=11
## + Fold1: mtry=12
## - Fold1: mtry=12
## + Fold1: mtry=13
## - Fold1: mtry=13
## + Fold1: mtry=14
## - Fold1: mtry=14
## + Fold1: mtry=15
## - Fold1: mtry=15
## + Fold1: mtry=16
## - Fold1: mtry=16
## + Fold2: mtry= 1
## - Fold2: mtry= 1
## + Fold2: mtry= 2
## - Fold2: mtry= 2
## + Fold2: mtry= 3
## - Fold2: mtry= 3
## + Fold2: mtry= 4
## - Fold2: mtry= 4
## + Fold2: mtry= 5
## - Fold2: mtry= 5
## + Fold2: mtry= 6
## - Fold2: mtry= 6
## + Fold2: mtry= 7
## - Fold2: mtry= 7
## + Fold2: mtry= 8
## - Fold2: mtry= 8
## + Fold2: mtry= 9
## - Fold2: mtry= 9
## + Fold2: mtry=10
## - Fold2: mtry=10
## + Fold2: mtry=11
```

```
## - Fold2: mtry=11
## + Fold2: mtry=12
## - Fold2: mtry=12
## + Fold2: mtry=13
## - Fold2: mtry=13
## + Fold2: mtry=14
## - Fold2: mtry=14
## + Fold2: mtry=15
## - Fold2: mtry=15
## + Fold2: mtry=16
## - Fold2: mtry=16
## + Fold3: mtry= 1
## - Fold3: mtry= 1
## + Fold3: mtry= 2
## - Fold3: mtry= 2
## + Fold3: mtry= 3
## - Fold3: mtry= 3
## + Fold3: mtry= 4
## - Fold3: mtry= 4
## + Fold3: mtry= 5
## - Fold3: mtry= 5
## + Fold3: mtry= 6
## - Fold3: mtry= 6
## + Fold3: mtry= 7
## - Fold3: mtry= 7
## + Fold3: mtry= 8
## - Fold3: mtry= 8
## + Fold3: mtry= 9
## - Fold3: mtry= 9
## + Fold3: mtry=10
## - Fold3: mtry=10
## + Fold3: mtry=11
## - Fold3: mtry=11
## + Fold3: mtry=12
## - Fold3: mtry=12
## + Fold3: mtry=13
## - Fold3: mtry=13
## + Fold3: mtry=14
## - Fold3: mtry=14
## + Fold3: mtry=15
## - Fold3: mtry=15
## + Fold3: mtry=16
## - Fold3: mtry=16
## + Fold4: mtry= 1
## - Fold4: mtry= 1
## + Fold4: mtry= 2
## - Fold4: mtry= 2
## + Fold4: mtry= 3
## - Fold4: mtry= 3
## + Fold4: mtry= 4
## - Fold4: mtry= 4
## + Fold4: mtry= 5
## - Fold4: mtry= 5
## + Fold4: mtry= 6
```

```
## - Fold4: mtry= 6
## + Fold4: mtry= 7
## - Fold4: mtry= 7
## + Fold4: mtry= 8
## - Fold4: mtry= 8
## + Fold4: mtry= 9
## - Fold4: mtry= 9
## + Fold4: mtry=10
## - Fold4: mtry=10
## + Fold4: mtry=11
## - Fold4: mtry=11
## + Fold4: mtry=12
## - Fold4: mtry=12
## + Fold4: mtry=13
## - Fold4: mtry=13
## + Fold4: mtry=14
## - Fold4: mtry=14
## + Fold4: mtry=15
## - Fold4: mtry=15
## + Fold4: mtry=16
## - Fold4: mtry=16
## + Fold5: mtry= 1
## - Fold5: mtry= 1
## + Fold5: mtry= 2
## - Fold5: mtry= 2
## + Fold5: mtry= 3
## - Fold5: mtry= 3
## + Fold5: mtry= 4
## - Fold5: mtry= 4
## + Fold5: mtry= 5
## - Fold5: mtry= 5
## + Fold5: mtry= 6
## - Fold5: mtry= 6
## + Fold5: mtry= 7
## - Fold5: mtry= 7
## + Fold5: mtry= 8
## - Fold5: mtry= 8
## + Fold5: mtry= 9
## - Fold5: mtry= 9
## + Fold5: mtry=10
## - Fold5: mtry=10
## + Fold5: mtry=11
## - Fold5: mtry=11
## + Fold5: mtry=12
## - Fold5: mtry=12
## + Fold5: mtry=13
## - Fold5: mtry=13
## + Fold5: mtry=14
## - Fold5: mtry=14
## + Fold5: mtry=15
## - Fold5: mtry=15
## + Fold5: mtry=16
## - Fold5: mtry=16
## Aggregating results
```

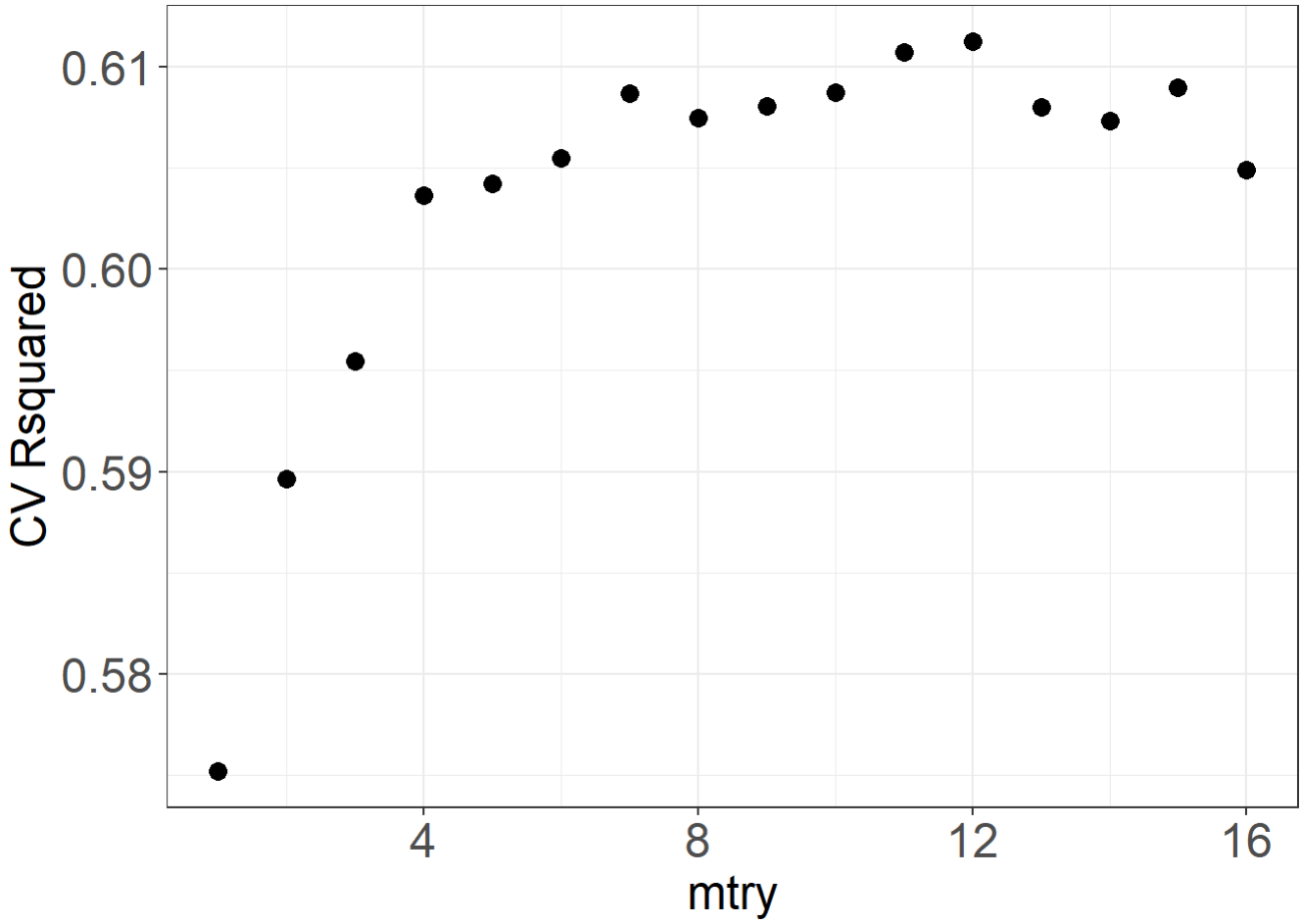
```
## Selecting tuning parameters
## Fitting mtry = 12 on full training set
```

```
train.rf #mtry=12
```

```
## Random Forest
##
## 637 samples
##  16 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 509, 508, 510, 512, 509
## Resampling results across tuning parameters:
##
##   mtry  RMSE       Rsquared   MAE
##    1    0.1729006  0.5751842  0.1148861
##    2    0.1677458  0.5896253  0.1091635
##    3    0.1659232  0.5954343  0.1067127
##    4    0.1642990  0.6036294  0.1052672
##    5    0.1640126  0.6042265  0.1045772
##    6    0.1636150  0.6054612  0.1041081
##    7    0.1628583  0.6086627  0.1030604
##    8    0.1630133  0.6074687  0.1027573
##    9    0.1627223  0.6080682  0.1025852
##   10    0.1626249  0.6087426  0.1023939
##   11    0.1624621  0.6107147  0.1020349
##   12    0.1621851  0.6112369  0.1018550
##   13    0.1631822  0.6079965  0.1023682
##   14    0.1631774  0.6073143  0.1027458
##   15    0.1628195  0.6089939  0.1024110
##   16    0.1637064  0.6049178  0.1031926
##
## RMSE was used to select the optimal model using the smallest value.
## The final value used for the model was mtry = 12.
```

```
best.rf <- train.rf$finalModel
pred.best.rf <- predict(best.rf, newdata = nba_csv.test) # can use same model matrix

ggplot(train.rf$results, aes(x = mtry, y = Rsquared)) + geom_point(size = 3) +
  ylab("CV Rsquared") + theme_bw() + theme(axis.title=element_text(size=18), axis.text=element_t
ext(size=18))
```




```
SSE = sum((nba_csv.test$award_share - pred.best.rf)^2)
SST = sum((nba_csv.test$award_share - mean(nba_csv.train$award_share))^2)
OSR2 = 1 - SSE/SST
OSR2 #0.7677164
```

