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Finding the Next NBA Superstar: How to Predict a Player's Performance?

STAT 410 Project

Hongyu Zhang

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What factors determine an excellent basketball player?

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Hall of Fame

14x All Star	10x Scoring Champ
3x STL Champ	6x NBA Champ
11x All-NBA	9x All-Defensive
1984-85 All-Rookie	3x AS MVP
1987-88 Def. POY	6x Finals MVP
5x MVP	1984-85 ROY

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https://cdn.revistagq.com/uploads/images/thumbs/201340/michael_jordan_3508_645x485.jpg
https://www.basketball-reference.com/players/j/jordami01.html

Goal

Construct a statistical model that can use players' statistics to explain players' performance in game.

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Introduction

1. How to evaluate performance?

Average points scored in game.

2. 2 ways to score points in game: field goals and free throws.

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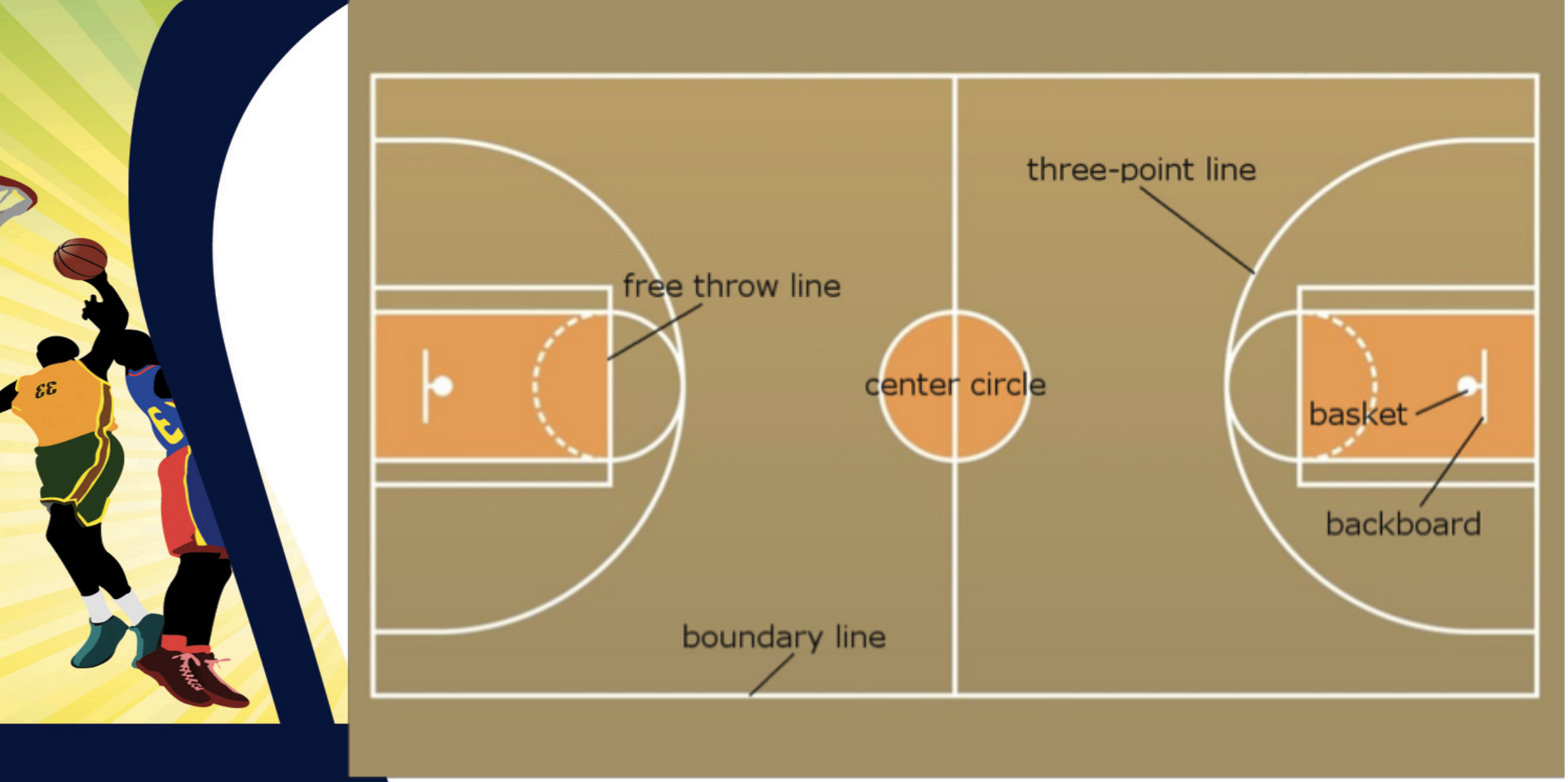

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Data Collection

I obtained the dataset online from Cengage. This dataset referred *The official NBA basketball Encyclopedia*, Villard Books.

This dataset contains 54 players' data in 5 categories:

height (in feet), **weight** (in pounds), **field** (percent of successful field goals out of 100 attempted), **free** (percent of successful free throws out of 100 attempted) and **points** (average points scored per game).

Here, the response variable is **points**, since it is the variable that I want to predict.

