MSD Final Project Report

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2019-05-02 16:36:14

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```
teams <- read_csv(here('teams.csv'))
salaries <- read_csv(here('salaries.csv'))
```

```
teams <- teams %>%
  filter(1985 <= yearID & yearID <= 2016) %>%
  mutate(winPercentage = W / (W + L) * 1000)

salaries <- salaries %>%
  filter(1985 <= yearID & yearID <= 2016) %>%
  mutate(salaryMil = salary / 1000000)
```

```
teams <- teams %>%
  inner_join(salaries) %>%
  group_by(yearID, teamID, G, W, L, winPercentage) %>%
  summarize(totalSalaryMil = sum(salaryMil))
```

```r
salaries <- salaries %>%
  inner_join(teams) %>%
  mutate(salaryShare = salaryMil / totalSalaryMil * 100) %>%
  mutate(salaryShareSquared = salaryShare ^ 2) %>%
  select(yearID, teamID, playerID, salary, salaryShare, salaryShareSquared)
```

```r
teams <- teams %>%
  inner_join(salaries) %>%
  group_by(yearID, teamID, G, W, L, winPercentage, totalSalaryMil) %>%
  summarize(HHI = sum(salaryShareSquared))
```

```r
teams_old <- teams %>%
  filter(1985 <= yearID & yearID <= 1998) %>%
  mutate(normalizedYear = yearID - 1985)

salaries_old <- salaries %>%
  filter(1985 <= yearID & yearID <= 1998)
```

```r
summary(teams_old$winPercentage)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   327.2   456.8   498.4   500.0   543.2   703.7
```

```r
summary(teams_old$totalSalaryMil)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##    0.88   12.76   22.32   25.16   36.29   72.36
```

```r
summary(teams_old$HHI)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   427.5   668.6   756.3   815.6   879.1  5300.1
```

```r
linear_fixed_old <- lm(formula = winPercentage ~ totalSalaryMil + HHI +
                                                 normalizedYear + teamID + 0,
                       data = teams_old)
summary(linear_fixed_old)$coefficients
```

```
##                    Estimate Std. Error   t value     Pr(>|t|)
## totalSalaryMil    2.1493337  0.4551468  4.722287 3.404816e-06
## HHI              -0.0120376  0.0114311 -1.053057 2.930560e-01
## normalizedYear   -5.4184670  1.5790948 -3.431375 6.738811e-04
## teamIDANA       520.3412853 46.2484875 11.250990 3.305855e-25
## teamIDARI       415.5845633 64.8210953  6.411255 4.778053e-10
## teamIDATL       500.2874262 20.6822732 24.189190 3.912949e-76
## teamIDBAL       474.6888319 20.3677945 23.305853 1.106243e-72
## teamIDBOS       500.3674770 20.4325763 24.488712 2.689059e-77
## teamIDCAL       478.6676384 20.6569410 23.172242 3.703357e-72
## teamIDCHA       497.3367589 20.2754263 24.529041 1.876375e-77
## teamIDCHN       472.8105792 20.2318161 23.369656 6.216065e-73
## teamIDCIN       504.8712038 19.9756579 25.274322 2.501974e-80
## teamIDCLE       487.3371161 19.2104121 25.368384 1.089483e-80
## teamIDCOL       477.3269106 28.3184575 16.855682 7.284719e-47
## teamIDDET       473.4187213 20.1658328 23.476279 2.374228e-73
## teamIDFLO       454.7556672 29.7189381 15.301881 1.175689e-40
## teamIDHOU       515.7181444 19.7505419 26.111595 1.581432e-83
## teamIDKCA       485.9458762 19.9615669 24.344075 9.787601e-77
```

```
## teamIDLAN      493.3318390 20.1372547 24.498466 2.464889e-77
## teamIDMIL      463.0607429 64.2852565  7.203218 3.755772e-12
## teamIDMIN      483.9572756 20.5503113 23.549876 1.222548e-73
## teamIDML4      494.3727955 20.2820858 24.374850 7.433918e-77
## teamIDMON      530.4524240 19.9905472 26.535163 3.921532e-85
## teamIDNYA      509.7065265 20.9672346 24.309669 1.331302e-76
## teamIDNYN      510.0199257 20.5600619 24.806342 1.587344e-78
## teamIDOAK      503.2701041 20.1869933 24.930414 5.270447e-79
## teamIDPHI      463.7557037 19.8160927 23.402984 4.600568e-73
## teamIDPIT      487.6110175 19.2593013 25.318209 1.697337e-80
## teamIDSDN      485.9750617 19.7978035 24.546918 1.599795e-77
## teamIDSEA      472.4450902 20.2362005 23.346531 7.659991e-73
## teamIDSFN      492.8906814 19.9322566 24.728293 3.178580e-78
## teamIDSLN      495.9950092 19.8301500 25.012166 2.551096e-79
## teamIDTBA      413.7955581 64.7841998  6.387291 5.497036e-10
## teamIDTEX      489.5752569 21.9602263 22.293726 1.084455e-68
## teamIDTOR      512.4375949 20.6188893 24.852822 1.050052e-78
```