```
## [1] 0.7677164
```

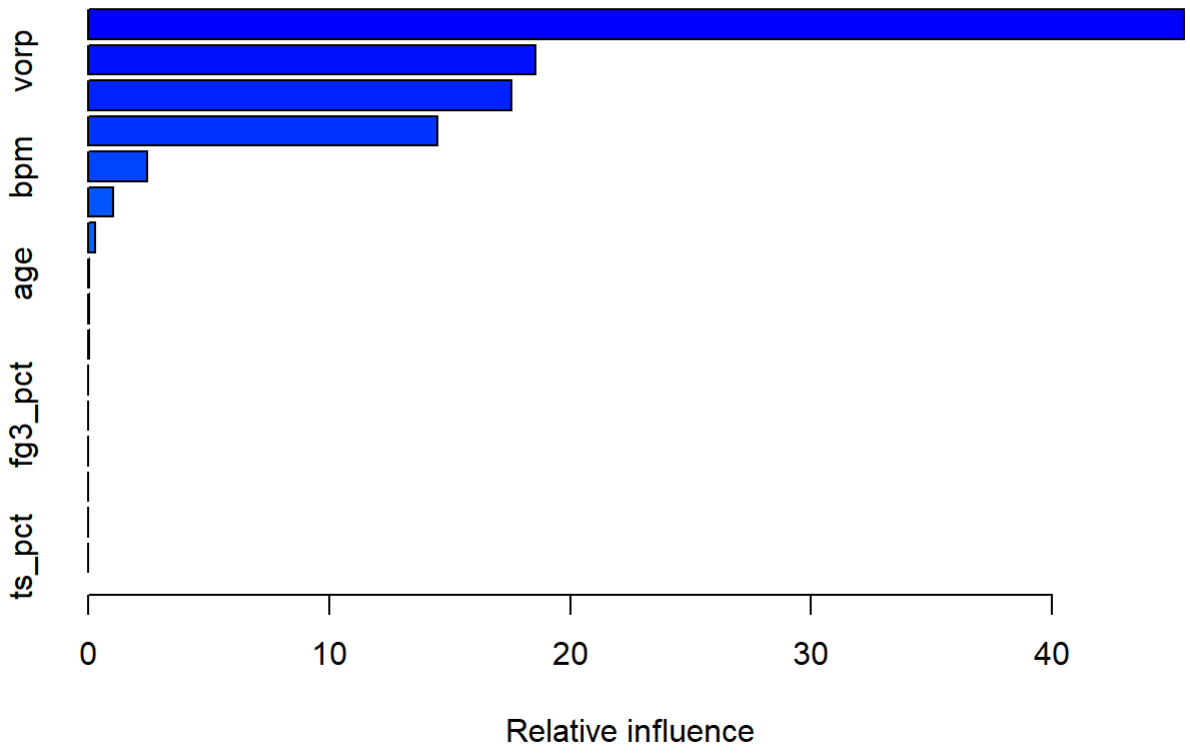
Boosting – basic and cross-validated

```
#boosting model
mod.boost <- gbm(award_share ~ .,
                 data = nba_csv.train,
                 distribution = "gaussian",
                 n.trees = 1000,
                 shrinkage = 0.001,
                 interaction.depth = 2)

pred.boost <- predict(mod.boost, newdata = nba_csv.test, n.trees=1000)

pred.boost.earlier <- predict(mod.boost, newdata = nba_csv.test, n.trees=330)

summary(mod.boost) #most influential features are ws, vorp, per, win_pct
```




```
##                var     rel.inf
## ws              ws 45.46286772
## vorp          vorp 18.55601031
## per            per 17.57885978
## win_pct    win_pct 14.47977396
## bpm            bpm  2.44925995
## usg_pct    usg_pct  1.05795822
## pts_per_g pts_per_g  0.29577981
## age            age  0.04456713
## ft_pct      ft_pct  0.04326546
## ast_per_g ast_per_g  0.03165767
## fg_pct      fg_pct  0.00000000
## fg3_pct    fg3_pct  0.00000000
## trb_per_g trb_per_g  0.00000000
## stl_per_g stl_per_g  0.00000000
## blk_per_g blk_per_g  0.00000000
## ts_pct      ts_pct  0.00000000
```

```
#cross validation on n.trees and interaction depth
tGrid = expand.grid(n.trees = (1:75)*500, interaction.depth = c(1,2,4,6,8,10),
                    shrinkage = 0.001, n.minobsinnode = 10)

set.seed(849)
train.boost <- train(award_share ~ .,
                     data = nba_csv.train,
                     method = "gbm",
                     tuneGrid = tGrid,
                     trControl = trainControl(method="cv", number=5,
                                              verboseIter = TRUE),
                     metric = "RMSE",
                     distribution = "gaussian")
```

```
## + Fold1: shrinkage=0.001, interaction.depth= 1, n.minobsinnode=10, n.trees=37500
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.0665             nan     0.0010    0.0001
##      2        0.0665             nan     0.0010    0.0000
##      3        0.0664             nan     0.0010    0.0000
##      4        0.0663             nan     0.0010    0.0000
##      5        0.0663             nan     0.0010    0.0000
##      6        0.0662             nan     0.0010    0.0000
##      7        0.0662             nan     0.0010    0.0001
##      8        0.0662             nan     0.0010    0.0000
##      9        0.0661             nan     0.0010    0.0000
##     10        0.0661             nan     0.0010    0.0000
##     20        0.0656             nan     0.0010    0.0000
##     40        0.0646             nan     0.0010    0.0000
##     60        0.0637             nan     0.0010    0.0000
##     80        0.0628             nan     0.0010    0.0000
##    100        0.0620             nan     0.0010    0.0000
##    120        0.0611             nan     0.0010    0.0000
##    140        0.0603             nan     0.0010    0.0001
##    160        0.0595             nan     0.0010    0.0000
##    180        0.0587             nan     0.0010    0.0000
##    200        0.0579             nan     0.0010    0.0000
##    220        0.0572             nan     0.0010    0.0000
##    240        0.0565             nan     0.0010    0.0000
##    260        0.0558             nan     0.0010    0.0000
##    280        0.0551             nan     0.0010    0.0000
##    300        0.0545             nan     0.0010    0.0000
##    320        0.0539             nan     0.0010    0.0000
##    340        0.0533             nan     0.0010    0.0000
##    360        0.0527             nan     0.0010    0.0000
##    380        0.0521             nan     0.0010    0.0000
##    400        0.0516             nan     0.0010    0.0000
##    420        0.0510             nan     0.0010    0.0000
##    440        0.0505             nan     0.0010    0.0000
##    460        0.0500             nan     0.0010    0.0000
##    480        0.0495             nan     0.0010    0.0000
##    500        0.0490             nan     0.0010    0.0000
##    520        0.0486             nan     0.0010    0.0000
##    540        0.0481             nan     0.0010    0.0000
##    560        0.0477             nan     0.0010    0.0000
##    580        0.0472             nan     0.0010    0.0000
##    600        0.0468             nan     0.0010    0.0000
##    620        0.0464             nan     0.0010    0.0000
##    640        0.0460             nan     0.0010    0.0000
##    660        0.0456             nan     0.0010    0.0000
##    680        0.0452             nan     0.0010    0.0000
##    700        0.0449             nan     0.0010    0.0000
##    720        0.0445             nan     0.0010    0.0000
##    740        0.0442             nan     0.0010    0.0000
##    760        0.0438             nan     0.0010    0.0000
##    780        0.0435             nan     0.0010    0.0000
##    800        0.0432             nan     0.0010    0.0000
##    820        0.0428             nan     0.0010    0.0000
```

```
##    840        0.0425             nan     0.0010    0.0000
##    860        0.0422             nan     0.0010    0.0000
##    880        0.0419             nan     0.0010    0.0000
##    900        0.0417             nan     0.0010    0.0000
##    920        0.0414             nan     0.0010    0.0000
##    940        0.0411             nan     0.0010    0.0000
##    960        0.0408             nan     0.0010    0.0000
##    980        0.0406             nan     0.0010    0.0000
##   1000        0.0403             nan     0.0010    0.0000
##   1020        0.0400             nan     0.0010    0.0000
##   1040        0.0398             nan     0.0010    0.0000
##   1060        0.0396             nan     0.0010    0.0000
##   1080        0.0393             nan     0.0010    0.0000
##   1100        0.0391             nan     0.0010    0.0000
##   1120        0.0388             nan     0.0010    0.0000
##   1140        0.0386             nan     0.0010    0.0000
##   1160        0.0384             nan     0.0010    0.0000
##   1180        0.0382             nan     0.0010    0.0000
##   1200        0.0380             nan     0.0010    0.0000
##   1220        0.0378             nan     0.0010    0.0000
##   1240        0.0376             nan     0.0010    0.0000
##   1260        0.0374             nan     0.0010    0.0000
##   1280        0.0372             nan     0.0010    0.0000
##   1300        0.0370             nan     0.0010    0.0000
##   1320        0.0368             nan     0.0010    0.0000
##   1340        0.0366             nan     0.0010    0.0000
##   1360        0.0365             nan     0.0010    0.0000
##   1380        0.0363             nan     0.0010    0.0000
##   1400        0.0361             nan     0.0010    0.0000
##   1420        0.0359             nan     0.0010    0.0000
##   1440        0.0358             nan     0.0010    0.0000
##   1460        0.0356             nan     0.0010    0.0000
##   1480        0.0355             nan     0.0010    0.0000
##   1500        0.0353             nan     0.0010    0.0000
##   1520        0.0351             nan     0.0010    0.0000
##   1540        0.0350             nan     0.0010    0.0000
##   1560        0.0348             nan     0.0010    0.0000
##   1580        0.0347             nan     0.0010    0.0000
##   1600        0.0345             nan     0.0010    0.0000
##   1620        0.0344             nan     0.0010    0.0000
##   1640        0.0342             nan     0.0010    0.0000
##   1660        0.0341             nan     0.0010    0.0000
##   1680        0.0339             nan     0.0010    0.0000
##   1700        0.0338             nan     0.0010    0.0000
##   1720        0.0337             nan     0.0010    0.0000
##   1740        0.0335             nan     0.0010    0.0000
##   1760        0.0334             nan     0.0010    0.0000
##   1780        0.0333             nan     0.0010    0.0000
##   1800        0.0331             nan     0.0010    0.0000
##   1820        0.0330             nan     0.0010    0.0000
##   1840        0.0329             nan     0.0010    0.0000
##   1860        0.0328             nan     0.0010    0.0000
##   1880        0.0327             nan     0.0010    0.0000
##   1900        0.0325             nan     0.0010    0.0000
```