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http://college.cengage.com/mathematics/brase/understandable_statistics/7e/students/datasets/mlr/frames/mlr09.html

Visualization

	height	weight	percent_field_goals	percent_free_throws	avg_points
1	6.8	225	0.442	0.672	9.2
2	6.3	180	0.435	0.797	11.7
3	6.4	190	0.456	0.761	15.8
4	6.2	180	0.416	0.651	8.6
5	6.9	205	0.449	0.900	23.2
6	6.4	225	0.431	0.780	27.4

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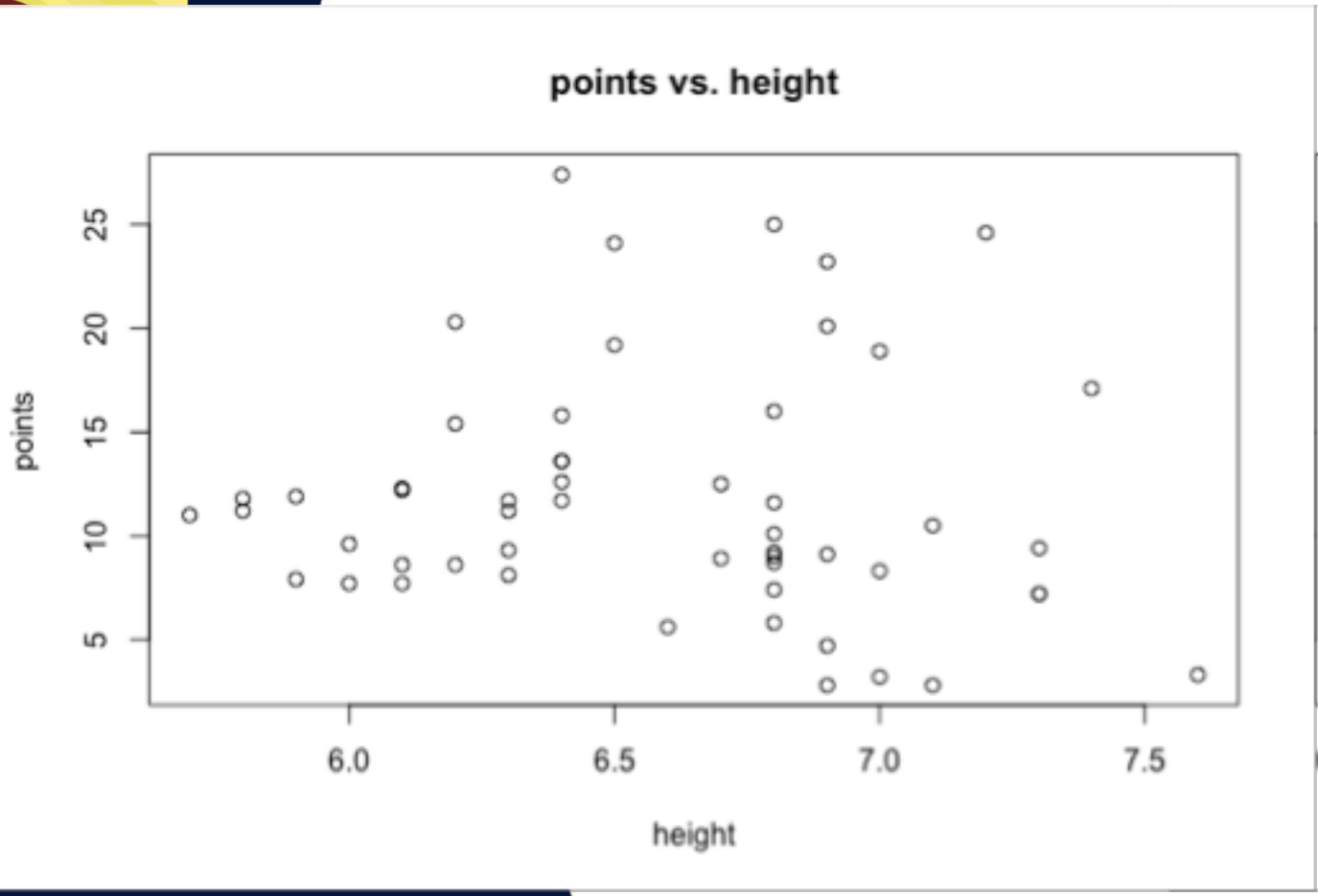
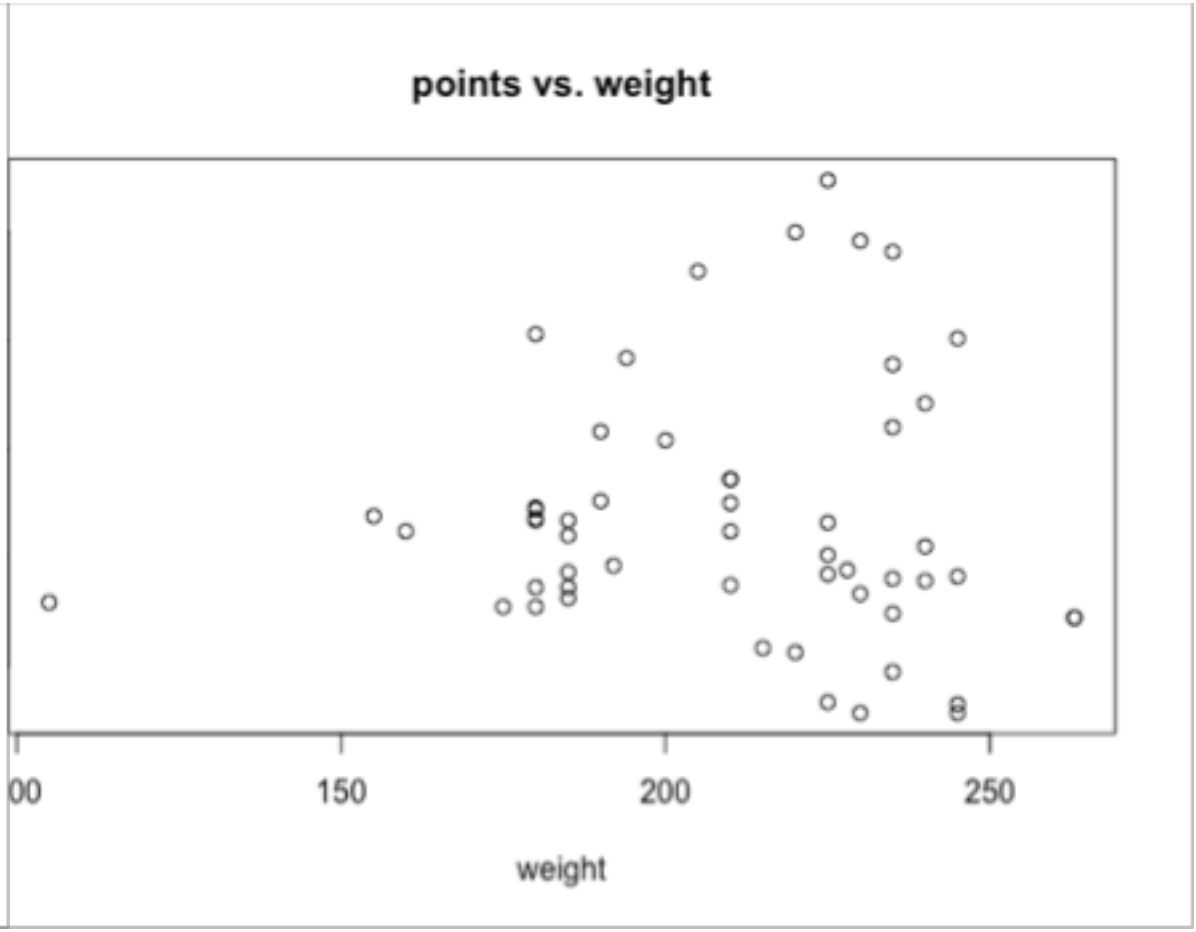
Visualization