```
linear_random_old <- lm(formula = winPercentage ~ totalSalaryMil + HHI + normalizedYear,
                        data = teams_old)
summary(linear_random_old)$coefficients
```

```
##                    Estimate  Std. Error   t value      Pr(>|t|)
## (Intercept)    494.46265725 10.80464965 45.763877 2.501463e-155
## totalSalaryMil   2.27827992  0.38799272  5.871966  9.513353e-09
## HHI             -0.01402974  0.01077516 -1.302045  1.937025e-01
## normalizedYear  -6.05527713  1.38637176 -4.367715  1.627858e-05
```

```
log_log_fixed_old <- lm(formula = log(winPercentage) ~ log(totalSalaryMil) + log(HHI) +
                                                       normalizedYear + teamID + 0,
                        data = teams_old)
summary(log_log_fixed_old)$coefficients
```

```
##                          Estimate  Std. Error   t value     Pr(>|t|)
## log(totalSalaryMil)  0.068481958 0.023048764  2.971177 3.175940e-03
## log(HHI)            -0.043092478 0.034083173 -1.264333 2.069690e-01
## normalizedYear      -0.006815679 0.003712079 -1.836081 6.721103e-02
## teamIDANA            6.381277477 0.258802544 24.656935 6.000401e-78
## teamIDARI            6.147474260 0.284859701 21.580709 7.375618e-66
## teamIDATL            6.341780647 0.254054450 24.962289 3.971429e-79
## teamIDBAL            6.304392674 0.252227238 24.994892 2.973619e-79
## teamIDBOS            6.356680411 0.254042578 25.022106 2.335784e-79
## teamIDCAL            6.296501097 0.251358491 25.049884 1.825754e-79
## teamIDCHA            6.353561607 0.253145391 25.098468 1.186854e-79
## teamIDCHN            6.295614193 0.255035277 24.685268 4.662152e-78
## teamIDCIN            6.363998559 0.252046869 25.249267 3.122677e-80
## teamIDCLE            6.314417826 0.244194538 25.858145 1.458689e-82
## teamIDCOL            6.302669708 0.251774555 25.032989 2.120858e-79
## teamIDDET            6.278537472 0.253687081 24.749142 2.640295e-78
## teamIDFLO            6.239856049 0.264167071 23.620870 6.447698e-74
## teamIDHOU            6.372617406 0.251976225 25.290550 2.167500e-80
## teamIDKCA            6.318245392 0.253724277 24.902014 6.782519e-79
## teamIDLAN            6.336534401 0.251504203 25.194547 5.067834e-80
## teamIDMIL            6.255310674 0.272629757 22.944343 2.918809e-71
## teamIDMIN            6.311256118 0.257376609 24.521483 2.007254e-77
```

```
## teamIDML4            6.331026869 0.253671900 24.957541 4.142388e-79
## teamIDMON            6.395786312 0.251422901 25.438360 5.873302e-81
## teamIDNYA            6.374791978 0.252496126 25.247088 3.183433e-80
## teamIDNYN            6.363423835 0.257124220 24.748442 2.656785e-78
## teamIDOAK            6.346043232 0.254205727 24.964202 3.904550e-79
## teamIDPHI            6.268077847 0.253347335 24.741045 2.837549e-78
## teamIDPIT            6.304910264 0.247423029 25.482310 3.985336e-81
## teamIDSDN            6.310660952 0.252946680 24.948582 4.485311e-79
## teamIDSEA            6.303619286 0.251664392 25.047720 1.861126e-79
## teamIDSFN            6.332517546 0.251659418 25.163046 6.698016e-80
## teamIDSLN            6.339364845 0.252096946 25.146536 7.752631e-80
## teamIDTBA            6.126803927 0.282074273 21.720534 2.046862e-66
## teamIDTEX            6.344583695 0.255152738 24.865826 9.354495e-79
## teamIDTOR            6.379838453 0.255083738 25.010761 2.583095e-79
```