```
##   1920        0.0324             nan     0.0010    0.0000
##   1940        0.0323             nan     0.0010    0.0000
##   1960        0.0322             nan     0.0010    0.0000
##   1980        0.0321             nan     0.0010    0.0000
##   2000        0.0320             nan     0.0010    0.0000
##   2020        0.0319             nan     0.0010   -0.0000
##   2040        0.0318             nan     0.0010    0.0000
##   2060        0.0317             nan     0.0010    0.0000
##   2080        0.0316             nan     0.0010    0.0000
##   2100        0.0315             nan     0.0010    0.0000
##   2120        0.0314             nan     0.0010    0.0000
##   2140        0.0313             nan     0.0010    0.0000
##   2160        0.0312             nan     0.0010    0.0000
##   2180        0.0311             nan     0.0010    0.0000
##   2200        0.0310             nan     0.0010    0.0000
##   2220        0.0309             nan     0.0010    0.0000
##   2240        0.0308             nan     0.0010    0.0000
##   2260        0.0307             nan     0.0010    0.0000
##   2280        0.0306             nan     0.0010    0.0000
##   2300        0.0305             nan     0.0010    0.0000
##   2320        0.0304             nan     0.0010    0.0000
##   2340        0.0304             nan     0.0010    0.0000
##   2360        0.0303             nan     0.0010    0.0000
##   2380        0.0302             nan     0.0010    0.0000
##   2400        0.0301             nan     0.0010    0.0000
##   2420        0.0300             nan     0.0010    0.0000
##   2440        0.0300             nan     0.0010    0.0000
##   2460        0.0299             nan     0.0010    0.0000
##   2480        0.0298             nan     0.0010    0.0000
##   2500        0.0297             nan     0.0010    0.0000
##   2520        0.0297             nan     0.0010    0.0000
##   2540        0.0296             nan     0.0010    0.0000
##   2560        0.0295             nan     0.0010    0.0000
##   2580        0.0294             nan     0.0010    0.0000
##   2600        0.0294             nan     0.0010    0.0000
##   2620        0.0293             nan     0.0010    0.0000
##   2640        0.0292             nan     0.0010    0.0000
##   2660        0.0291             nan     0.0010    0.0000
##   2680        0.0291             nan     0.0010    0.0000
##   2700        0.0290             nan     0.0010    0.0000
##   2720        0.0289             nan     0.0010    0.0000
##   2740        0.0289             nan     0.0010    0.0000
##   2760        0.0288             nan     0.0010    0.0000
##   2780        0.0288             nan     0.0010    0.0000
##   2800        0.0287             nan     0.0010    0.0000
##   2820        0.0286             nan     0.0010    0.0000
##   2840        0.0286             nan     0.0010    0.0000
##   2860        0.0285             nan     0.0010    0.0000
##   2880        0.0285             nan     0.0010    0.0000
##   2900        0.0284             nan     0.0010    0.0000
##   2920        0.0284             nan     0.0010    0.0000
##   2940        0.0283             nan     0.0010    0.0000
##   2960        0.0282             nan     0.0010    0.0000
##   2980        0.0282             nan     0.0010    0.0000
```

```
##  34900        0.0003             nan     0.0010   -0.0000
##  34920        0.0003             nan     0.0010   -0.0000
##  34940        0.0003             nan     0.0010   -0.0000
##  34960        0.0003             nan     0.0010   -0.0000
##  34980        0.0003             nan     0.0010   -0.0000
##  35000        0.0003             nan     0.0010   -0.0000
##  35020        0.0003             nan     0.0010   -0.0000
##  35040        0.0003             nan     0.0010   -0.0000
##  35060        0.0003             nan     0.0010   -0.0000
##  35080        0.0003             nan     0.0010   -0.0000
##  35100        0.0003             nan     0.0010   -0.0000
##  35120        0.0003             nan     0.0010   -0.0000
##  35140        0.0003             nan     0.0010   -0.0000
##  35160        0.0003             nan     0.0010   -0.0000
##  35180        0.0003             nan     0.0010   -0.0000
##  35200        0.0003             nan     0.0010   -0.0000
##  35220        0.0003             nan     0.0010   -0.0000
##  35240        0.0003             nan     0.0010   -0.0000
##  35260        0.0003             nan     0.0010   -0.0000
##  35280        0.0003             nan     0.0010   -0.0000
##  35300        0.0003             nan     0.0010   -0.0000
##  35320        0.0003             nan     0.0010   -0.0000
##  35340        0.0003             nan     0.0010   -0.0000
##  35360        0.0003             nan     0.0010   -0.0000
##  35380        0.0003             nan     0.0010   -0.0000
##  35400        0.0003             nan     0.0010   -0.0000
##  35420        0.0003             nan     0.0010   -0.0000
##  35440        0.0003             nan     0.0010   -0.0000
##  35460        0.0003             nan     0.0010   -0.0000
##  35480        0.0003             nan     0.0010   -0.0000
##  35500        0.0003             nan     0.0010   -0.0000
##  35520        0.0003             nan     0.0010   -0.0000
##  35540        0.0003             nan     0.0010   -0.0000
##  35560        0.0003             nan     0.0010   -0.0000
##  35580        0.0003             nan     0.0010   -0.0000
##  35600        0.0003             nan     0.0010   -0.0000
##  35620        0.0003             nan     0.0010   -0.0000
##  35640        0.0003             nan     0.0010   -0.0000
##  35660        0.0003             nan     0.0010   -0.0000
##  35680        0.0003             nan     0.0010   -0.0000
##  35700        0.0003             nan     0.0010   -0.0000
##  35720        0.0003             nan     0.0010   -0.0000
##  35740        0.0003             nan     0.0010   -0.0000
##  35760        0.0003             nan     0.0010   -0.0000
##  35780        0.0003             nan     0.0010   -0.0000
##  35800        0.0003             nan     0.0010   -0.0000
##  35820        0.0003             nan     0.0010   -0.0000
##  35840        0.0003             nan     0.0010   -0.0000
##  35860        0.0003             nan     0.0010   -0.0000
##  35880        0.0003             nan     0.0010   -0.0000
##  35900        0.0003             nan     0.0010   -0.0000
##  35920        0.0003             nan     0.0010   -0.0000
##  35940        0.0003             nan     0.0010   -0.0000
##  35960        0.0003             nan     0.0010   -0.0000
```

```
##  35980        0.0003             nan     0.0010   -0.0000
##  36000        0.0003             nan     0.0010   -0.0000
##  36020        0.0003             nan     0.0010   -0.0000
##  36040        0.0003             nan     0.0010   -0.0000
##  36060        0.0003             nan     0.0010   -0.0000
##  36080        0.0003             nan     0.0010   -0.0000
##  36100        0.0003             nan     0.0010   -0.0000
##  36120        0.0003             nan     0.0010   -0.0000
##  36140        0.0003             nan     0.0010   -0.0000
##  36160        0.0003             nan     0.0010   -0.0000
##  36180        0.0003             nan     0.0010   -0.0000
##  36200        0.0003             nan     0.0010   -0.0000
##  36220        0.0003             nan     0.0010   -0.0000
##  36240        0.0003             nan     0.0010   -0.0000
##  36260        0.0003             nan     0.0010   -0.0000
##  36280        0.0003             nan     0.0010   -0.0000
##  36300        0.0003             nan     0.0010   -0.0000
##  36320        0.0003             nan     0.0010   -0.0000
##  36340        0.0003             nan     0.0010   -0.0000
##  36360        0.0003             nan     0.0010   -0.0000
##  36380        0.0003             nan     0.0010   -0.0000
##  36400        0.0003             nan     0.0010   -0.0000
##  36420        0.0003             nan     0.0010   -0.0000
##  36440        0.0003             nan     0.0010   -0.0000
##  36460        0.0003             nan     0.0010   -0.0000
##  36480        0.0003             nan     0.0010   -0.0000
##  36500        0.0003             nan     0.0010   -0.0000
##  36520        0.0003             nan     0.0010   -0.0000
##  36540        0.0003             nan     0.0010   -0.0000
##  36560        0.0003             nan     0.0010   -0.0000
##  36580        0.0003             nan     0.0010   -0.0000
##  36600        0.0003             nan     0.0010   -0.0000
##  36620        0.0003             nan     0.0010   -0.0000
##  36640        0.0003             nan     0.0010   -0.0000
##  36660        0.0003             nan     0.0010   -0.0000
##  36680        0.0003             nan     0.0010   -0.0000
##  36700        0.0003             nan     0.0010   -0.0000
##  36720        0.0003             nan     0.0010   -0.0000
##  36740        0.0003             nan     0.0010   -0.0000
##  36760        0.0003             nan     0.0010   -0.0000
##  36780        0.0003             nan     0.0010   -0.0000
##  36800        0.0003             nan     0.0010   -0.0000
##  36820        0.0003             nan     0.0010   -0.0000
##  36840        0.0003             nan     0.0010   -0.0000
##  36860        0.0003             nan     0.0010   -0.0000
##  36880        0.0003             nan     0.0010   -0.0000
##  36900        0.0003             nan     0.0010   -0.0000
##  36920        0.0003             nan     0.0010   -0.0000
##  36940        0.0003             nan     0.0010   -0.0000
##  36960        0.0003             nan     0.0010   -0.0000
##  36980        0.0003             nan     0.0010   -0.0000
##  37000        0.0003             nan     0.0010   -0.0000
##  37020        0.0003             nan     0.0010   -0.0000
##  37040        0.0003             nan     0.0010   -0.0000
```

