Basketball II

Produced by Dr. Mario

UNC STOR 390

+/- Player Ratings

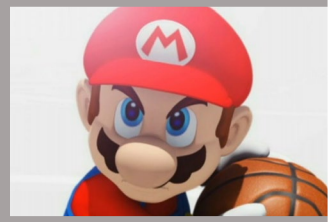
- Recall the Box Score

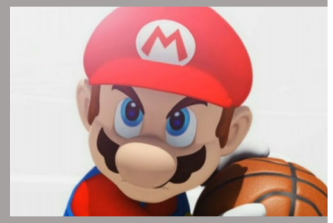
Toronto Raptors

PLAYERS	MIN	FG	3FG	FT	+/-	OFF	DEF	REB	AST	STL	BLK	TO	PF	PTS
Siakam	46	10-17	3-6	3-4	2	2	8	10	3	1	1	2	2	26
Lowry	42	9-16	4-7	4-6	16	2	5	7	10	3	0	3	5	26
Leonard	41	7-16	1-5	7-8	-2	1	5	6	3	2	1	2	4	22
Gasol	27	0-5	0-2	3-4	-7	3	6	9	4	0	0	1	4	3
Green	18	0-0	0-0	0-0	7	0	1	1	3	1	0	1	1	0

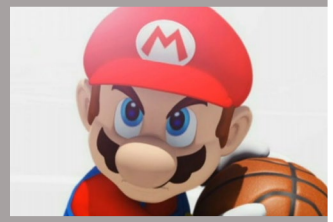
Notice the Additional Metric

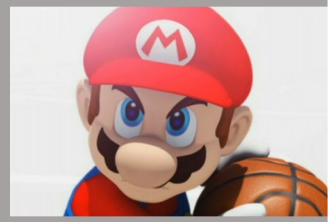
- Traditional Statistics Do Not Measure Player's Ability to … "Make the Team Better"






+/- Player Ratings





- Pure +/- Ratings
  - Historically from Hockey
    - Number of Goals a Player's Team Outscores Opponent When a Specific Player is Playing on Ice
    - Highest: Bobby Orr, 1970-1971, +124
    - "Worst Statistic in Hockey" by Hockey-Graphs.com
    - Counting Statistic of Rare Event (Subject to Outliers)
    - Time on Ice Not Reflected
    - Players Who Play the Most and Least Have +/- Closer to 0
    - Weakest Players Not Given Time to Accumulate Negative +/-
    - Same Values are Not Equal i.e. +5 Can Result from Many Scenarios
  - Application to Basketball
    - Pure +/- Statistic Based on Points and Scaled to 48 Minutes
    - Depends on Quality of Players When Player is on Court
    - Players on Bad Teams (Below .500 Record) Get Penalized

+/- Player Ratings

- Pure +/- Ratings
  - Found on www.82games.com
    - Cavs Championship Season
    - Seasonal Player Stats
    - Lebron James on the Court +-

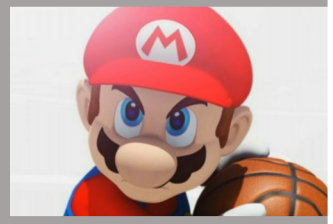
$$Net\ Points\ Per\ Min \times 48\ Min = \frac{617}{2709} \times 48$$
$$= 0.22776 \times 48 = 10.9$$

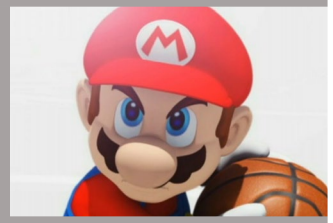
    - Lebron James on Bench +-

$$Net\ Points\ Per\ Min \times 48\ Min = \frac{-125}{1261} \times 48$$
$$= -0.09913 \times 48 = -4.8$$