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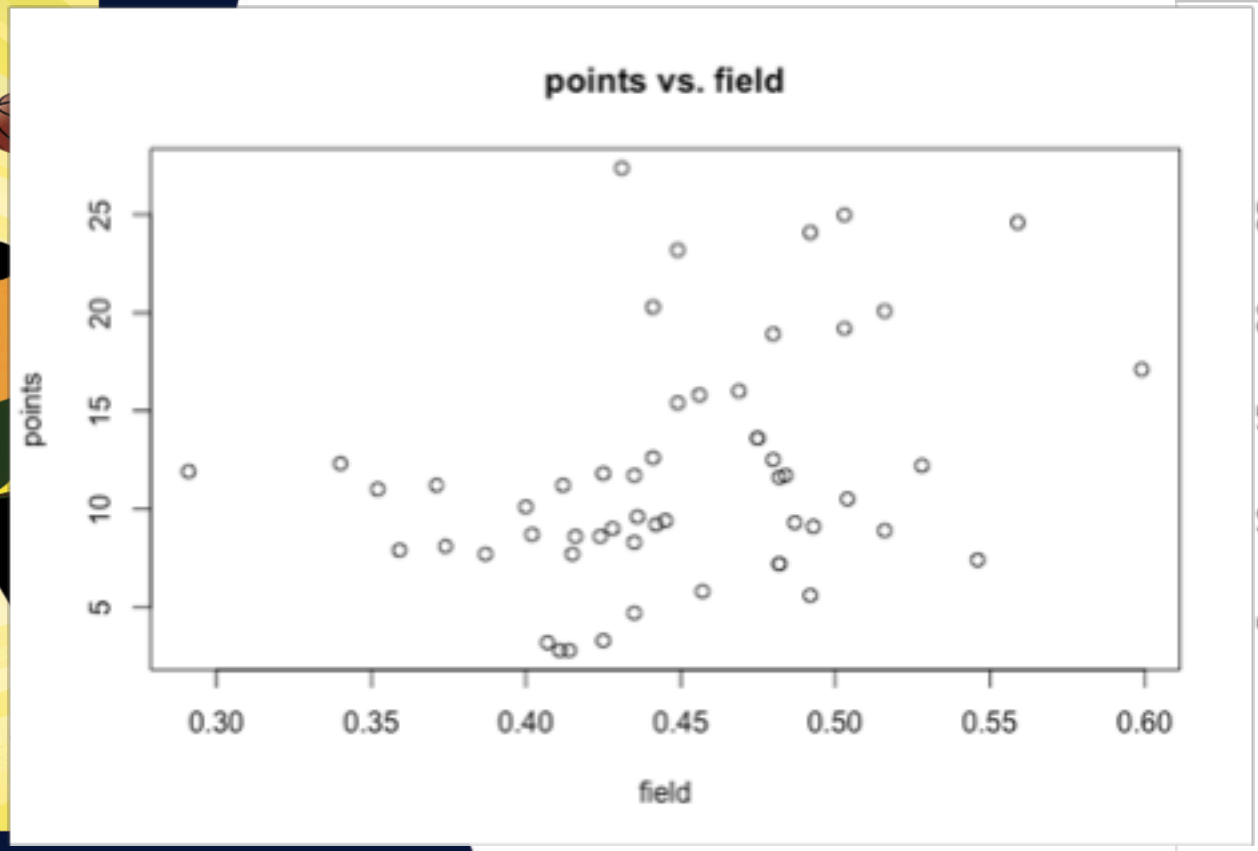
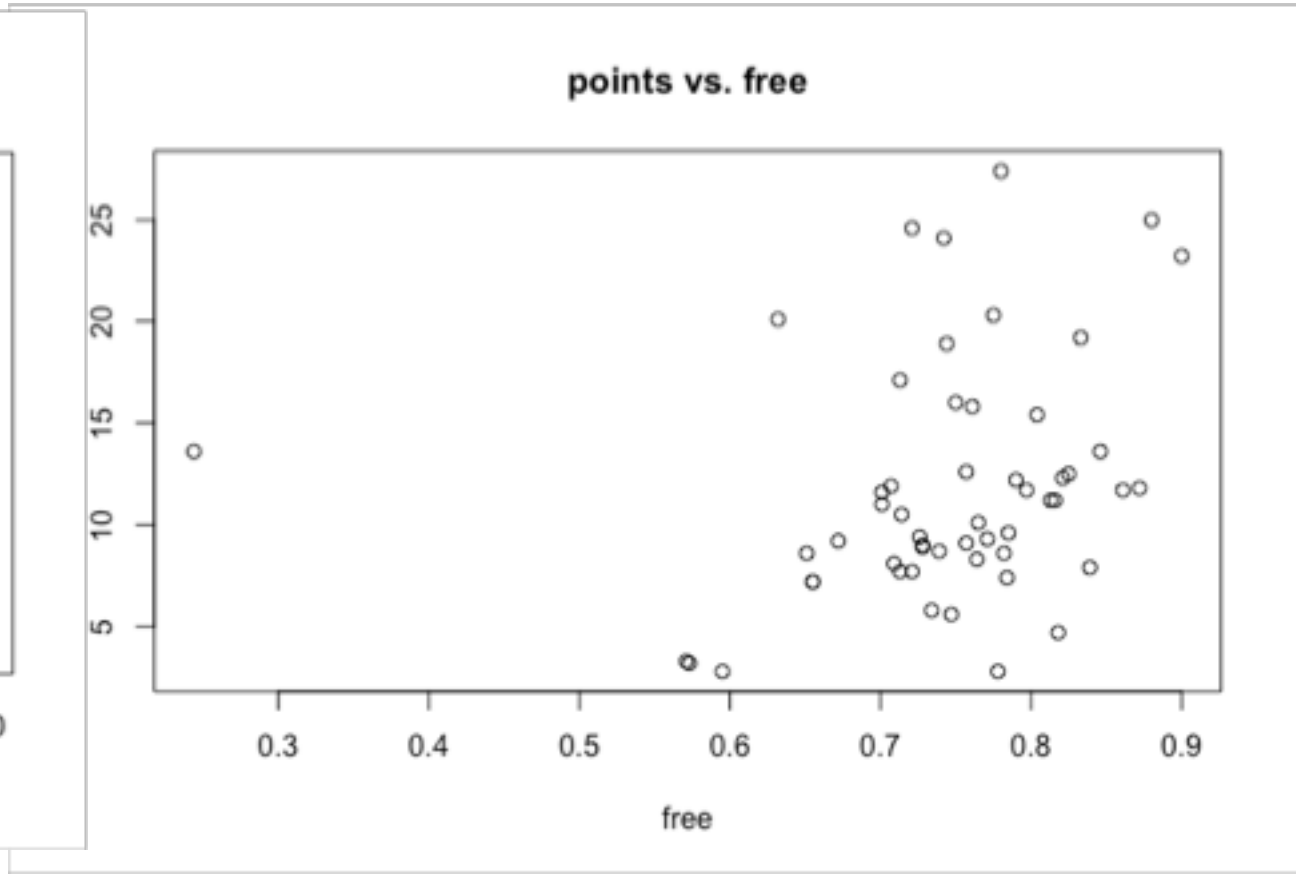
Visualization