```
##  37060        0.0003             nan     0.0010   -0.0000
##  37080        0.0003             nan     0.0010   -0.0000
##  37100        0.0003             nan     0.0010   -0.0000
##  37120        0.0003             nan     0.0010   -0.0000
##  37140        0.0003             nan     0.0010   -0.0000
##  37160        0.0003             nan     0.0010   -0.0000
##  37180        0.0003             nan     0.0010   -0.0000
##  37200        0.0003             nan     0.0010   -0.0000
##  37220        0.0003             nan     0.0010   -0.0000
##  37240        0.0003             nan     0.0010   -0.0000
##  37260        0.0003             nan     0.0010   -0.0000
##  37280        0.0003             nan     0.0010   -0.0000
##  37300        0.0003             nan     0.0010   -0.0000
##  37320        0.0003             nan     0.0010   -0.0000
##  37340        0.0003             nan     0.0010   -0.0000
##  37360        0.0003             nan     0.0010   -0.0000
##  37380        0.0003             nan     0.0010   -0.0000
##  37400        0.0003             nan     0.0010   -0.0000
##  37420        0.0003             nan     0.0010   -0.0000
##  37440        0.0003             nan     0.0010   -0.0000
##  37460        0.0003             nan     0.0010   -0.0000
##  37480        0.0003             nan     0.0010   -0.0000
##  37500        0.0003             nan     0.0010   -0.0000
##
## - Fold5: shrinkage=0.001, interaction.depth=10, n.minobsinnode=10, n.trees=37500
## Aggregating results
## Selecting tuning parameters
## Fitting n.trees = 4000, interaction.depth = 4, shrinkage = 0.001, n.minobsinnode = 10 on full
training set
## Iter   TrainDeviance   ValidDeviance   StepSize   Improve
##      1        0.0658             nan     0.0010    0.0001
##      2        0.0657             nan     0.0010    0.0001
##      3        0.0657             nan     0.0010    0.0001
##      4        0.0656             nan     0.0010    0.0001
##      5        0.0655             nan     0.0010    0.0001
##      6        0.0655             nan     0.0010    0.0001
##      7        0.0654             nan     0.0010    0.0001
##      8        0.0653             nan     0.0010    0.0001
##      9        0.0652             nan     0.0010    0.0001
##     10        0.0652             nan     0.0010    0.0001
##     20        0.0644             nan     0.0010    0.0001
##     40        0.0631             nan     0.0010    0.0000
##     60        0.0617             nan     0.0010    0.0001
##     80        0.0604             nan     0.0010    0.0001
##    100        0.0592             nan     0.0010    0.0000
##    120        0.0580             nan     0.0010    0.0000
##    140        0.0568             nan     0.0010    0.0001
##    160        0.0556             nan     0.0010    0.0001
##    180        0.0546             nan     0.0010    0.0000
##    200        0.0535             nan     0.0010    0.0000
##    220        0.0524             nan     0.0010    0.0000
##    240        0.0514             nan     0.0010    0.0000
##    260        0.0505             nan     0.0010    0.0000
##    280        0.0495             nan     0.0010    0.0000
```

```
##    300        0.0486             nan     0.0010    0.0000
##    320        0.0477             nan     0.0010    0.0000
##    340        0.0469             nan     0.0010    0.0000
##    360        0.0461             nan     0.0010    0.0000
##    380        0.0453             nan     0.0010    0.0000
##    400        0.0445             nan     0.0010    0.0000
##    420        0.0437             nan     0.0010    0.0000
##    440        0.0430             nan     0.0010    0.0000
##    460        0.0423             nan     0.0010    0.0000
##    480        0.0416             nan     0.0010    0.0000
##    500        0.0409             nan     0.0010    0.0000
##    520        0.0403             nan     0.0010    0.0000
##    540        0.0397             nan     0.0010    0.0000
##    560        0.0390             nan     0.0010    0.0000
##    580        0.0385             nan     0.0010    0.0000
##    600        0.0379             nan     0.0010    0.0000
##    620        0.0374             nan     0.0010    0.0000
##    640        0.0368             nan     0.0010    0.0000
##    660        0.0363             nan     0.0010    0.0000
##    680        0.0358             nan     0.0010    0.0000
##    700        0.0353             nan     0.0010    0.0000
##    720        0.0348             nan     0.0010    0.0000
##    740        0.0344             nan     0.0010    0.0000
##    760        0.0339             nan     0.0010    0.0000
##    780        0.0335             nan     0.0010    0.0000
##    800        0.0331             nan     0.0010    0.0000
##    820        0.0326             nan     0.0010    0.0000
##    840        0.0322             nan     0.0010    0.0000
##    860        0.0318             nan     0.0010    0.0000
##    880        0.0315             nan     0.0010    0.0000
##    900        0.0311             nan     0.0010    0.0000
##    920        0.0308             nan     0.0010    0.0000
##    940        0.0304             nan     0.0010    0.0000
##    960        0.0301             nan     0.0010    0.0000
##    980        0.0297             nan     0.0010    0.0000
##   1000        0.0294             nan     0.0010    0.0000
##   1020        0.0291             nan     0.0010    0.0000
##   1040        0.0288             nan     0.0010    0.0000
##   1060        0.0285             nan     0.0010    0.0000
##   1080        0.0282             nan     0.0010    0.0000
##   1100        0.0280             nan     0.0010    0.0000
##   1120        0.0277             nan     0.0010    0.0000
##   1140        0.0274             nan     0.0010    0.0000
##   1160        0.0272             nan     0.0010    0.0000
##   1180        0.0269             nan     0.0010    0.0000
##   1200        0.0267             nan     0.0010    0.0000
##   1220        0.0264             nan     0.0010    0.0000
##   1240        0.0262             nan     0.0010    0.0000
##   1260        0.0260             nan     0.0010    0.0000
##   1280        0.0257             nan     0.0010    0.0000
##   1300        0.0255             nan     0.0010    0.0000
##   1320        0.0253             nan     0.0010    0.0000
##   1340        0.0251             nan     0.0010    0.0000
##   1360        0.0249             nan     0.0010    0.0000
```

```
##   1380        0.0247             nan     0.0010    0.0000
##   1400        0.0245             nan     0.0010    0.0000
##   1420        0.0243             nan     0.0010    0.0000
##   1440        0.0242             nan     0.0010    0.0000
##   1460        0.0240             nan     0.0010    0.0000
##   1480        0.0238             nan     0.0010    0.0000
##   1500        0.0236             nan     0.0010    0.0000
##   1520        0.0235             nan     0.0010    0.0000
##   1540        0.0233             nan     0.0010    0.0000
##   1560        0.0231             nan     0.0010    0.0000
##   1580        0.0230             nan     0.0010    0.0000
##   1600        0.0228             nan     0.0010    0.0000
##   1620        0.0227             nan     0.0010    0.0000
##   1640        0.0225             nan     0.0010    0.0000
##   1660        0.0224             nan     0.0010    0.0000
##   1680        0.0222             nan     0.0010    0.0000
##   1700        0.0221             nan     0.0010    0.0000
##   1720        0.0220             nan     0.0010    0.0000
##   1740        0.0218             nan     0.0010    0.0000
##   1760        0.0217             nan     0.0010    0.0000
##   1780        0.0216             nan     0.0010    0.0000
##   1800        0.0215             nan     0.0010    0.0000
##   1820        0.0214             nan     0.0010    0.0000
##   1840        0.0212             nan     0.0010    0.0000
##   1860        0.0211             nan     0.0010    0.0000
##   1880        0.0210             nan     0.0010    0.0000
##   1900        0.0209             nan     0.0010    0.0000
##   1920        0.0208             nan     0.0010    0.0000
##   1940        0.0207             nan     0.0010    0.0000
##   1960        0.0206             nan     0.0010    0.0000
##   1980        0.0205             nan     0.0010    0.0000
##   2000        0.0204             nan     0.0010    0.0000
##   2020        0.0203             nan     0.0010   -0.0000
##   2040        0.0202             nan     0.0010    0.0000
##   2060        0.0201             nan     0.0010    0.0000
##   2080        0.0200             nan     0.0010    0.0000
##   2100        0.0199             nan     0.0010    0.0000
##   2120        0.0198             nan     0.0010    0.0000
##   2140        0.0197             nan     0.0010    0.0000
##   2160        0.0196             nan     0.0010    0.0000
##   2180        0.0195             nan     0.0010    0.0000
##   2200        0.0194             nan     0.0010    0.0000
##   2220        0.0194             nan     0.0010    0.0000
##   2240        0.0193             nan     0.0010    0.0000
##   2260        0.0192             nan     0.0010   -0.0000
##   2280        0.0191             nan     0.0010    0.0000
##   2300        0.0190             nan     0.0010   -0.0000
##   2320        0.0190             nan     0.0010    0.0000
##   2340        0.0189             nan     0.0010    0.0000
##   2360        0.0188             nan     0.0010    0.0000
##   2380        0.0188             nan     0.0010    0.0000
##   2400        0.0187             nan     0.0010    0.0000
##   2420        0.0186             nan     0.0010    0.0000
##   2440        0.0185             nan     0.0010    0.0000
```

```
##   2460        0.0185             nan     0.0010    0.0000
##   2480        0.0184             nan     0.0010   -0.0000
##   2500        0.0183             nan     0.0010   -0.0000
##   2520        0.0183             nan     0.0010    0.0000
##   2540        0.0182             nan     0.0010    0.0000
##   2560        0.0182             nan     0.0010    0.0000
##   2580        0.0181             nan     0.0010   -0.0000
##   2600        0.0180             nan     0.0010    0.0000
##   2620        0.0180             nan     0.0010   -0.0000
##   2640        0.0179             nan     0.0010    0.0000
##   2660        0.0179             nan     0.0010   -0.0000
##   2680        0.0178             nan     0.0010   -0.0000
##   2700        0.0178             nan     0.0010   -0.0000
##   2720        0.0177             nan     0.0010   -0.0000
##   2740        0.0176             nan     0.0010   -0.0000
##   2760        0.0176             nan     0.0010   -0.0000
##   2780        0.0175             nan     0.0010    0.0000
##   2800        0.0175             nan     0.0010    0.0000
##   2820        0.0174             nan     0.0010    0.0000
##   2840        0.0174             nan     0.0010   -0.0000
##   2860        0.0173             nan     0.0010   -0.0000
##   2880        0.0173             nan     0.0010    0.0000
##   2900        0.0172             nan     0.0010   -0.0000
##   2920        0.0172             nan     0.0010    0.0000
##   2940        0.0171             nan     0.0010   -0.0000
##   2960        0.0171             nan     0.0010    0.0000
##   2980        0.0170             nan     0.0010   -0.0000
##   3000        0.0170             nan     0.0010   -0.0000
##   3020        0.0169             nan     0.0010   -0.0000
##   3040        0.0169             nan     0.0010   -0.0000
##   3060        0.0168             nan     0.0010    0.0000
##   3080        0.0168             nan     0.0010   -0.0000
##   3100        0.0168             nan     0.0010   -0.0000
##   3120        0.0167             nan     0.0010    0.0000
##   3140        0.0167             nan     0.0010   -0.0000
##   3160        0.0166             nan     0.0010   -0.0000
##   3180        0.0166             nan     0.0010   -0.0000
##   3200        0.0165             nan     0.0010   -0.0000
##   3220        0.0165             nan     0.0010   -0.0000
##   3240        0.0165             nan     0.0010    0.0000
##   3260        0.0164             nan     0.0010   -0.0000
##   3280        0.0164             nan     0.0010   -0.0000
##   3300        0.0163             nan     0.0010   -0.0000
##   3320        0.0163             nan     0.0010   -0.0000
##   3340        0.0163             nan     0.0010   -0.0000
##   3360        0.0162             nan     0.0010   -0.0000
##   3380        0.0162             nan     0.0010    0.0000
##   3400        0.0161             nan     0.0010   -0.0000
##   3420        0.0161             nan     0.0010   -0.0000
##   3440        0.0161             nan     0.0010   -0.0000
##   3460        0.0160             nan     0.0010    0.0000
##   3480        0.0160             nan     0.0010   -0.0000
##   3500        0.0160             nan     0.0010   -0.0000
##   3520        0.0159             nan     0.0010   -0.0000
```