```
log_log_random_old <- lm(formula = log(winPercentage) ~ log(totalSalaryMil) + log(HHI) +
                                                        normalizedYear,
                         data = teams_old)
summary(log_log_random_old)$coefficients
```

```
##                         Estimate  Std. Error   t value     Pr(>|t|)
## (Intercept)          6.336734123 0.228514736 27.730090 9.463580e-93
## log(totalSalaryMil)  0.077748160 0.019984364  3.890450 1.184254e-04
## log(HHI)            -0.046572660 0.031165596 -1.494361 1.359244e-01
## normalizedYear      -0.008653452 0.003294086 -2.626966 8.969280e-03
```

Reproduction Notes

- original author did not describe how time fixed effects are accounted for (across expansion periods or every year)
- no discussion about limiting to 25 man roster vs 40 man roster
- no discussion of cut players, traded players
- no discussion of signing bonuses

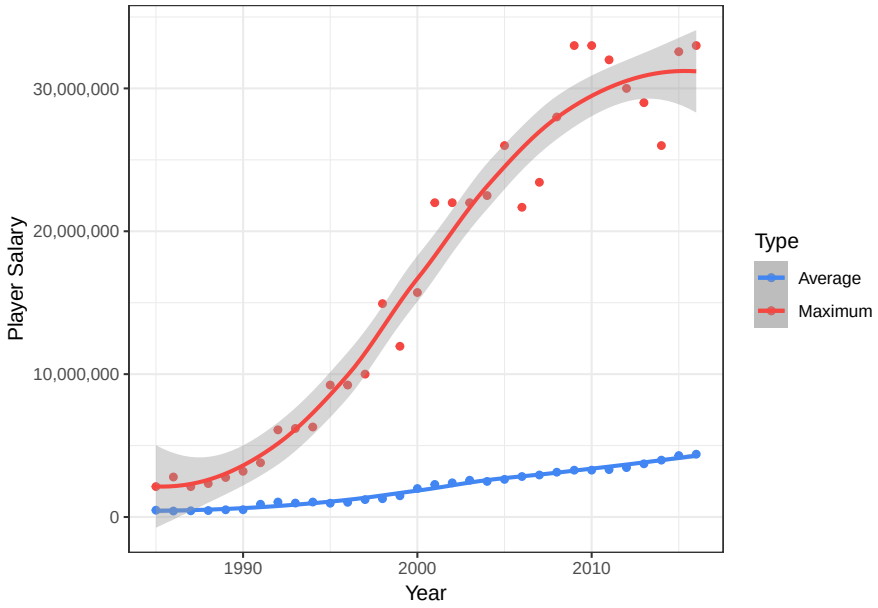
Reproduction Analysis

Extension

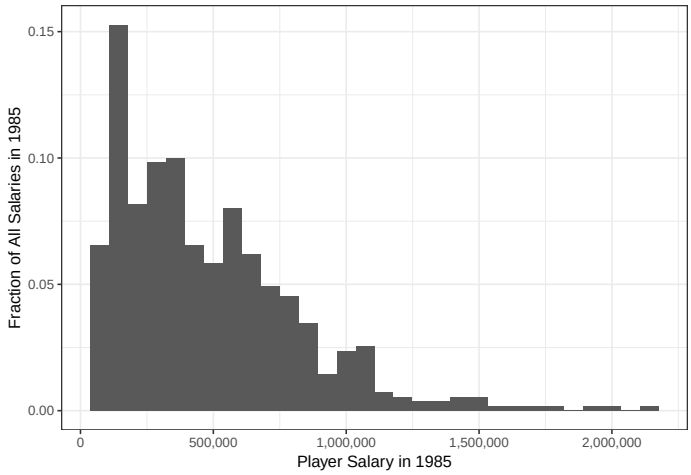
Extension Code