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Simple Approach

Relationship between average points scored and percent of successful field goals and free throws.

If a player has high successful field goals rates and free throw rates, then he will probably have high average points per game because of his accuracy, and vice versa.

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Simple Approach

Here I try to build a multiple linear regression model of average points scored and 2 regressors: **field** (successful field goal percentage) and **free** (successful free throw percentage).

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Simple Approach

$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$

In matrix form, $\mathbf{y} = \mathbf{X\beta} + \boldsymbol{\varepsilon}$

Using R, $\hat{\beta} = \begin{bmatrix} -15.27738 \\ 35.82503 \\ 14.79905 \end{bmatrix}$

$SS_{res} = 1516.422$

$\widehat{\sigma^2}$ (MS_{res}) = 29.16196

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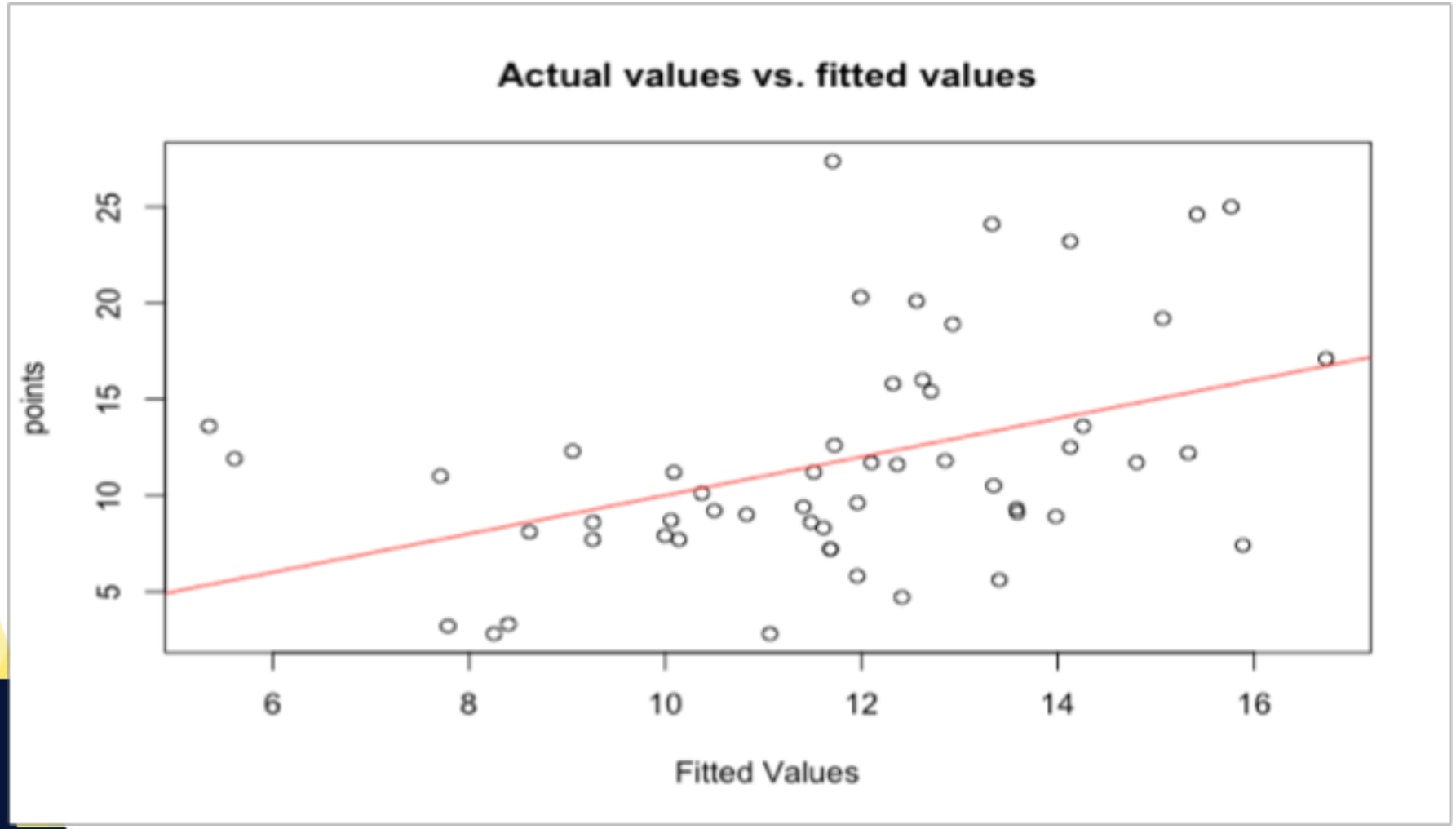
actual values vs. fitted values