```
##   3540        0.0159             nan     0.0010   -0.0000
##   3560        0.0158             nan     0.0010   -0.0000
##   3580        0.0158             nan     0.0010   -0.0000
##   3600        0.0158             nan     0.0010   -0.0000
##   3620        0.0157             nan     0.0010   -0.0000
##   3640        0.0157             nan     0.0010    0.0000
##   3660        0.0157             nan     0.0010    0.0000
##   3680        0.0156             nan     0.0010   -0.0000
##   3700        0.0156             nan     0.0010   -0.0000
##   3720        0.0156             nan     0.0010   -0.0000
##   3740        0.0155             nan     0.0010   -0.0000
##   3760        0.0155             nan     0.0010    0.0000
##   3780        0.0155             nan     0.0010   -0.0000
##   3800        0.0154             nan     0.0010   -0.0000
##   3820        0.0154             nan     0.0010   -0.0000
##   3840        0.0154             nan     0.0010   -0.0000
##   3860        0.0153             nan     0.0010   -0.0000
##   3880        0.0153             nan     0.0010   -0.0000
##   3900        0.0153             nan     0.0010   -0.0000
##   3920        0.0152             nan     0.0010   -0.0000
##   3940        0.0152             nan     0.0010   -0.0000
##   3960        0.0152             nan     0.0010   -0.0000
##   3980        0.0152             nan     0.0010    0.0000
##   4000        0.0151             nan     0.0010   -0.0000
```

```
train.boost #ntrees=4000,interaction.depth=4
```

```
## Stochastic Gradient Boosting
##
## 637 samples
##  16 predictor
##
## No pre-processing
## Resampling: Cross-Validated (5 fold)
## Summary of sample sizes: 509, 508, 510, 512, 509
## Resampling results across tuning parameters:
##
##   interaction.depth  n.trees  RMSE       Rsquared   MAE
##    1                   500    0.2214558  0.4792111  0.16511538
##    1                  1000    0.2020549  0.4969852  0.14811466
##    1                  1500    0.1907759  0.5191214  0.13683499
##    1                  2000    0.1831320  0.5373833  0.12848911
##    1                  2500    0.1778574  0.5505235  0.12209313
##    1                  3000    0.1742092  0.5597227  0.11716936
##    1                  3500    0.1716621  0.5664189  0.11334564
##    1                  4000    0.1701625  0.5703639  0.11062390
##    1                  4500    0.1691255  0.5734536  0.10869947
##    1                  5000    0.1685429  0.5752649  0.10789840
##    1                  5500    0.1681944  0.5763153  0.10764586
##    1                  6000    0.1679193  0.5772218  0.10766962
##    1                  6500    0.1676691  0.5782582  0.10781953
##    1                  7000    0.1675026  0.5791145  0.10807441
##    1                  7500    0.1674431  0.5794730  0.10839219
##    1                  8000    0.1673553  0.5798363  0.10872500
##    1                  8500    0.1672696  0.5802706  0.10906576
##    1                  9000    0.1671723  0.5808824  0.10944028
##    1                  9500    0.1671933  0.5809542  0.10978272
##    1                 10000    0.1671539  0.5812307  0.11012546
##    1                 10500    0.1671547  0.5813962  0.11046063
##    1                 11000    0.1671482  0.5815500  0.11076698
##    1                 11500    0.1670776  0.5818552  0.11103891
##    1                 12000    0.1670899  0.5819566  0.11134365
##    1                 12500    0.1670744  0.5820467  0.11163698
##    1                 13000    0.1670629  0.5820531  0.11185851
##    1                 13500    0.1671021  0.5820431  0.11212352
##    1                 14000    0.1671688  0.5819046  0.11242023
##    1                 14500    0.1672609  0.5815236  0.11271889
##    1                 15000    0.1672414  0.5815486  0.11294315
##    1                 15500    0.1672694  0.5814595  0.11315290
##    1                 16000    0.1672855  0.5815873  0.11336020
##    1                 16500    0.1672617  0.5816539  0.11356570
##    1                 17000    0.1673041  0.5815828  0.11375661
##    1                 17500    0.1673724  0.5814112  0.11394510
##    1                 18000    0.1674393  0.5811127  0.11415674
##    1                 18500    0.1675226  0.5809154  0.11436165
##    1                 19000    0.1675932  0.5806968  0.11456401
##    1                 19500    0.1675779  0.5808066  0.11469208
##    1                 20000    0.1676236  0.5806323  0.11487004
##    1                 20500    0.1676828  0.5804456  0.11500101
##    1                 21000    0.1677423  0.5802403  0.11517986
```

```
##    1                21500    0.1678338  0.5799192  0.11536466
##    1                22000    0.1678938  0.5796839  0.11554429
##    1                22500    0.1678971  0.5797352  0.11565831
##    1                23000    0.1679281  0.5796376  0.11579512
##    1                23500    0.1679813  0.5795677  0.11591496
##    1                24000    0.1680311  0.5794820  0.11604862
##    1                24500    0.1680568  0.5792360  0.11615515
##    1                25000    0.1680816  0.5792260  0.11628105
##    1                25500    0.1681189  0.5791069  0.11638408
##    1                26000    0.1682174  0.5787820  0.11652927
##    1                26500    0.1682819  0.5786252  0.11663353
##    1                27000    0.1683325  0.5782847  0.11673454
##    1                27500    0.1683847  0.5781400  0.11682979
##    1                28000    0.1684494  0.5778956  0.11696772
##    1                28500    0.1685378  0.5776667  0.11708884
##    1                29000    0.1685966  0.5773497  0.11720647
##    1                29500    0.1686372  0.5771779  0.11731944
##    1                30000    0.1686736  0.5770251  0.11742131
##    1                30500    0.1687696  0.5767262  0.11751840
##    1                31000    0.1688152  0.5765563  0.11758834
##    1                31500    0.1688788  0.5763740  0.11768664
##    1                32000    0.1689261  0.5761759  0.11776235
##    1                32500    0.1689816  0.5760901  0.11785943
##    1                33000    0.1690188  0.5758197  0.11793775
##    1                33500    0.1690658  0.5757314  0.11801278
##    1                34000    0.1691419  0.5755570  0.11812002
##    1                34500    0.1691867  0.5754365  0.11818911
##    1                35000    0.1692360  0.5751593  0.11825524
##    1                35500    0.1692954  0.5749372  0.11836039
##    1                36000    0.1693476  0.5747394  0.11842810
##    1                36500    0.1694348  0.5744117  0.11853231
##    1                37000    0.1694931  0.5742627  0.11859583
##    1                37500    0.1695597  0.5741320  0.11868027
##    2                  500    0.2137503  0.5604232  0.15977050
##    2                 1000    0.1900088  0.5781564  0.13913312
##    2                 1500    0.1765877  0.5921661  0.12559398
##    2                 2000    0.1688755  0.6028566  0.11634537
##    2                 2500    0.1643709  0.6105790  0.10959152
##    2                 3000    0.1619216  0.6152882  0.10496616
##    2                 3500    0.1606477  0.6185082  0.10192181
##    2                 4000    0.1598136  0.6211583  0.09998822
##    2                 4500    0.1593077  0.6231082  0.09880187
##    2                 5000    0.1590381  0.6241381  0.09823526
##    2                 5500    0.1589199  0.6245225  0.09810074
##    2                 6000    0.1588604  0.6248718  0.09824476
##    2                 6500    0.1589107  0.6249419  0.09854758
##    2                 7000    0.1590157  0.6245981  0.09897750
##    2                 7500    0.1590626  0.6243050  0.09928272
##    2                 8000    0.1591175  0.6241695  0.09964640
##    2                 8500    0.1592280  0.6238063  0.09997356
##    2                 9000    0.1594571  0.6228850  0.10036185
##    2                 9500    0.1596208  0.6221653  0.10070837
##    2                10000    0.1597952  0.6215747  0.10105302
##    2                10500    0.1600374  0.6206522  0.10140356
```

```
##    2                 11000    0.1602157  0.6199648  0.10172315
##    2                 11500    0.1604588  0.6191029  0.10203659
##    2                 12000    0.1606167  0.6184754  0.10230569
##    2                 12500    0.1608240  0.6176909  0.10255068
##    2                 13000    0.1609856  0.6170830  0.10275346
##    2                 13500    0.1610696  0.6165900  0.10293637
##    2                 14000    0.1612863  0.6158137  0.10317954
##    2                 14500    0.1614250  0.6152745  0.10330915
##    2                 15000    0.1616299  0.6144505  0.10354205
##    2                 15500    0.1617791  0.6139780  0.10371125
##    2                 16000    0.1619087  0.6134491  0.10383206
##    2                 16500    0.1621331  0.6126041  0.10402804
##    2                 17000    0.1622810  0.6121171  0.10422085
##    2                 17500    0.1624086  0.6117243  0.10436348
##    2                 18000    0.1626084  0.6109255  0.10451729
##    2                 18500    0.1627691  0.6103134  0.10465935
##    2                 19000    0.1628951  0.6098289  0.10477137
##    2                 19500    0.1631061  0.6090511  0.10497543
##    2                 20000    0.1632228  0.6087294  0.10511400
##    2                 20500    0.1633785  0.6080979  0.10522949
##    2                 21000    0.1635344  0.6075315  0.10536598
##    2                 21500    0.1636318  0.6071449  0.10544792
##    2                 22000    0.1638008  0.6065304  0.10558707
##    2                 22500    0.1639156  0.6060297  0.10570732
##    2                 23000    0.1640671  0.6054805  0.10580877
##    2                 23500    0.1641638  0.6051929  0.10589365
##    2                 24000    0.1643228  0.6044657  0.10599951
##    2                 24500    0.1644884  0.6037854  0.10613654
##    2                 25000    0.1646500  0.6031625  0.10628593
##    2                 25500    0.1647519  0.6026876  0.10637125
##    2                 26000    0.1648764  0.6022171  0.10648756
##    2                 26500    0.1649698  0.6017583  0.10656465
##    2                 27000    0.1650527  0.6014732  0.10663942
##    2                 27500    0.1651658  0.6010775  0.10675308
##    2                 28000    0.1652546  0.6007621  0.10684296
##    2                 28500    0.1653858  0.6001812  0.10696463
##    2                 29000    0.1655380  0.5995648  0.10710268
##    2                 29500    0.1656556  0.5990614  0.10718974
##    2                 30000    0.1658216  0.5984188  0.10729817
##    2                 30500    0.1659337  0.5979505  0.10738733
##    2                 31000    0.1659881  0.5977160  0.10743805
##    2                 31500    0.1660786  0.5974156  0.10753321
##    2                 32000    0.1661791  0.5969972  0.10762031
##    2                 32500    0.1663089  0.5963877  0.10774770
##    2                 33000    0.1664091  0.5960499  0.10782755
##    2                 33500    0.1665558  0.5954389  0.10793625
##    2                 34000    0.1666956  0.5949787  0.10807434
##    2                 34500    0.1668367  0.5943526  0.10819605
##    2                 35000    0.1669858  0.5937913  0.10831560
##    2                 35500    0.1670568  0.5935155  0.10836493
##    2                 36000    0.1671539  0.5930449  0.10843982
##    2                 36500    0.1672478  0.5926805  0.10853983
##    2                 37000    0.1673684  0.5922293  0.10863388
##    2                 37500    0.1674849  0.5917337  0.10872547
```