```
salary_vs_time <- salaries %>%
  group_by(yearID) %>%
  summarize(avg = mean(salary), max = max(salary))

ggplot(data = salary_vs_time) +
  geom_point(aes(x = yearID, y = avg, color = 'Average')) +
  geom_smooth(aes(x = yearID, y = avg, color = 'Average')) +
  geom_point(aes(x = yearID, y = max, color = 'Maximum')) +
  geom_smooth(aes(x = yearID, y = max, color = 'Maximum')) +
  scale_color_manual(values = c('#4286f4', '#f44741')) +
  scale_y_continuous(labels = comma) +
```

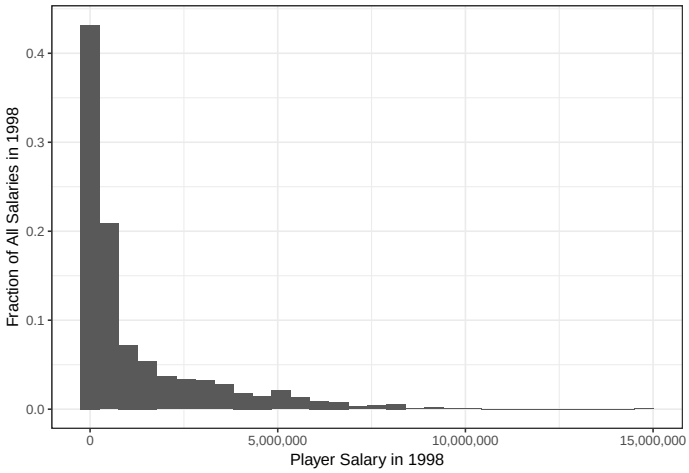
```
  labs(color = 'Type') +
  xlab('Year') +
  ylab('Player Salary')
```



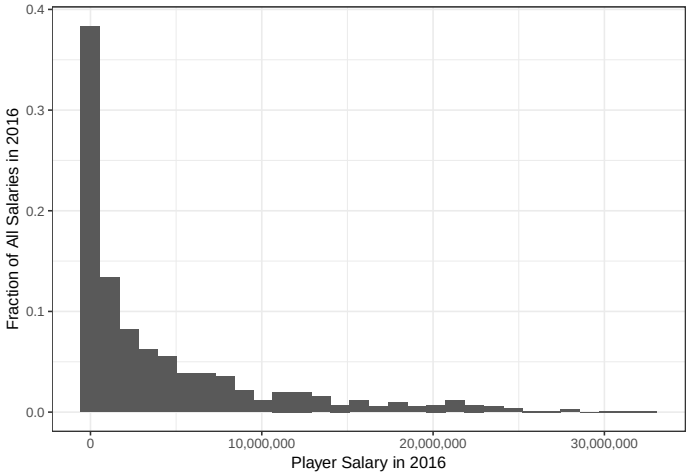

```
salaries_1985 <- filter(salaries, yearID == 1985)
salaries_1998 <- filter(salaries, yearID == 1998)
salaries_2016 <- filter(salaries, yearID == 2016)

ggplot(data = salaries_1985) +
  geom_histogram(aes(x = salary, y = (..count..) / sum(..count..))) +
  scale_x_continuous(labels = comma) +
  xlab('Player Salary in 1985') +
  ylab('Fraction of All Salaries in 1985')
```




```
ggplot(data = salaries_1998) +
  geom_histogram(aes(x = salary, y = (..count..) / sum(..count..))) +
  scale_x_continuous(labels = comma) +
  xlab('Player Salary in 1998') +
  ylab('Fraction of All Salaries in 1998')
```

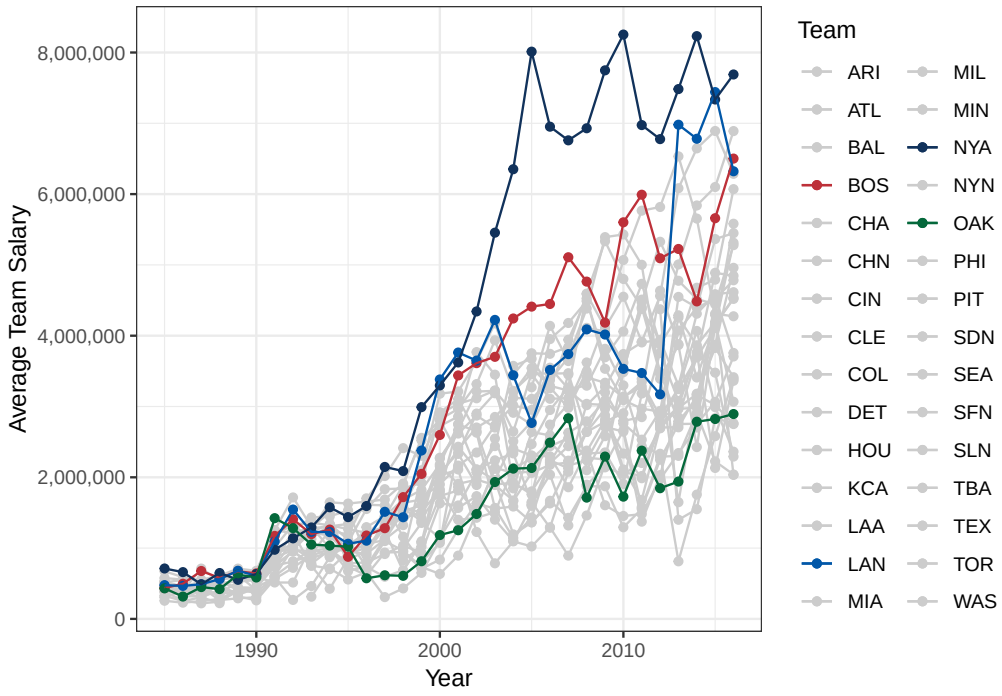