    - Net Per 48 Minutes

$$Court\ -\ Bench = 10.9 - (-4.8) = 15.7$$

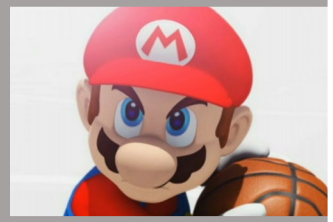


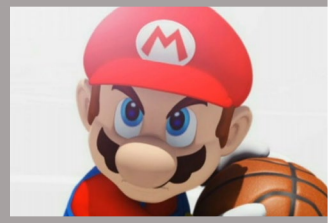


		Production			On Court/Off Court			Simple
Player	Min	Own	Opp	Net	On	Off	Net	Rating
James	68%	30.3	10.7	+19.6	+10.9	-4.8	+15.7	+18.3
Love	61%	21.2	15.3	+5.9	+8.4	+2.2	+6.2	+6.0
Irving	42%	21.4	18.5	+2.9	+5.9	+6.0	-0.1	+1.9
Thompson	57%	17.9	17.3	+0.5	+7.6	+3.7	+3.9	+1.6
McRae	3%	15.2	16.8	-1.6	+13.1	+5.7	+7.4	+1.4
Varejao	8%	12.7	12.7	-0.0	+8.1	+5.8	+2.3	+0.8
Dellavedova	47%	12.2	15.4	-3.2	+9.8	+2.6	+7.2	+0.2
Frye	11%	16.3	16.7	-0.3	+5.5	+6.0	-0.5	-0.4
JR.Smith	59%	13.4	14.4	-1.0	+6.3	+5.5	+0.8	-0.4
Shumpert	33%	9.4	14.9	-5.5	+6.8	+5.5	+1.3	-3.2
Jones	12%	12.7	13.8	-1.1	-2.2	+7.0	-9.2	-3.8
Mozgov	33%	16.2	19.8	-3.6	+0.1	+8.9	-8.8	-5.3
Kaun	2%	13.4	18.5	-5.1	-2.0	+6.1	-8.1	-6.1
Jefferson	33%	10.6	15.6	-5.0	-1.6	+9.7	-11.4	-7.1
Mo.Williams	19%	13.4	18.5	-5.2	-3.2	+8.1	-11.3	-7.2
D.Jones	1%	11.1	21.6	-10.6	-1.1	+6.0	-7.2	-9.4
Cunningham	9%	6.4	18.3	-11.9	-1.9	+6.7	-8.6	-10.8
Harris	0%	3.8	34.1	-30.3	-66.0	+6.2	-72.3	-30.2

Stat	ON Court	OFF Court	Net
Minutes	2709	1261	68%
Offense: Pts per 100 Poss.	116.6	103.0	+13.6
Defense: Pts per 100 Poss.	105.1	107.8	-2.7
Net Points per 100 Possessions	+11.5	-4.8	+16.3
Points Scored	6089	2466	+3623
Points Allowed	5472	2591	+2881
Net Points	+617	-125	+742

+/- Player Ratings





- Adjusted +/- Rating
  - Adjustment for Teammates Played With
  - Adjustment for Opponents Played Against
  - Adjustments Based on Play-by-Play Data Over Whole Season
  - Average +/- Rating = 0
- Simulated Game Data
  - Players 1-9 Compete Against Players 10-18 in 20 Games
  - Assume Starters Play the Entire Game
  - Results of Game Shown Below

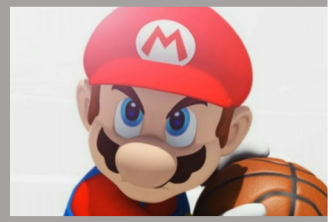
```
head(GameData)
```

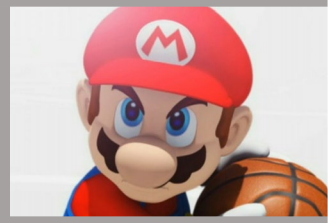
A tibble: 6 x 12

Game	Result	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
<int>	<int>	<int>	<int>	<int>	<int>	<int>	<int>	<int>	<int>	<int>	<int>
1	-13	4	1	7	5	2	15	16	10	17	14
2	19	1	6	2	5	4	11	17	14	15	18
3	-4	1	9	2	8	4	15	14	10	17	13
4	29	1	6	5	3	2	16	17	18	14	11
5	-3	9	7	1	5	6	17	15	12	18	10
6	12	7	2	5	1	4	17	11	15	16	18

+/- Player Ratings

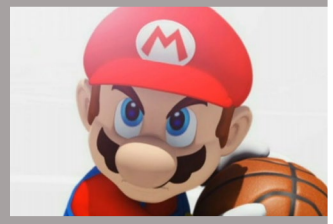
- Modified Game Data into Matrix (*A*)
  - Each Row is a Different Game (Except Last Row)
  - Each Column is A Different Player
    - 1 = Played on Team 1
    - 0 = Did Not Play
    - -1 = Played on Team 2
  - Notice Last Row of All 1's