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Stepwise Search to Find the Best Model

4 possible regressors: **height**, **weight**, **field** and **free**.

There might be a 5th possible regressor: interaction term between **field** and **free**. I want to find out whether there exists association between percent of successful field goals and percent of successful free throws.

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Stepwise Search to Find the Best Model

Use forward selection based on Bayesian Information Criterion (BIC). The reason I use BIC is that I want to obtain the best fitting model using fewest variables.

$BIC = -2log L(\hat{\theta}) + K log n.$

Compared to Akaike's Information Criterion (AIC) which penalizes the complexity of model by a factor of 2, BIC penalizes the complexity of the model by a factor of $log n$, where n is the sample size.

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Stepwise Search to Find the Best Model

```
Start:  AIC=194.66
points ~ 1

         Df Sum of Sq    RSS    AIC
+ field   1   211.668 1632.8 192.07
<none>                1844.5 194.66
+ free    1   110.580 1733.9 195.31
+ height  1     8.758 1835.7 198.39
+ weight  1     0.179 1844.3 198.65

Step:  AIC=192.07
points ~ field

         Df Sum of Sq    RSS    AIC
+ height  1   137.066 1495.7 191.32
+ free    1   116.375 1516.4 192.06
<none>                1632.8 192.07
+ weight  1    85.725 1547.1 193.14

Step:  AIC=191.32
points ~ field + height

         Df Sum of Sq    RSS    AIC
<none>                1495.7 191.32
+ free    1    59.978 1435.8 193.10
+ weight  1     0.060 1495.7 195.31
```

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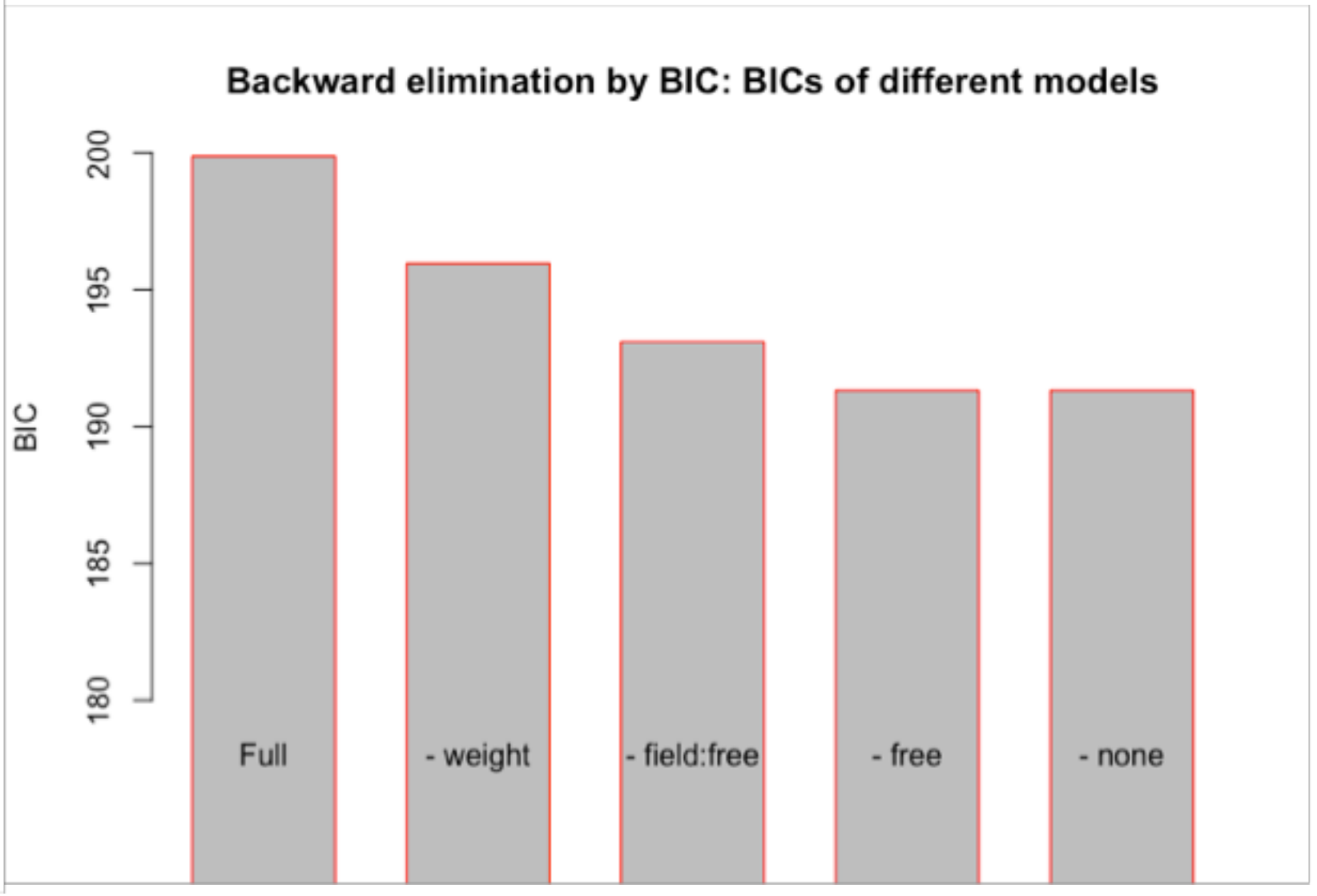
Stepwise Search to Find the Best Model

```
Start:  AIC=199.87
points ~ height + weight + field + free + field:free

             Df Sum of Sq    RSS    AIC
- weight      1     1.964 1405.9 195.96
- field:free  1    30.564 1434.5 197.04
- height      1    41.906 1445.9 197.47
<none>                    1404.0 199.87

Step:  AIC=195.96
points ~ height + field + free + field:free

             Df Sum of Sq    RSS    AIC
- field:free  1    29.821 1435.8 193.10
- height      1    67.418 1473.3 194.50
<none>                    1405.9 195.96

Step:  AIC=193.1
points ~ height + field + free

         Df Sum of Sq    RSS    AIC
- free    1    59.978 1495.7 191.32
- height  1    80.668 1516.4 192.06
<none>                1435.8 193.10
- field   1   298.073 1733.8 199.30

Step:  AIC=191.32
points ~ height + field
```