```
ggplot(data = salaries_2016) +
  geom_histogram(aes(x = salary, y = (..count..) / sum(..count..))) +
  scale_x_continuous(labels = comma) +
  xlab('Player Salary in 2016') +
  ylab('Fraction of All Salaries in 2016')
```

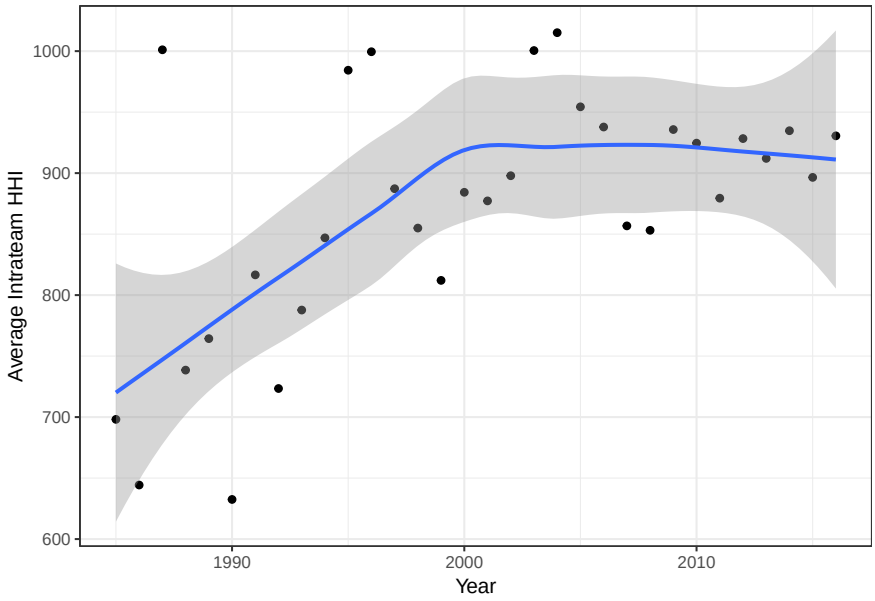



```
current_teamIDs <- c('ARI', 'ATL', 'BAL', 'BOS', 'CHA', 'CHN', 'CIN', 'CLE', 'COL', 'DET',
                     'HOU', 'KCA', 'LAA', 'LAN', 'MIA', 'MIL', 'MIN', 'NYA', 'NYN', 'OAK',
                     'PHI', 'PIT', 'SDN', 'SEA', 'SFN', 'SLN', 'TBA', 'TEX', 'TOR', 'WAS')
team_colors <- c('#cccccc', '#cccccc', '#cccccc', '#BD3039', '#cccccc',
                 '#cccccc', '#cccccc', '#cccccc', '#cccccc', '#cccccc',
                 '#cccccc', '#cccccc', '#cccccc', '#0157a8', '#cccccc',
                 '#cccccc', '#cccccc', '#11325b', '#cccccc', '#04683b',
                 '#cccccc', '#cccccc', '#cccccc', '#cccccc', '#cccccc',
                 '#cccccc', '#cccccc', '#cccccc', '#cccccc', '#cccccc')
colored_teamIDs <- c('BOS', 'LAN', 'NYA', 'OAK')