```
##    4                   500    0.2081001  0.5930581  0.15506055
##    4                  1000    0.1831339  0.6020570  0.13234731
##    4                  1500    0.1705480  0.6106607  0.11842771
##    4                  2000    0.1642763  0.6177361  0.10947892
##    4                  2500    0.1611253  0.6229935  0.10379603
##    4                  3000    0.1595433  0.6265126  0.10021965
##    4                  3500    0.1588250  0.6284245  0.09816705
##    4                  4000    0.1585888  0.6289045  0.09730911
##    4                  4500    0.1586172  0.6289872  0.09712436
##    4                  5000    0.1586710  0.6287279  0.09721216
##    4                  5500    0.1588093  0.6281724  0.09753125
##    4                  6000    0.1591624  0.6266933  0.09798206
##    4                  6500    0.1594750  0.6252876  0.09844005
##    4                  7000    0.1597877  0.6238037  0.09886474
##    4                  7500    0.1601182  0.6224451  0.09933991
##    4                  8000    0.1604669  0.6210524  0.09971809
##    4                  8500    0.1608090  0.6195923  0.10008900
##    4                  9000    0.1611486  0.6182290  0.10047200
##    4                  9500    0.1614466  0.6169540  0.10078336
##    4                 10000    0.1617722  0.6155133  0.10113906
##    4                 10500    0.1620352  0.6144409  0.10145201
##    4                 11000    0.1623149  0.6133813  0.10172519
##    4                 11500    0.1626354  0.6119679  0.10201037
##    4                 12000    0.1628977  0.6107972  0.10227710
##    4                 12500    0.1631919  0.6096134  0.10252108
##    4                 13000    0.1634325  0.6086692  0.10275018
##    4                 13500    0.1636501  0.6077203  0.10292078
##    4                 14000    0.1638746  0.6067647  0.10310736
##    4                 14500    0.1640733  0.6058495  0.10329800
##    4                 15000    0.1643461  0.6047095  0.10349918
##    4                 15500    0.1645750  0.6037229  0.10366859
##    4                 16000    0.1647998  0.6027834  0.10383637
##    4                 16500    0.1649999  0.6018412  0.10400886
##    4                 17000    0.1652350  0.6008822  0.10417221
##    4                 17500    0.1654106  0.6001028  0.10435615
##    4                 18000    0.1656218  0.5992080  0.10452839
##    4                 18500    0.1658166  0.5982908  0.10468686
##    4                 19000    0.1660728  0.5971898  0.10489168
##    4                 19500    0.1662586  0.5964464  0.10507368
##    4                 20000    0.1664480  0.5956697  0.10522151
##    4                 20500    0.1666183  0.5950179  0.10535695
##    4                 21000    0.1668123  0.5941862  0.10552806
##    4                 21500    0.1669522  0.5936082  0.10564676
##    4                 22000    0.1671218  0.5928233  0.10581134
##    4                 22500    0.1672841  0.5921121  0.10596674
##    4                 23000    0.1674383  0.5915153  0.10610127
##    4                 23500    0.1676237  0.5907184  0.10626492
##    4                 24000    0.1678090  0.5899697  0.10643673
##    4                 24500    0.1679593  0.5892991  0.10658273
##    4                 25000    0.1680940  0.5887025  0.10668507
##    4                 25500    0.1683023  0.5878532  0.10685865
##    4                 26000    0.1684177  0.5874002  0.10695632
##    4                 26500    0.1685526  0.5868480  0.10707024
##    4                 27000    0.1686666  0.5862840  0.10718260
```

```
##    4               27500    0.1688009  0.5856872  0.10729071
##    4               28000    0.1689137  0.5852355  0.10740345
##    4               28500    0.1690462  0.5846803  0.10755196
##    4               29000    0.1692570  0.5838181  0.10771089
##    4               29500    0.1693952  0.5832416  0.10782277
##    4               30000    0.1695108  0.5827616  0.10790706
##    4               30500    0.1696414  0.5823012  0.10801855
##    4               31000    0.1697798  0.5817395  0.10812054
##    4               31500    0.1698884  0.5812252  0.10823241
##    4               32000    0.1700139  0.5807376  0.10835756
##    4               32500    0.1701239  0.5802719  0.10844615
##    4               33000    0.1702166  0.5798486  0.10855412
##    4               33500    0.1703346  0.5794286  0.10864441
##    4               34000    0.1704742  0.5788458  0.10875689
##    4               34500    0.1705881  0.5782908  0.10885696
##    4               35000    0.1706793  0.5779450  0.10892784
##    4               35500    0.1707891  0.5774974  0.10900901
##    4               36000    0.1709009  0.5770026  0.10910501
##    4               36500    0.1710219  0.5765225  0.10918304
##    4               37000    0.1711095  0.5761821  0.10926702
##    4               37500    0.1712092  0.5757935  0.10936477
##    6                 500    0.2062742  0.6012482  0.15339828
##    6                1000    0.1809392  0.6101613  0.12998589
##    6                1500    0.1687524  0.6164286  0.11614566
##    6                2000    0.1629721  0.6222686  0.10754441
##    6                2500    0.1603198  0.6261458  0.10229248
##    6                3000    0.1593016  0.6279180  0.09924148
##    6                3500    0.1588865  0.6288074  0.09777288
##    6                4000    0.1588843  0.6286181  0.09740707
##    6                4500    0.1591060  0.6275732  0.09748808
##    6                5000    0.1593639  0.6265285  0.09782845
##    6                5500    0.1597698  0.6246656  0.09834818
##    6                6000    0.1601350  0.6230271  0.09879440
##    6                6500    0.1605253  0.6213253  0.09918451
##    6                7000    0.1610039  0.6193616  0.09963463
##    6                7500    0.1614863  0.6172603  0.10010738
##    6                8000    0.1618985  0.6154619  0.10048556
##    6                8500    0.1622634  0.6139025  0.10082191
##    6                9000    0.1626910  0.6121194  0.10117574
##    6                9500    0.1630061  0.6106655  0.10146560
##    6               10000    0.1633947  0.6089960  0.10178402
##    6               10500    0.1637044  0.6076224  0.10205452
##    6               11000    0.1640731  0.6060814  0.10232065
##    6               11500    0.1644335  0.6045285  0.10261128
##    6               12000    0.1646876  0.6033523  0.10285240
##    6               12500    0.1649701  0.6021348  0.10312565
##    6               13000    0.1652288  0.6010556  0.10333379
##    6               13500    0.1654504  0.6000441  0.10352183
##    6               14000    0.1657430  0.5987300  0.10373237
##    6               14500    0.1660121  0.5975615  0.10395490
##    6               15000    0.1663250  0.5961947  0.10417761
##    6               15500    0.1665370  0.5952758  0.10431987
##    6               16000    0.1667689  0.5942024  0.10447840
##    6               16500    0.1669717  0.5932760  0.10463377
```