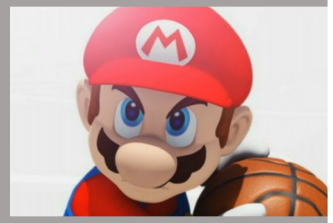




```
print(A)
 [,1] [,2] [,3] [,4] [,5] [,6] [,7] [,8] [,9] [,10] [,11] [,12] [,13] [,14] [,15] [,16] [,17] [,18]
    1    1    0    1    1    0    1    0    0   -1    0    0    0   -1   -1   -1   -1    0
    1    1    0    1    1    1    0    0    0    0   -1    0    0   -1   -1    0   -1   -1
    1    1    0    1    0    0    0    1    1   -1    0    0   -1   -1   -1    0   -1    0
    1    1    1    0    1    1    0    0    0    0   -1    0    0   -1    0   -1   -1   -1
    1    0    0    0    1    1    1    0    1   -1    0   -1    0    0   -1    0   -1   -1
    1    1    0    1    1    0    1    0    0    0   -1    0    0    0   -1   -1   -1   -1
    1    0    0    0    1    1    0    1    1   -1    0   -1   -1    0   -1   -1    0    0
    0    1    1    1    1    0    0    0    1   -1    0   -1    0    0   -1    0   -1   -1
    1    0    1    0    0    0    1    1    1    0   -1    0    0   -1   -1   -1   -1    0
    1    1    0    1    0    1    0    0    1   -1   -1    0   -1    0    0   -1    0   -1
    0    1    1    0    1    1    1    0    0    0    0   -1   -1   -1   -1    0   -1    0
    0    0    1    1    0    1    1    1    0    0   -1   -1    0    0   -1    0   -1   -1
    0    1    0    1    1    1    0    0    1    0   -1    0   -1   -1    0    0   -1   -1
    1    1    0    1    0    0    1    1    0    0    0   -1   -1   -1    0    0   -1   -1
    1    0    0    0    0    1    1    1    1   -1    0   -1    0   -1   -1    0   -1    0
    1    1    1    0    0    1    0    1    0   -1    0    0    0   -1    0   -1   -1   -1
    0    1    1    0    1    1    1    0    0   -1   -1    0   -1   -1    0   -1    0    0
    1    0    1    1    0    1    1    0    0    0   -1    0   -1   -1   -1    0    0   -1
    1    1    0    0    1    1    0    1    0    0    0   -1   -1   -1   -1    0    0   -1
    0    1    1    1    1    0    0    1    0   -1   -1    0    0    0    0   -1   -1   -1
    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1    1
```

+/- Player Ratings





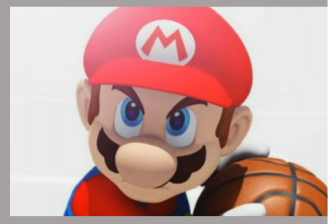
- Game Results into Vector (*y*)
  - Each Element is a Different Game (Except Last One)
  - Notice 0 in Last Element

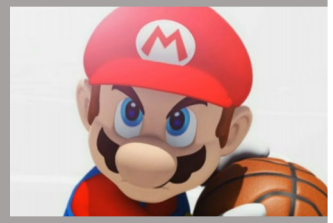
- Code Used to Create Matrix *A* and Vector *y*

```
#Modifed Data
GameData2 = cbind(GameData[,1:2],matrix(NA,20,18))
names(GameData2)[3:20]=paste("Player",1:18,sep="")

for(j in 1:20){
  for(k in 1:18)
  GameData2[j,k+2]= as.numeric(k %in% GameData[j,3:12])
}

GameData2[,12:20]=-GameData2[,12:20]
Games.Played=colSums(GameData2[,3:20])


#Added Constraint to Data (Sum of Effects = 0)
GameData2[21,]=c(NA,0,rep(1,18))

#Create Matrix A
A=as.matrix(GameData2[,3:20])

#Create Vector y
y=as.matrix(GameData2[,2])
```

```
print(y)
      [,1]
[1,]   -13
[2,]    19
[3,]    -4
[4,]    29
[5,]    -3
[6,]    12
[7,]    -5
[8,]   -32
[9,]    18
10,]    17
11,]   -11
12,]   -14
13,]    29
14,]    17
15,]    -4
16,]    -7
17,]     9
18,]    24
19,]    18
20,]   -24
21,]     0
```