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Stepwise Search to Find the Best Model

Final model with 2 regressors **height** and **field**.

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Analysis of Final Model

- Our final model is: $y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \varepsilon$, where y is **points**, x_1 is **height**, and x_2 is **field**.

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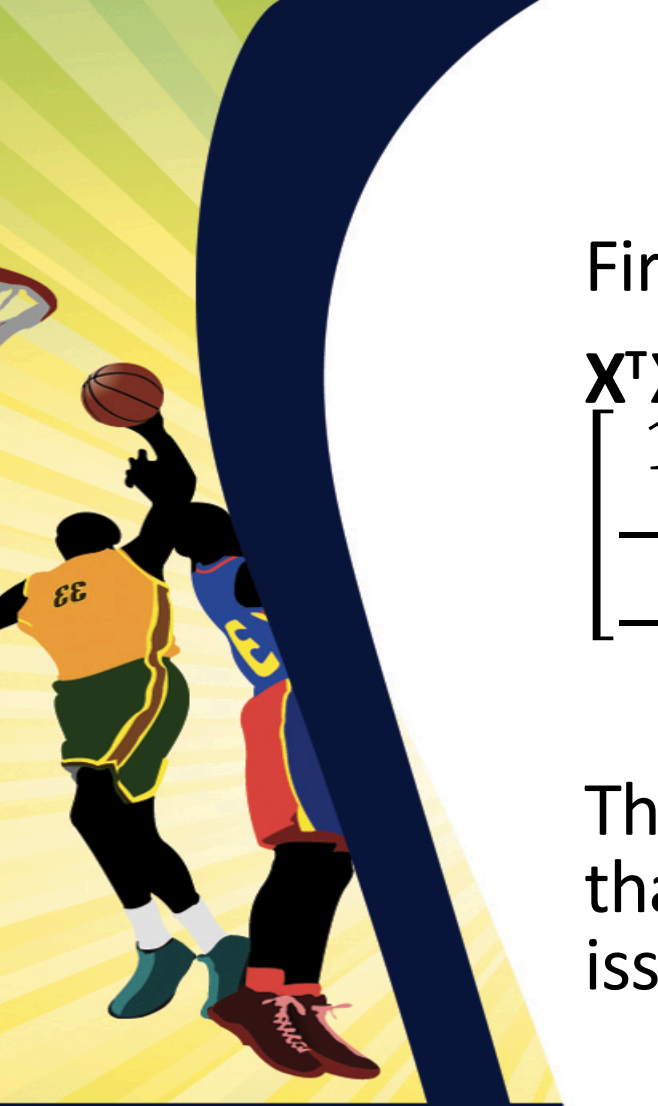

Analysis of Final Model

First check that $\mathbf{X}^T\mathbf{X}$ is not a singular matrix.

$\mathbf{X}^T\mathbf{X} * (\mathbf{X}^T\mathbf{X})^{-1} =$

$$\begin{bmatrix} 1.000000e^{+00} & 7.105427e^{-15} & -2.842171e^{-14} \\ -2.842171e^{-14} & 1.000000e^{+00} & 0.000000e^{+00} \\ -6.217249e^{-15} & -5.329071e^{-15} & 1.000000e^{+00} \end{bmatrix}$$

The result is very close to the identity matrix. This shows that our design matrix does not have multicollinearity issue.