team_salary_vs_time <- salaries %>%
  filter(teamID %in% current_teamIDs) %>%
  group_by(yearID, teamID) %>%
  summarize(avg = mean(salary)) %>%
  mutate(flag = teamID %in% colored_teamIDs)
```

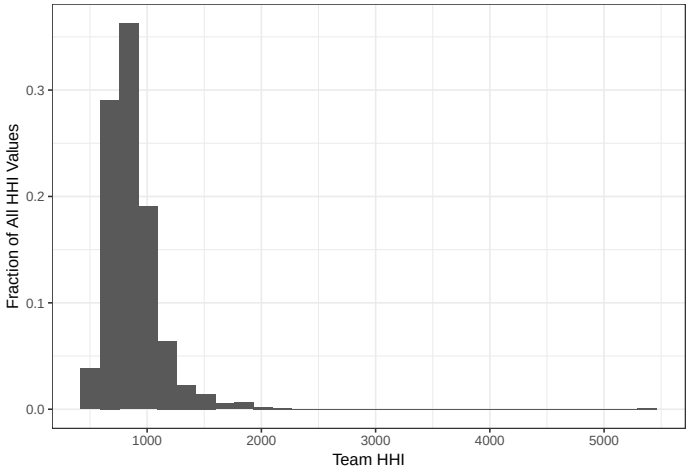
```
underlay_data <- filter(team_salary_vs_time, !flag)
overlay_data <- filter(team_salary_vs_time, flag)

ggplot() +
  geom_point(data = underlay_data, aes(x = yearID, y = avg, color = teamID)) +
  geom_line(data = underlay_data, aes(x = yearID, y = avg, color = teamID)) +
  geom_point(data = overlay_data, aes(x = yearID, y = avg, color = teamID)) +
  geom_line(data = overlay_data, aes(x = yearID, y = avg, color = teamID)) +
  scale_y_continuous(labels = comma) +
  scale_color_manual(values = team_colors) +
  labs(color = 'Team') +
  xlab('Year') +
  ylab('Average Team Salary')
```




```
hhi_vs_time <- teams %>%
  group_by(yearID) %>%
  summarize(avg = mean(HHI))

ggplot(data = hhi_vs_time) +
  geom_point(aes(x = yearID, y = avg)) +
  geom_smooth(aes(x = yearID, y = avg)) +
  xlab('Year') +
  ylab('Average Intrateam HHI')
```

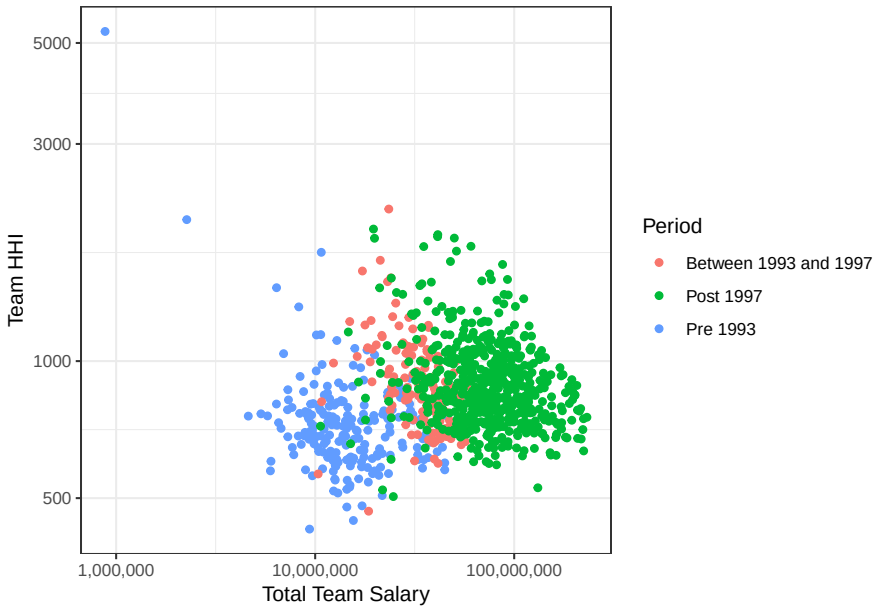



```
ggplot(data = teams) +
  geom_histogram(aes(x = HHI, y = (..count..) / sum(..count..))) +
  xlab('Team HHI') +
  ylab('Fraction of All HHI Values')
```