+/- Player Ratings





- **Goal: Estimate Adjusted +/- for All 18 Players**
  - Expressed into Vector (*b*)

    $\vec{b} = [b_1, b_2, \cdots, b_{18}]'$
  - Constraint: We Want The Sum of Adjusted +/- to Equal 0
  - We Invoke Constraint With Last Row of A and Element of y
  - Solve the Linear Equation Using Least Squares Regression

    $\vec{y} = \mathbf{A}\vec{b} + \epsilon \longrightarrow \vec{b} \approx (A'A)^{-1}A'\vec{y}$

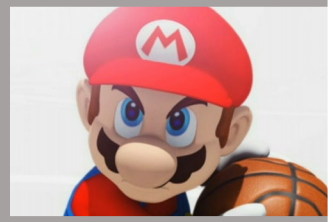
  - Code for Solving System of Linear Equations

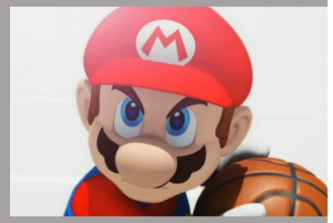
```
#Solve Linear Equations
b=solve(t(A)%*%A)%*%t(A)%*%y
```

  - Adjusted +/- For Each Player →

```
> print(b)
                [,1]
Player1    13.441601
Player2    -1.306216
Player3    -7.755180
Player4    -7.446202
Player5     1.759840
Player6    -1.925423
Player7     2.055698
Player8    -3.983937
Player9     7.633862
Player10   14.295170
Player11  -14.596050
Player12    1.285212
Player13   -4.753639
Player14  -11.077068
Player15    9.742491
Player16    2.115617
Player17    6.092244
Player18   -5.578021
```

+/- Player Ratings



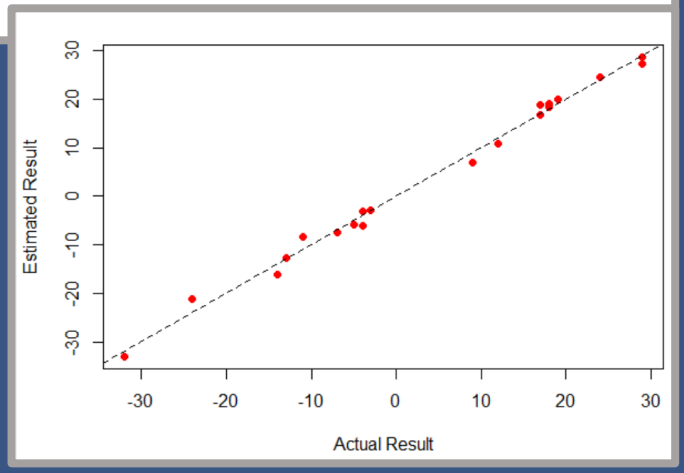


- Can Be Used to Approximate Game Result
  - Code to Calculate Predicted Scores Using Adjusted +/-

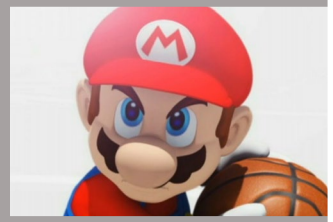
```
Approx.Score=rep(NA,20)
for(k in 1:20){
  Team1Total=sum(as.numeric(b)[as.numeric(GameData[k,3:7])])
  Team2Total=sum(as.numeric(b)[as.numeric(GameData[k,8:12])])
  Approx.Score[k]=Team1Total-Team2Total
}
```

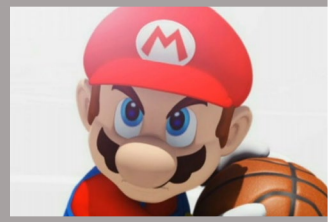
  - Code and Graphic Comparing Predicted Versus Actual

```
plot(x=y[-21],y=Approx.Score,col="red",pch=16,
     xlab="Actual Result",ylab="Estimated Result")
abline(a=0,b=1,lty=2)
```