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Analysis of Final Model

- Using R, I obtain $\hat{\beta} = \begin{bmatrix} 15.209793 \\ -4.034628 \\ 51.562276 \end{bmatrix}$.
- SS_{res} = 1495.732
- $\widehat{\sigma^2}$ (MS_{res}) = 28.76407
- The fitting model becomes:

$$\hat{y} = 15.210 - 4.035x_1 + 51.562x_2.$$

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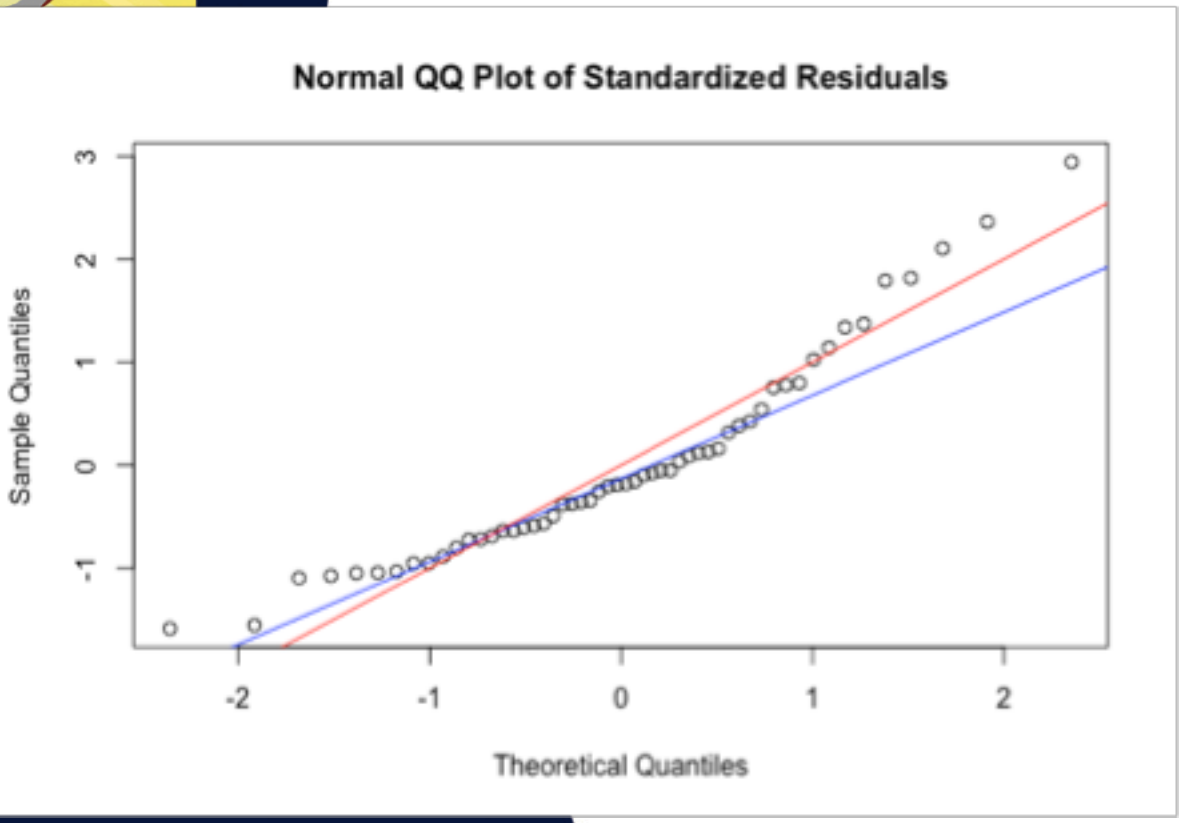
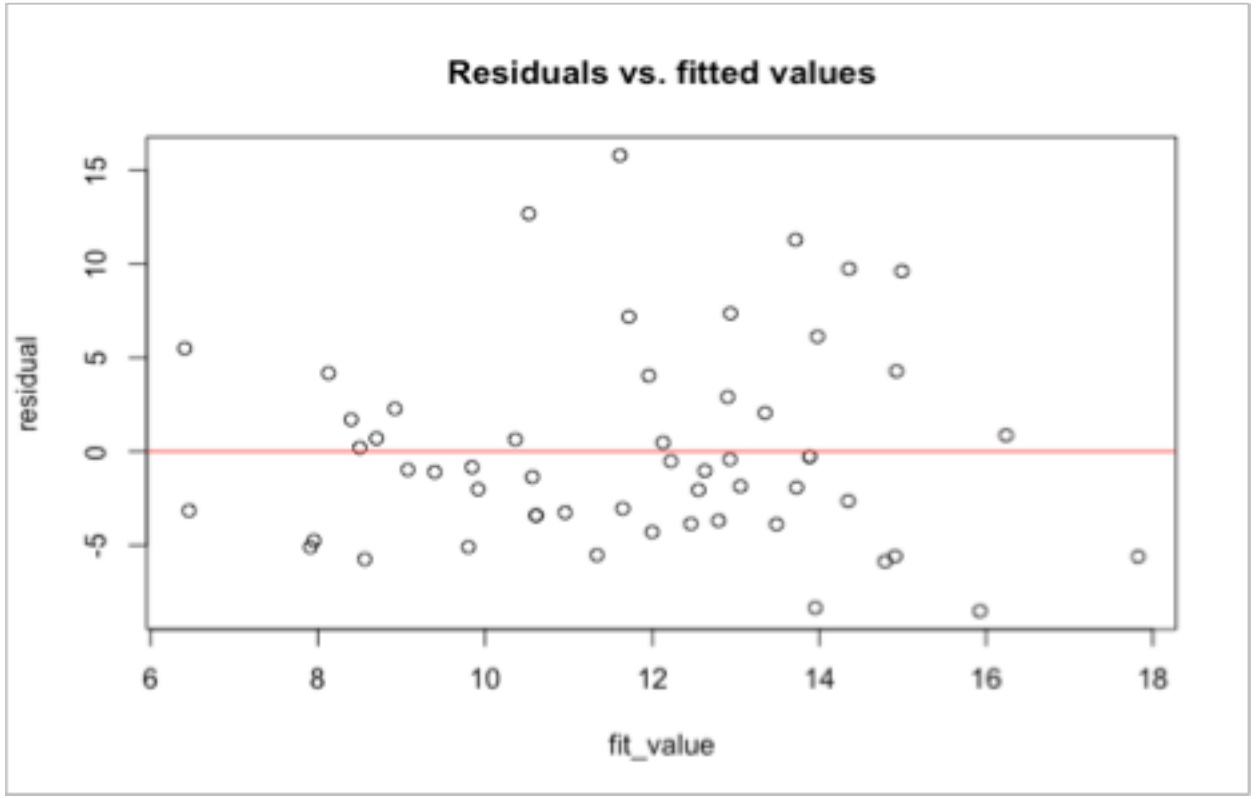
Analysis of Final Model

Normal assumption and homogeneity assumption.