```
##    6                 17000    0.1671798  0.5923788  0.10481005
##    6                 17500    0.1673755  0.5916151  0.10496103
##    6                 18000    0.1675964  0.5906946  0.10514607
##    6                 18500    0.1678058  0.5898655  0.10532107
##    6                 19000    0.1679845  0.5891321  0.10545738
##    6                 19500    0.1681568  0.5882760  0.10564420
##    6                 20000    0.1683034  0.5876082  0.10577413
##    6                 20500    0.1684910  0.5868241  0.10595575
##    6                 21000    0.1686735  0.5860131  0.10611852
##    6                 21500    0.1688634  0.5851839  0.10628469
##    6                 22000    0.1690340  0.5844878  0.10643509
##    6                 22500    0.1691823  0.5839013  0.10657057
##    6                 23000    0.1693301  0.5832654  0.10669796
##    6                 23500    0.1694919  0.5825754  0.10683236
##    6                 24000    0.1696317  0.5819980  0.10692455
##    6                 24500    0.1697697  0.5814524  0.10704839
##    6                 25000    0.1699091  0.5809223  0.10715336
##    6                 25500    0.1700438  0.5802984  0.10728196
##    6                 26000    0.1701859  0.5796818  0.10738237
##    6                 26500    0.1703177  0.5791111  0.10749251
##    6                 27000    0.1704677  0.5785403  0.10764465
##    6                 27500    0.1705798  0.5780616  0.10773864
##    6                 28000    0.1706827  0.5776539  0.10783402
##    6                 28500    0.1707882  0.5772259  0.10790984
##    6                 29000    0.1708922  0.5767972  0.10798989
##    6                 29500    0.1710107  0.5762526  0.10809600
##    6                 30000    0.1711197  0.5758264  0.10818352
##    6                 30500    0.1712382  0.5753036  0.10829063
##    6                 31000    0.1713437  0.5748381  0.10838585
##    6                 31500    0.1714284  0.5744365  0.10846881
##    6                 32000    0.1715349  0.5739525  0.10855328
##    6                 32500    0.1716204  0.5736513  0.10862160
##    6                 33000    0.1717187  0.5732653  0.10871153
##    6                 33500    0.1718129  0.5729223  0.10879245
##    6                 34000    0.1718861  0.5726156  0.10884123
##    6                 34500    0.1719582  0.5723176  0.10889610
##    6                 35000    0.1720431  0.5719629  0.10897737
##    6                 35500    0.1721154  0.5716671  0.10902591
##    6                 36000    0.1721900  0.5713887  0.10908647
##    6                 36500    0.1722616  0.5710899  0.10914798
##    6                 37000    0.1723336  0.5707940  0.10919233
##    6                 37500    0.1723913  0.5705614  0.10923649
##    8                   500    0.2056724  0.6043325  0.15266172
##    8                  1000    0.1800684  0.6117354  0.12885505
##    8                  1500    0.1682629  0.6170662  0.11515708
##    8                  2000    0.1628897  0.6221450  0.10679539
##    8                  2500    0.1604849  0.6255679  0.10180923
##    8                  3000    0.1596672  0.6263910  0.09924485
##    8                  3500    0.1594553  0.6264584  0.09825181
##    8                  4000    0.1597797  0.6247565  0.09822361
##    8                  4500    0.1601196  0.6230558  0.09851142
##    8                  5000    0.1605655  0.6210311  0.09887941
##    8                  5500    0.1610580  0.6191105  0.09927876
##    8                  6000    0.1615487  0.6169906  0.09971674
```

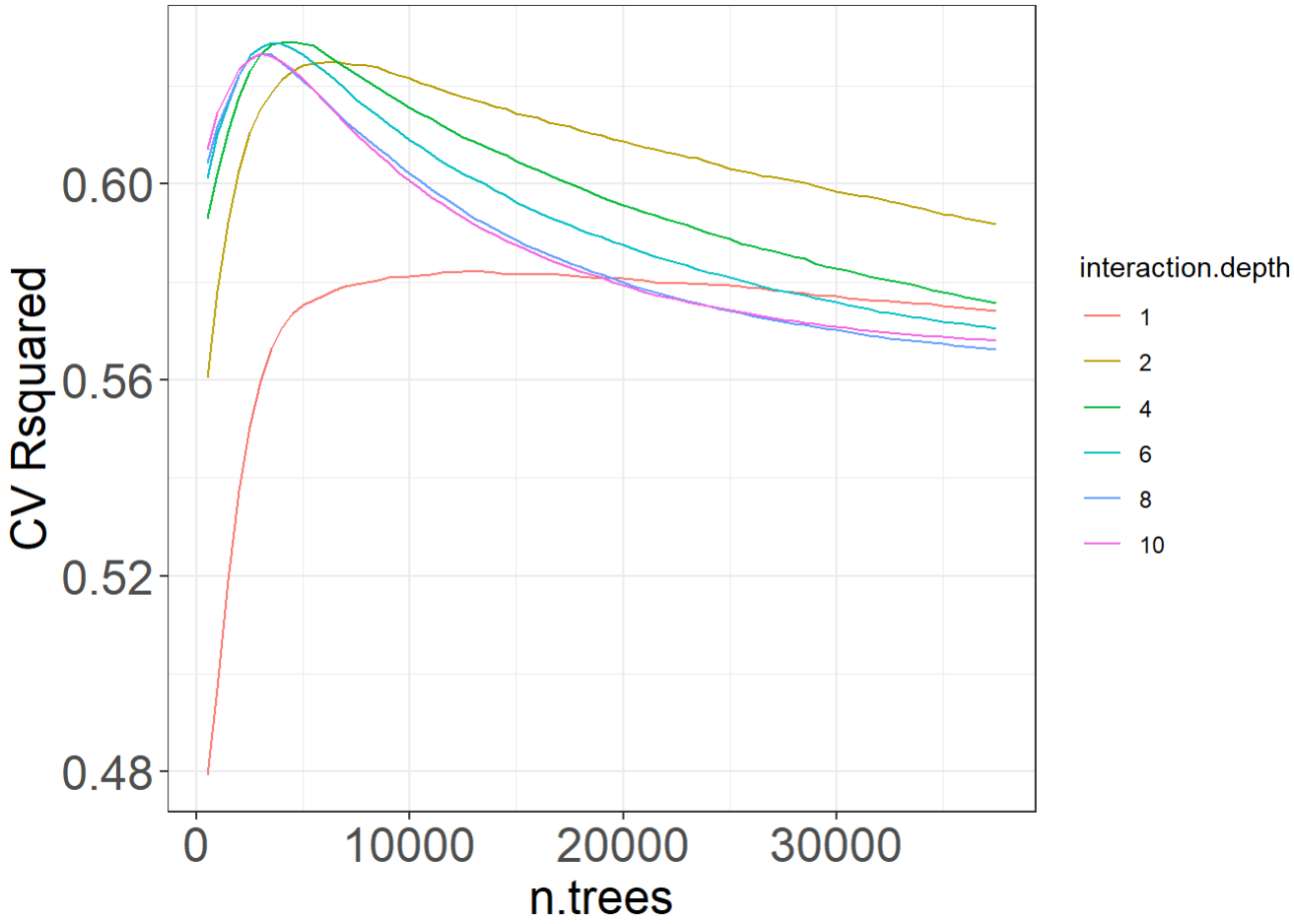
```
##    8                6500    0.1620194  0.6149453  0.10012626
##    8                7000    0.1624932  0.6128172  0.10054394
##    8                7500    0.1629046  0.6109574  0.10083853
##    8                8000    0.1633469  0.6090814  0.10119174
##    8                8500    0.1637542  0.6072844  0.10149558
##    8                9000    0.1641326  0.6056509  0.10179599
##    8                9500    0.1645473  0.6038767  0.10209211
##    8               10000    0.1649385  0.6020996  0.10239276
##    8               10500    0.1652967  0.6005745  0.10267627
##    8               11000    0.1656526  0.5989190  0.10297880
##    8               11500    0.1659840  0.5975343  0.10324656
##    8               12000    0.1663013  0.5960288  0.10349512
##    8               12500    0.1666123  0.5946988  0.10367286
##    8               13000    0.1669615  0.5930681  0.10397115
##    8               13500    0.1672248  0.5919293  0.10417162
##    8               14000    0.1674720  0.5908541  0.10436238
##    8               14500    0.1677548  0.5895907  0.10455701
##    8               15000    0.1679971  0.5885377  0.10475239
##    8               15500    0.1682494  0.5874278  0.10493570
##    8               16000    0.1684328  0.5865559  0.10511171
##    8               16500    0.1686664  0.5855437  0.10532156
##    8               17000    0.1688702  0.5846732  0.10547201
##    8               17500    0.1690614  0.5838019  0.10564713
##    8               18000    0.1692411  0.5830555  0.10580668
##    8               18500    0.1694527  0.5821351  0.10598701
##    8               19000    0.1696136  0.5814892  0.10611391
##    8               19500    0.1697758  0.5807506  0.10624270
##    8               20000    0.1699712  0.5799023  0.10641804
##    8               20500    0.1701448  0.5791349  0.10657525
##    8               21000    0.1703082  0.5784205  0.10671977
##    8               21500    0.1704661  0.5778334  0.10684511
##    8               22000    0.1706072  0.5772613  0.10697183
##    8               22500    0.1707364  0.5767219  0.10708514
##    8               23000    0.1708670  0.5761375  0.10719049
##    8               23500    0.1709795  0.5756785  0.10727387
##    8               24000    0.1711308  0.5750210  0.10738757
##    8               24500    0.1712524  0.5745143  0.10749021
##    8               25000    0.1713637  0.5740602  0.10759146
##    8               25500    0.1714674  0.5736381  0.10767362
##    8               26000    0.1715815  0.5731544  0.10776158
##    8               26500    0.1716972  0.5726663  0.10784594
##    8               27000    0.1717854  0.5722727  0.10790558
##    8               27500    0.1718736  0.5719146  0.10798474
##    8               28000    0.1719573  0.5715688  0.10804256
##    8               28500    0.1720472  0.5711947  0.10811889
##    8               29000    0.1721249  0.5708551  0.10817994
##    8               29500    0.1722156  0.5704617  0.10824505
##    8               30000    0.1722912  0.5701667  0.10830692
##    8               30500    0.1723984  0.5697577  0.10837783
##    8               31000    0.1724673  0.5694767  0.10844187
##    8               31500    0.1725511  0.5691460  0.10851079
##    8               32000    0.1726409  0.5687683  0.10858323
##    8               32500    0.1726979  0.5685351  0.10862665
##    8               33000    0.1727582  0.5682779  0.10866226
```

```
##    8                33500    0.1728055  0.5681233  0.10870440
##    8                34000    0.1728673  0.5678887  0.10875261
##    8                34500    0.1729380  0.5675809  0.10881606
##    8                35000    0.1729945  0.5673634  0.10886621
##    8                35500    0.1730617  0.5670987  0.10891549
##    8                36000    0.1731237  0.5668235  0.10896268
##    8                36500    0.1731733  0.5666317  0.10899807
##    8                37000    0.1732122  0.5665012  0.10903885
##    8                37500    0.1732712  0.5662506  0.10909732
##   10                  500    0.2050995  0.6070552  0.15213500
##   10                 1000    0.1794826  0.6144966  0.12818444
##   10                 1500    0.1678623  0.6190703  0.11473030
##   10                 2000    0.1625576  0.6234839  0.10644799
##   10                 2500    0.1604984  0.6254875  0.10181403
##   10                 3000    0.1597459  0.6265611  0.09946826
##   10                 3500    0.1596889  0.6260491  0.09869884
##   10                 4000    0.1599152  0.6249949  0.09863401
##   10                 4500    0.1602804  0.6235022  0.09885348
##   10                 5000    0.1607582  0.6213569  0.09923379
##   10                 5500    0.1612263  0.6191451  0.09956037
##   10                 6000    0.1617702  0.6167579  0.09996534
##   10                 6500    0.1622116  0.6147627  0.10033022
##   10                 7000    0.1627188  0.6124314  0.10072645
##   10                 7500    0.1632301  0.6101826  0.10110538
##   10                 8000    0.1637088  0.6080121  0.10144854
##   10                 8500    0.1641718  0.6060066  0.10176423
##   10                 9000    0.1645616  0.6042373  0.10204506
##   10                 9500    0.1650055  0.6022799  0.10234784
##   10                10000    0.1653673  0.6006051  0.10258157
##   10                10500    0.1656853  0.5991435  0.10284603
##   10                11000    0.1660691  0.5973076  0.10312015
##   10                11500    0.1663792  0.5959649  0.10332460
##   10                12000    0.1667406  0.5943463  0.10359089
##   10                12500    0.1670243  0.5931649  0.10378341
##   10                13000    0.1672967  0.5918803  0.10399682
##   10                13500    0.1675936  0.5906074  0.10421585
##   10                14000    0.1678361  0.5895497  0.10439079
##   10                14500    0.1680878  0.5884447  0.10459422
##   10                15000    0.1683000  0.5875320  0.10477279
##   10                15500    0.1685428  0.5865087  0.10496216
##   10                16000    0.1687551  0.5855014  0.10514819
##   10                16500    0.1689953  0.5844682  0.10533331
##   10                17000    0.1691620  0.5837118  0.10550409
##   10                17500    0.1693429  0.5829502  0.10565185
##   10                18000    0.1695334  0.5821340  0.10579576
##   10                18500    0.1696699  0.5815415  0.10591229
##   10                19000    0.1698174  0.5809213  0.10602152
##   10                19500    0.1700235  0.5800012  0.10616833
##   10                20000    0.1701643  0.5793453  0.10625569
##   10                20500    0.1703184  0.5786641  0.10636889
##   10                21000    0.1704776  0.5779786  0.10649549
##   10                21500    0.1706105  0.5774015  0.10660078
##   10                22000    0.1707360  0.5768998  0.10668013
##   10                22500    0.1708497  0.5764261  0.10676641
```