+/- Player Ratings





- Comparing Adjusted +/- to Pure +/-
  - Let's Look at Player 15 Who Played 13/20 Games on Team 2
  - When in Game, Team 1 Averaged 5.4918 Points Above Average
  - When in Game, Team 2 Averaged 5.1072 Points Above Average
  - This Leads to a Pure +/- of -0.3846154 Points (Approximately Even)
  - When in Game and Ignoring Player 15, Team 2 Averaged 4.635 Points Below Average
  - Ignoring Player 15, the Pure +/- Would Be Horrible …

$$(-4.635) - 5.4918 = -10.12711$$

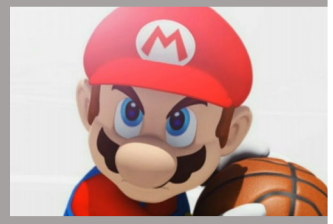
  - Adjusting for the Teammates Player 15 Was Playing With, We Would Adjust the +/- by Subtracting Pure +/- With Player 15 Minus Pure +/- Without Player 15 Would Be…

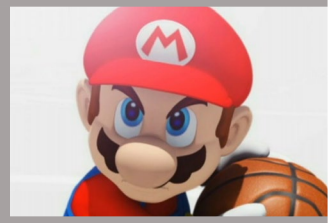
$$-0.3846154 - (-10.12711) = 9.742491$$ → Player 15's Adjusted +/-

+/- Player Ratings

- Comparing Adjusted +/- to Pure +/-
  - Code for These Calculations on Player 15

```
Games.Played.15=GameData2[GameData2$Player15==-1,]
Opponent.Points=rep(NA,dim(Games.Played.15)[1])
Team.Points=rep(NA,dim(Games.Played.15)[1])
for(k in 1:dim(Games.Played.15)[1]){
  Opponent.Points[k]=sum(b[which(Games.Played.15[k,3:20]==1)])
  Team.Points[k]=sum(b[which(Games.Played.15[k,3:20]==-1)])
}
x1=mean(Team.Points)-mean(Opponent.Points)

Team.Points2=rep(NA,dim(Games.Played.15)[1])
for(k in 1:dim(Games.Played.15)[1]){
  Team.Points2[k]=sum(b[which(Games.Played.15[k,3:20]==-1)])-9.742491
}
x2=mean(Team.Points2)-mean(Opponent.Points)

x1-x2
```





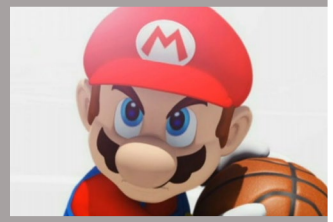

+/- Player Ratings

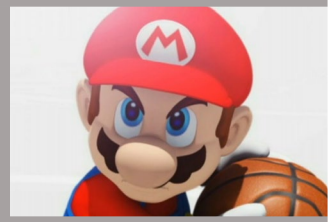
- WINVAL System
  - Created by Wayne Winston and Jeff Sagarin
  - Adjusts for Home Team Advantage (+3.2 Points Per 48 Minutes)
  - Adjusts for Time Interval Where Court Composition is Constant
  - Home Team Scores 9, Away Team Scores 7, and 3 Minute Time Segment

$$Adjusted\ Home\ Team\ Score = 9 - \left(\frac{3}{48}\right) \times 0.5(3.2) = 8.9$$

$$Adjusted\ Away\ Team\ Score = 7 + \left(\frac{3}{48}\right) \times 0.5(3.2) = 7.1$$

  - Actual Adjusted Margin is 1.8 Points
  - Actual Adjusted Margin Per Minute is 1.8/3 = 0.6 Points



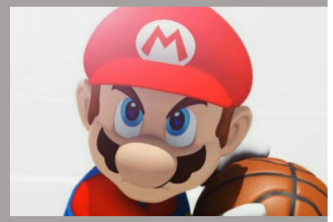


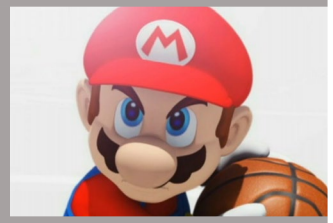

+/- Player Ratings

- WINVAL System
  - Predicted Margin Per Minute

$$Predicted = \left[\frac{3.2 + Sum(Home\ Player\ Ratings)}{48} \times\right] - \left[\frac{Sum(Away\ Player\ Ratings)}{48}\right]$$