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Analysis of Final Model

$$\hat{y} = 15.210 - 4.035x_1 + 51.562x_2.$$

Hypothesis testing 1:

Are there differences in average points scored for players who have the same percent of successful field goals?

$H_0: \beta_1 = 0$, $H_1: \beta_1 \neq 0$

p-value 0.03357903

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Analysis of Final Model

$$\hat{y} = 15.210 - 4.035x_1 + 51.562x_2.$$

Hypothesis testing 2:

Are there differences in average points scored for players who have the same height?

$H_0: \beta_2 = 0$, $H_1: \beta_2 \neq 0$

p-value 0.001161757

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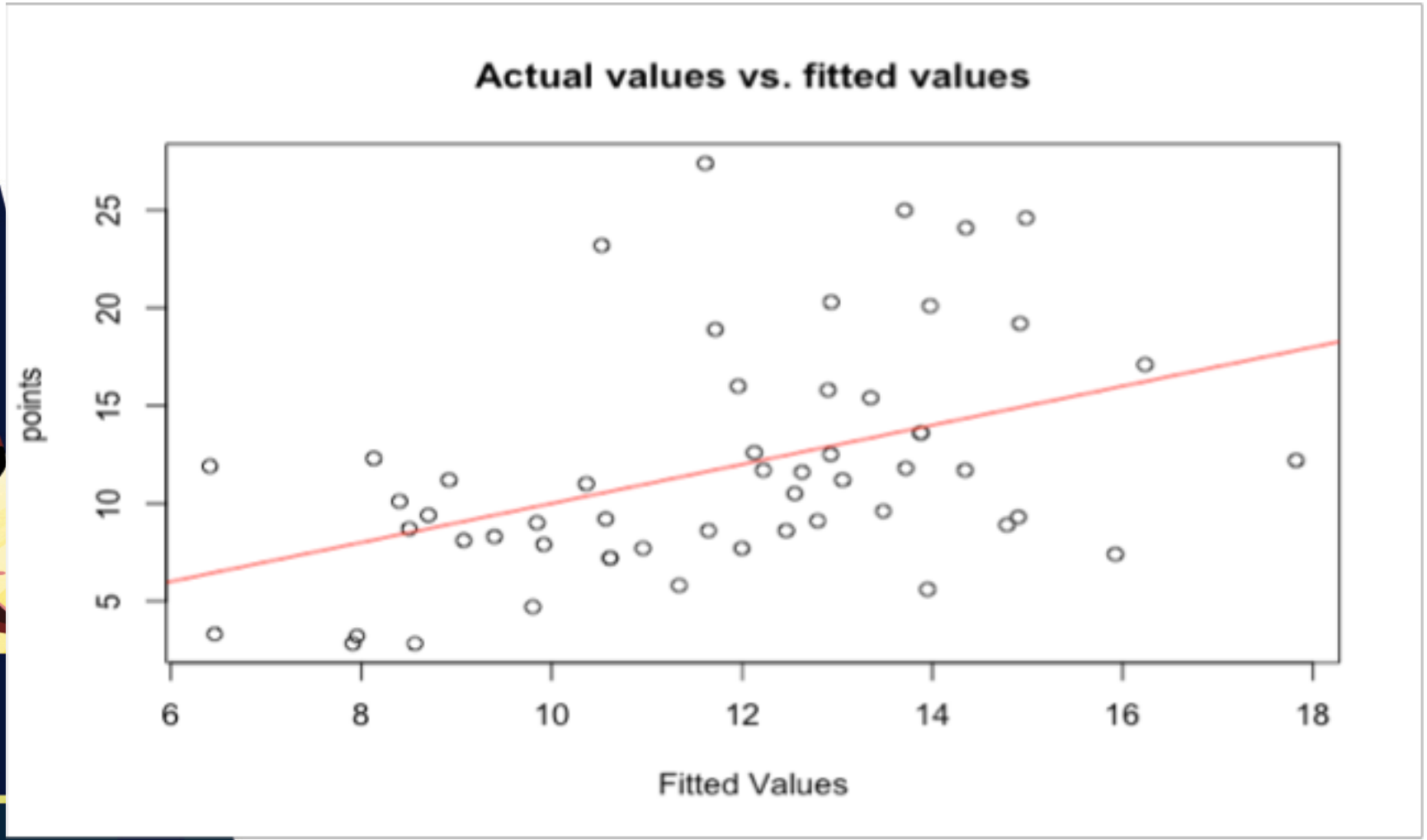
Analysis of Final Model

actual values vs. fitted values



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Discussion

Final model: $\hat{y} = 15.210 - 4.035x_1 + 51.562x_2$

If player A is 6.3 feet tall and has 45% successful field goals, then his predicted average points scored is approximately:

15.210 – 4.035 * 6.3 + 51.562 * 0.45 = 12.9924.

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Discussion

If player B is 6.4 feet tall and has 46% successful field goals, then his predicted average points scored is approximately:

$$15.210 - 4.035 * 6.4 + 51.562 * 0.46 = 13.10452.$$

Basketball manager and team coach will probably choose player B instead of player A.

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Discussion

Final model: $\hat{y} = 15.210 - 4.035x_1 + 51.562x_2$

Performance determined by 2 factors: height and percent of successful field goals.

Percent of successful field goals is the more influential factor in this model.

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Future Work

1. Include more up-to-date players' statistics in the current year, and include more variables in the dataset, like assists, rebounds, steals, blocks and so on.

2. Compare NCAA (National Collegiate Athletic Association) players with NBA players.

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Thank you!

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