```
year_to_period <- function(year) {
  if (year <= 1992) {
    return('Pre 1993')
  }
  else if (1993 <= year & year <= 1997) {
    return('Between 1993 and 1997')
  }
  else {
    return('Post 1997')
  }
}

hhi_vs_total_salary <- teams %>%
  mutate(period = year_to_period(yearID))
```

```
ggplot(data = hhi_vs_total_salary) +
  geom_point(aes(x = totalSalaryMil * 1000000, y = HHI, color = period)) +
  scale_x_log10(labels = comma) +
  scale_y_log10() +
  labs(color = 'Period') +
  xlab('Total Team Salary') +
  ylab('Team HHI')
```




```
teams_new <- teams %>%
  filter(1999 <= yearID & yearID <= 2016) %>%
  mutate(normalizedYear = yearID - 1999)

salaries_new <- salaries %>%
  filter(1999 <= yearID & yearID <= 2016)
```

```
linear_fixed_new <- lm(formula = winPercentage ~ totalSalaryMil + HHI +
                                                 normalizedYear + teamID + 0,
                       data = teams_new)
summary(linear_fixed_new)$coefficients
```

```
##                    Estimate  Std. Error   t value      Pr(>|t|)
## totalSalaryMil    0.4631102  0.12923492  3.583476  3.719897e-04
## HHI              -0.0553023  0.01424983 -3.880909  1.178918e-04
## normalizedYear   -1.6956041  0.71841311 -2.360208  1.864475e-02
## teamIDANA       534.0510413 30.32251871 17.612358  1.851759e-54
## teamIDARI       522.6681026 21.36538952 24.463308  1.047528e-87
## teamIDATL       569.3170240 22.92559143 24.833254  1.665801e-89
## teamIDBAL       484.9265672 21.06741301 23.017851  1.167009e-80
## teamIDBOS       542.6474465 24.12132558 22.496585  4.100106e-78
## teamIDCHA       531.3769146 22.49874935 23.618065  1.373755e-83
## teamIDCHN       502.5817360 22.31441654 22.522737  3.055310e-78
## teamIDCIN       520.5153565 22.12384338 23.527348  3.805496e-83
## teamIDCLE       538.5674501 20.75582500 25.947774  6.627617e-95
## teamIDCOL       502.0606698 23.25797199 21.586606  1.139945e-73
## teamIDDET       499.2850080 23.14413396 21.572853  1.330503e-73
```

```
## teamIDFLO      536.5231862 22.92755695 23.400801  1.576996e-82
## teamIDHOU      525.3068861 23.23338235 22.610005  1.145004e-78
## teamIDKCA      481.7852916 20.76489561 23.201913  1.473992e-81
## teamIDLAA      560.7032015 26.04105391 21.531510  2.117516e-73
## teamIDLAN      535.4644196 24.23363154 22.095921  3.713914e-76
## teamIDMIA      491.0864245 32.11590364 15.291067  1.223742e-43
## teamIDMIL      504.7618772 21.31842823 23.677256  7.066975e-84
## teamIDMIN      531.4465850 22.60709560 23.507955  4.731704e-83
## teamIDMON      487.4651979 29.20533345 16.690965  4.124246e-50
## teamIDNYA      553.9452816 28.70673867 19.296699  1.553768e-62
## teamIDNYN      522.0042297 23.46601184 22.245119  6.935729e-77
## teamIDOAK      569.6007388 20.78021891 27.410719 6.100607e-102
## teamIDPHI      524.8218269 22.85586649 22.962237  2.180816e-80
## teamIDPIT      493.0886012 20.17956030 24.435052  1.437609e-87
## teamIDSDN      509.7572844 21.21759246 24.025218  1.422661e-85
## teamIDSEA      517.6689710 22.65298597 22.852130  7.521294e-80
## teamIDSFN      548.6625609 23.06561033 23.787038  2.060307e-84
## teamIDSLN      577.5566136 22.42201075 25.758467  5.450778e-94
## teamIDTBA      508.8919801 20.51144296 24.810150  2.157076e-89
## teamIDTEX      535.7386148 22.94066659 23.353228  2.691383e-82
## teamIDTOR      536.9642377 22.72659853 23.627127  1.240816e-83
## teamIDWAS      515.0379977 23.47179461 21.942847  2.077048e-75
```

```
linear_random_new <- lm(formula = winPercentage ~ totalSalaryMil + HHI + normalizedYear,
                        data = teams_new)
summary(linear_random_new)$coefficients
```