  - Goal: Choose Player Ratings So That the Predicted Margin is as Close as Possible to the Actual Adjusted Margin
  - Kevin Garnett Had Highest WINVAL of 19 in 2006-2007 Season = He Would Improve His Team by 19 Points Per 48 Minutes
  - WINVAL can Be Broken Up into Offense and Defense
  - Kevin Garnett Offense WINVAL of 7 and Defense WINVAL of -12

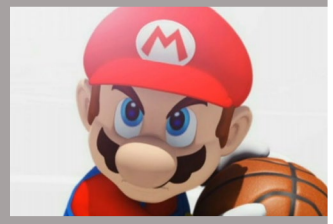


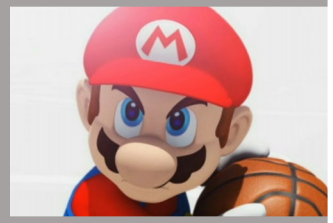


- Using Adjusted +/- to Rate Team
  - Each Player Has Own Adjusted +/- But Plays Different Minutes
  - Weighted Average Across Team Can Evaluate Entire Team

+/- Player Ratings

- Further Evaluation of Kevin Garnett's Greatness
  - Look at Kevin Garnett's Impact on Team's +/- When He is On the Court and On the Bench
  - Garnett In is Positive
  - Garnett Out is Negative
  - Shows Points Better than Average Team

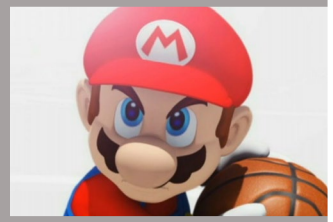


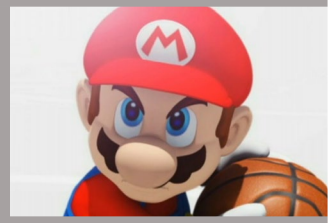



	Garnett in	Garnett out
Garnett	2.068623241	dnp
Smith	6.625117829	−19.1260921
Foye	2.687658381	−18.8363539
Jaric	1.528346916	−17.4928541
Davis	2.062763933	−19.804282
James	1.149827728	−25.2165387
Hassell	1.741019578	−25.8873062
Blount	1.1715841	−21.7697961
Madsen	6.752480906	−14.093463
Hudson	−1.458252856	−15.0936761
McCants	12.04746088	−27.8568458
Reed	−20.23843887	−11.1550147

+/- Player Ratings

- Problems With WINVAL
  - A Lot of Noise (We Can Observe Standard Error in +/- Ratings)
  - Little Confidence When Player Plays Less Than 500 Minutes
  - Impact to WINVAL at Meaningless Points of the Game



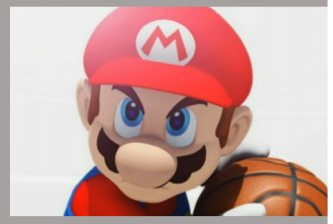


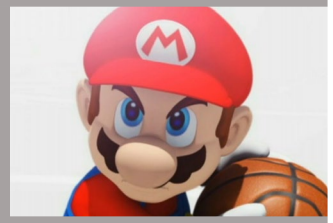
- WINVAL Impact Rating
  - Similar to SAGWIN Points From Baseball
  - Constantly Evaluate the Impact a Player Has on Probability of Win
  - I Play for 5 Minutes and Score is 14-5 Favoring My Team
  - For the Raw +/-, I Would Net +9 Points
  - Alternatively, I Increased My Team's Chance of Winning from 50% to 72%
  - For Impact +/-, I Would Net +22 Impact Points
  - Interpretation: Kevin Garnett (Impact = 42) with 4 Average Dudes Would Beat 5 Average Dudes 50%+42%=92% of the Time

+/- Player Ratings

- Improvements to Adjusted +/-
  - Research by Joseph Hill (2010 Winner of Sloan Paper Competition)
  - Applies Cross-Validation = Intentionally Splitting Up Data to Use Portions As Training and Test Sets and Then Averaging Over Splits
  - Applies Ridge Regression = Combat Overfitting and Shrinks Player's Adjusted +/- Toward 0
  - Cross-Validation Necessary for Selection of Tuning Parameter in Ridge
  - Applies Weights to Loss Function Based on Number of Possessions

$$\sum_i p_i(t_i - \mathbf{w} \cdot \mathbf{x})^2 + \lambda ||\mathbf{w}||^2$$





Final Inspiration

Nine out of 10 schools are cheating.
The other one is in last place.

- Jerry Tarkanian