```
##   10                 23000    0.1709721  0.5759802  0.10687519
##   10                 23500    0.1710754  0.5755409  0.10697615
##   10                 24000    0.1711622  0.5751896  0.10704606
##   10                 24500    0.1712842  0.5746484  0.10713869
##   10                 25000    0.1713792  0.5742640  0.10722314
##   10                 25500    0.1714736  0.5738752  0.10729927
##   10                 26000    0.1715899  0.5733928  0.10739968
##   10                 26500    0.1716582  0.5730863  0.10745911
##   10                 27000    0.1717587  0.5727277  0.10754360
##   10                 27500    0.1718427  0.5723652  0.10760192
##   10                 28000    0.1719220  0.5720314  0.10767169
##   10                 28500    0.1719854  0.5717694  0.10772143
##   10                 29000    0.1720531  0.5714521  0.10778694
##   10                 29500    0.1721260  0.5711641  0.10785504
##   10                 30000    0.1722062  0.5708877  0.10791577
##   10                 30500    0.1722825  0.5705834  0.10797993
##   10                 31000    0.1723429  0.5703322  0.10803090
##   10                 31500    0.1724014  0.5700926  0.10808018
##   10                 32000    0.1724527  0.5699104  0.10811601
##   10                 32500    0.1725021  0.5697188  0.10816437
##   10                 33000    0.1725510  0.5694976  0.10819819
##   10                 33500    0.1726131  0.5692463  0.10825754
##   10                 34000    0.1726633  0.5690446  0.10830037
##   10                 34500    0.1726951  0.5689104  0.10832944
##   10                 35000    0.1727387  0.5687660  0.10836671
##   10                 35500    0.1727813  0.5686262  0.10840026
##   10                 36000    0.1728243  0.5684690  0.10843440
##   10                 36500    0.1728644  0.5683091  0.10847078
##   10                 37000    0.1729034  0.5681476  0.10850440
##   10                 37500    0.1729425  0.5679821  0.10854408
##
## Tuning parameter 'shrinkage' was held constant at a value of 0.001
##
## Tuning parameter 'n.minobsinnode' was held constant at a value of 10
## RMSE was used to select the optimal model using the smallest value.
## The final values used for the model were n.trees = 4000,
##  interaction.depth = 4, shrinkage = 0.001 and n.minobsinnode = 10.
```

```
best.boost <- train.boost$finalModel
pred.best.boost <- predict(best.boost, newdata = nba_csv.test, n.trees = 4000) # can use same mo
del matrix

ggplot(train.boost$results, aes(x = n.trees, y = Rsquared, colour = as.factor(interaction.dept
h))) + geom_line() +
  ylab("CV Rsquared") + theme_bw() + theme(axis.title=element_text(size=18), axis.text=element_t
ext(size=18)) +
  scale_color_discrete(name = "interaction.depth")
```




```
SSE = sum((nba_csv.test$award_share - pred.best.boost)^2)
SST = sum((nba_csv.test$award_share - mean(nba_csv.train$award_share))^2)
OSR2 = 1 - SSE/SST
OSR2 #0.8231889
```

```
## [1] 0.8231889
```

Bootstrapping for performance metrics

```
library(boot)
```

```
##
## Attaching package: 'boot'
```

```
## The following object is masked from 'package:car':
##
##     logit
```

```
## The following object is masked from 'package:lattice':
##
##     melanoma
```

```
boot_osr <- function(data, index) {
  labels <- data$label[index]
  predictions <- data$prediction[index]
  return(1 - (sum((labels - predictions)^2)/
                sum((labels - mean(data$label))^2)))
}

boot_mae <- function(data, index) {
  labels <- data$label[index]
  predictions <- data$prediction[index]
  return(mean(abs(labels-predictions)))
}

boot_rmse <- function(data, index) {
  labels <- data$label[index]
  predictions <- data$prediction[index]
  return(sqrt(mean((labels-predictions)^2)))
}

boot_all_metrics <- function(data, index) {
  osr = boot_osr(data, index)
  mae = boot_mae(data, index)
  rmse = boot_rmse(data, index)
  return(c(osr, mae, rmse))
}

big_B = 10000

##baseline model
#predict.baseline = rep(mean_obs, nrow(nba_csv.test))
#baseline_df = data.frame(labels = nba_csv.test$award_share, predictions = predict.baseline)
#set.seed(6829)
#Baseline_boot = boot(baseline_df, boot_all_metrics, R = big_B)
#Baseline_boot
#boot.ci(Baseline_boot, index = 1, type = "basic")
#boot.ci(Baseline_boot, index = 2, type = "basic")
#boot.ci(Baseline_boot, index = 3, type = "basic")

##naive lin reg
lin_df = data.frame(labels = nba_csv.test$award_share, predictions = predictions_testlm)
set.seed(342)

Lin_boot = boot(lin_df, boot_all_metrics, R = big_B)
Lin_boot
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = lin_df, statistic = boot_all_metrics, R = big_B)
##
##
## Bootstrap Statistics :
##      original        bias    std. error
## t1* 0.5506391 -5.595224e-02  0.17788423
## t2* 0.1772665  3.304536e-05  0.02856057
## t3* 0.2030427 -2.661079e-03  0.03412865
```

```
boot.ci(Lin_boot, index = 1, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Lin_boot, type = "basic", index = 1)
##
## Intervals :
## Level      Basic
## 95%   ( 0.3989,  1.1281 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Lin_boot, index = 2, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Lin_boot, type = "basic", index = 2)
##
## Intervals :
## Level      Basic
## 95%   ( 0.1165,  0.2289 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Lin_boot, index = 3, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Lin_boot, type = "basic", index = 3)
##
## Intervals :
## Level      Basic
## 95%   ( 0.1363,  0.2635 )
## Calculations and Intervals on Original Scale
```

```
##backwards stepwise lin reg
stepwise_df = data.frame(labels = nba_csv.test$award_share, predictions =  pred.bswr)
set.seed(342)
Step_boot = boot(stepwise_df, boot_all_metrics, R = big_B)
Step_boot
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = stepwise_df, statistic = boot_all_metrics, R = big_B)
##
##
## Bootstrap Statistics :
##      original        bias    std. error
## t1* 0.5513073 -5.822719e-02  0.17656909
## t2* 0.1787127  3.674980e-06  0.02774371
## t3* 0.2028917 -2.379516e-03  0.03215793
```

```
boot.ci(Step_boot, index = 1, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Step_boot, type = "basic", index = 1)
##
## Intervals :
## Level      Basic
## 95%   ( 0.4139,  1.1281 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Step_boot, index = 2, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Step_boot, type = "basic", index = 2)
##
## Intervals :
## Level      Basic
## 95%   ( 0.1201,  0.2296 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Step_boot, index = 3, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Step_boot, type = "basic", index = 3)
##
## Intervals :
## Level      Basic
## 95%   ( 0.1397,  0.2602 )
## Calculations and Intervals on Original Scale
```

```
##random forest
rf_df = data.frame(labels = nba_csv.test$award_share, predictions = pred.best.rf)
set.seed(6722)
RF_boot = boot(rf_df, boot_all_metrics, R = big_B)
RF_boot
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = rf_df, statistic = boot_all_metrics, R = big_B)
##
##
## Bootstrap Statistics :
##      original        bias    std. error
## t1* 0.7581074 -5.016702e-02  0.16450474
## t2* 0.1248506  6.594466e-05  0.02327981
## t3* 0.1489708 -1.754376e-03  0.02357759
```

```
boot.ci(RF_boot, index = 1, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = RF_boot, type = "basic", index = 1)
##
## Intervals :
## Level      Basic
## 95%   ( 0.6397,  1.3085 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(RF_boot, index = 2, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = RF_boot, type = "basic", index = 2)
##
## Intervals :
## Level      Basic
## 95%   ( 0.0775,  0.1690 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(RF_boot, index = 3, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = RF_boot, type = "basic", index = 3)
##
## Intervals :
## Level      Basic
## 95%   ( 0.1068,  0.1989 )
## Calculations and Intervals on Original Scale
```

```
##boosting
boost_df = data.frame(labels = nba_csv.test$award_share, predictions = pred.best.boost)
set.seed(9391)
Boost_boot = boot(boost_df, boot_all_metrics, R = big_B)
Boost_boot
```

```
##
## ORDINARY NONPARAMETRIC BOOTSTRAP
##
##
## Call:
## boot(data = boost_df, statistic = boot_all_metrics, R = big_B)
##
##
## Bootstrap Statistics :
##       original        bias    std. error
## t1* 0.81587466 -0.0509104966  0.19324228
## t2* 0.09692254  0.0002631934  0.02466090
## t3* 0.12997102 -0.0033825419  0.03044758
```

```
boot.ci(Boost_boot, index = 1, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Boost_boot, type = "basic", index = 1)
##
## Intervals :
## Level      Basic
## 95%   ( 0.6919,  1.4153 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Boost_boot, index = 2, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Boost_boot, type = "basic", index = 2)
##
## Intervals :
## Level      Basic
## 95%   ( 0.0434,  0.1399 )
## Calculations and Intervals on Original Scale
```

```
boot.ci(Boost_boot, index = 3, type = "basic")
```

```
## BOOTSTRAP CONFIDENCE INTERVAL CALCULATIONS
## Based on 10000 bootstrap replicates
##
## CALL :
## boot.ci(boot.out = Boost_boot, type = "basic", index = 3)
##
## Intervals :
## Level      Basic
## 95%   ( 0.0746,  0.1925 )
## Calculations and Intervals on Original Scale
```