```
##                    Estimate  Std. Error   t value      Pr(>|t|)
## (Intercept)    504.53034280 15.53375065 32.479622 9.998674e-129
## totalSalaryMil   0.68988493  0.08449909  8.164406  2.324053e-15
## HHI             -0.04525471  0.01386628 -3.263651  1.169986e-03
## normalizedYear  -2.52975572  0.62573170 -4.042876  6.054218e-05
```

```
log_log_fixed_new <- lm(formula = log(winPercentage) ~ log(totalSalaryMil) + log(HHI) +
                                                       normalizedYear + teamID + 0,
                        data = teams_new)
summary(log_log_fixed_new)$coefficients
```

```
##                          Estimate  Std. Error   t value      Pr(>|t|)
## log(totalSalaryMil)  0.097454270 0.021330706  4.568732  6.177390e-06
## log(HHI)            -0.104976526 0.030167336 -3.479808  5.452894e-04
## normalizedYear      -0.004010857 0.001459855 -2.747436  6.221456e-03
## teamIDANA            6.545902569 0.251577167 26.019462  2.985881e-95
## teamIDARI            6.514528571 0.244647888 26.628182  3.472580e-98
## teamIDATL            6.607063266 0.250070357 26.420818  3.459804e-97
## teamIDBAL            6.441222144 0.243515517 26.450972  2.476197e-97
## teamIDBOS            6.556249344 0.247214746 26.520462  1.145852e-97
## teamIDCHA            6.543866668 0.247487119 26.441241  2.758410e-97
## teamIDCHN            6.473113563 0.246695111 26.239327  2.593789e-96
## teamIDCIN            6.521720508 0.246953478 26.408701  3.957586e-97
## teamIDCLE            6.555327851 0.242478267 27.034703 3.866303e-100
## teamIDCOL            6.479395569 0.250018166 25.915699  9.469698e-95
## teamIDDET            6.468131682 0.248154816 26.064905  1.801519e-95
## teamIDFLO            6.586182749 0.240359609 27.401371 6.762577e-102
## teamIDHOU            6.520628607 0.249140598 26.172485  5.449890e-96
```

```
## teamIDKCA            6.444804099 0.241295027 26.709229  1.415137e-98
## teamIDLAA            6.593793292 0.250724450 26.298964  1.337653e-96
## teamIDLAN            6.550167032 0.249014448 26.304365  1.259799e-96
## teamIDMIA            6.468418834 0.246672642 26.222684  3.120375e-96
## teamIDMIL            6.492244084 0.243896350 26.618865  3.850198e-98
## teamIDMIN            6.547342787 0.247192125 26.486858  1.663194e-97
## teamIDMON            6.482609709 0.244514177 26.512204  1.255718e-97
## teamIDNYA            6.589784353 0.252553776 26.092599  1.324156e-95
## teamIDNYN            6.517112372 0.249860313 26.083023  1.472872e-95
## teamIDOAK            6.626459061 0.242230449 27.356012 1.114900e-101
## teamIDPHI            6.529146172 0.247002247 26.433550  3.004085e-97
## teamIDPIT            6.473645991 0.239289686 27.053594 3.137998e-100
## teamIDSDN            6.505920153 0.243772080 26.688537  1.779558e-98
## teamIDSEA            6.498962798 0.247962143 26.209496  3.612647e-96
## teamIDSFN            6.574133594 0.248794121 26.423991  3.340126e-97
## teamIDSLN            6.625656726 0.247718821 26.746683  9.347701e-99
## teamIDTBA            6.505534931 0.239428766 27.171067 8.575645e-101
## teamIDTEX            6.547877551 0.249071467 26.289152  1.491609e-96
## teamIDTOR            6.554416557 0.247925135 26.437080  2.888728e-97
## teamIDWAS            6.506936212 0.242956253 26.782337  6.299524e-99
```

```
log_log_random_new <- lm(formula = log(winPercentage) ~ log(totalSalaryMil) + log(HHI) +
                                                        normalizedYear,
                         data = teams_new)
summary(log_log_random_new)$coefficients
```

```
##                         Estimate  Std. Error   t value      Pr(>|t|)
## (Intercept)          6.285422459 0.222740979 28.218528 4.704158e-108
## log(totalSalaryMil)  0.125655854 0.014620475  8.594512  9.189347e-17
## log(HHI)            -0.085180977 0.028918094 -2.945594  3.363412e-03
## normalizedYear      -0.005434256 0.001300813 -4.177585  3.439323e-05
```

Extension Notes

- note that minimum salary has increased over time: https://www.baseball-reference.com/bullpen/Minimum_salary

Extension Analysis