

# Basketball on a Budget

Euntak Jeong, Alex Huo, Tim Tianyang Yang, Minjie Xia, Ignat Kulinka

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## Abstract

While all players in the NBA are extremely talented athletes, many hone their skills to the point at which their expertise cannot be denied and simply demand massive salaries. This paper presents a possible solution to the old problem of creating the best possible performing sports team while at the same time minimizing the cost of the team. Through a selection-ranking algorithm our team created based on real game data, we can pinpoint player whose talents are impressive yet salaries are low in comparison. For each position on the court, the algorithm identifies cost efficient and prominent players and ranks them compared to each other. As a proof of concept, we create an optimal theoretical team as well as a backup for each position. In addition, to demonstrate the abilities of the picked performance to cost optimized team we use spatial analytics and graphics to create shot charts to compare it to top teams in the NBA such as Golden State Warriors and Cleveland Cavaliers. While the paper deals specifically with basketball, given the right data, the methodology presented can be easily adapted for any team based sport.

## 1 Introduction

The best combination of five players in the square field is a key to success in a basketball game. The simplest way to create the best team is to recruit the most well-known, high ranking players in the NBA. However, salaries that each team can offer are limited, and often combinations of less known players can be extremely competitive on the field. Thus, each NBA scouter’s mission is to find the most affordable players with highest performance possible.

We used a NBA play-by-play dataset of Season 2015-2016 from Big Data Ball website [1]. We determined the key statistics for each position that would separate top performers. Then, we created a ranking system for each position based on selected statistics. Our system allowed us to identify the players with the best performances-to-salaries ratio. With those players, we created our “Fantasy Team”. Finally, we created a collection of visual maps of the field for “sweet” and “unsweet” spots for the our team. These plots demonstrate comparative performance of our dream team with other top teams such as Golden State Warriors and Cleveland Cavaliers.

The long-term goals of our research are 1) to establish a proper ranking system for each position according to their roles, 2) to create a low cost and high performance team based on our ranking system, 3) to search for underestimated players who can perform better than players who are in the same salary brackets. In this paper, our specific aims are to 1) introduce the best players in each position with their salaries and 2) demonstrate visual analytics and spatial analysis that can expose differences and similarities between our theoretical team and other top NBA teams. We present a league-wide case study that attempts to answer one simple yet complex question: who will be a part of the highest performing yet budget efficient team in the NBA.

## 2 Methodology

### 2.1 Data Cleaning

The first step of the research is data cleaning and feature engineering. For the 2015-2016 season dataset, we exclude the players with Field Goal Attempts (FGA) lower than 300 first so that the statistics of the remaining players are a good indicator of their performance on the field. Then, we select the key features that are needed for the ranking system: player, Field Goal Percentage (FGP), Defense Rebound (DREB), Offense Rebound (OREB), Assist (AST), Turn Over (TOV), Block (BLK), and Field Goal Made (FGM), and assign the variables to a new empty data frame called features. We add the columns DREB and OREB together to get a new features called Rebound (REB).

Since each observation of features records the statistics for one player in one game, we group the players by names and add the statistics together. The resulted data frame “features” then has variables: player names and their sums of key features for season 15 to 16. Then, we engineer new features by dividing each player’s sums of key features by the number of games they played. The new features represent the averages of key features for each player. In order to better evaluate the performance of players, we rank the averages of key features respectively. In this way, each player now has seven rankings for each key features. Then, we scrape the salary and position for each player online (reference), and add these two variables to the data frame “features”.

Lastly, we divide the data frame “features” into five sections based on the positions of the players. So now we have five data frames: each one is for one position. And each data frame has variables: player names, the position, the sums of key features (DREB, OREB, AST, TOV and BLK), the averages of key features, the rankings, and the salaries.

### 2.2 Procedure

In order to find our best team, we devise an algorithm to optimize the players’ performance constrained on their salary in the 2015-2016 season. The selection algorithm first separates the top 75% of the players in the NBA based on the FGA. The motivation behind this is that we are only interested in the most active players as they would be the best prospects for our fantasy team. Next the players are separated by the positions they played in the 2015-2016 season. Using the statistics given in our data, we pick out statistics that are both accessible and are the most relevant for each of the positions on the team. The statistics used to rank players in each position are presented in Table 1 below.

Position	Statistics
Point Guard	FGP, AST, DREB
Shooting Guard	FGP, AST, DREB
Power Forward	FGP, BLK, REB
Small Forward	FGP, DREB
Center	FGP, BLK, REB

Table 1: Statistics chosen to rank players in each position

Since we are interested in the typical performance of a player regardless of the time he spends on the court, we rank each player based on the averages of each statistic

for the position. This step helps us to make sure that players who play less games are not unfairly penalized. Next, a weighted average of the statistics is calculated in order to guarantee that we are rewarding well balanced players who perform the tasks of their positions well. The weighted average is then recorded for each of the players and serves as their ranking score. The weight of each rank is defined as the statistic divided by the sum of all statistics for that position. Lastly, for each of the positions we create a plot with standardized salary on the vertical axis and the standardized ranking score on the horizontal axis. On this plot, the ideal player is at the origin because it represents a player that is free and has extremely low weighted average ranking score. Thus, to optimize the average performance of a player constrained on their salary we used Euclidean distance to find the player that is the closest to the ideal player at the origin.

### 3 Results

#### 3.1 Selection Plots

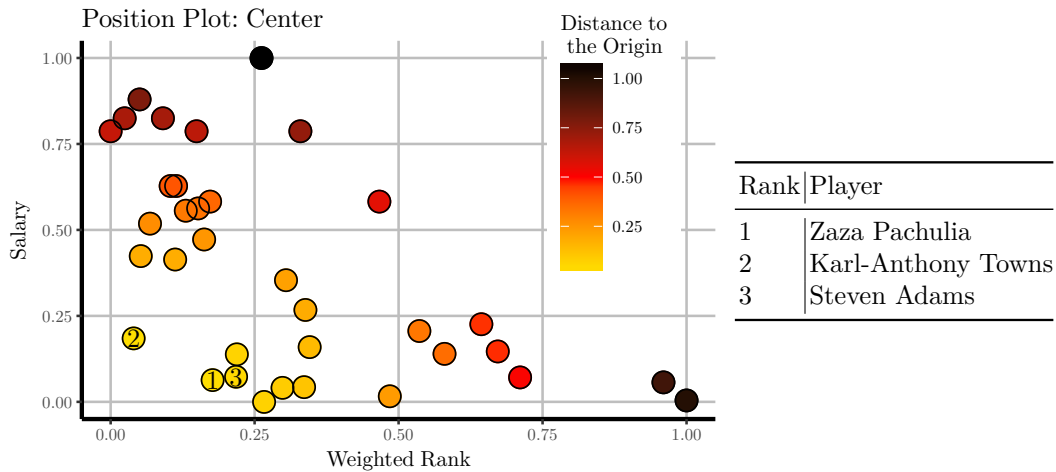
The plots below are the results of applying the selection algorithm defined above on the NBA data from the 2015 - 2016 season. The first and second picks for each of the five positions are included in the table below.

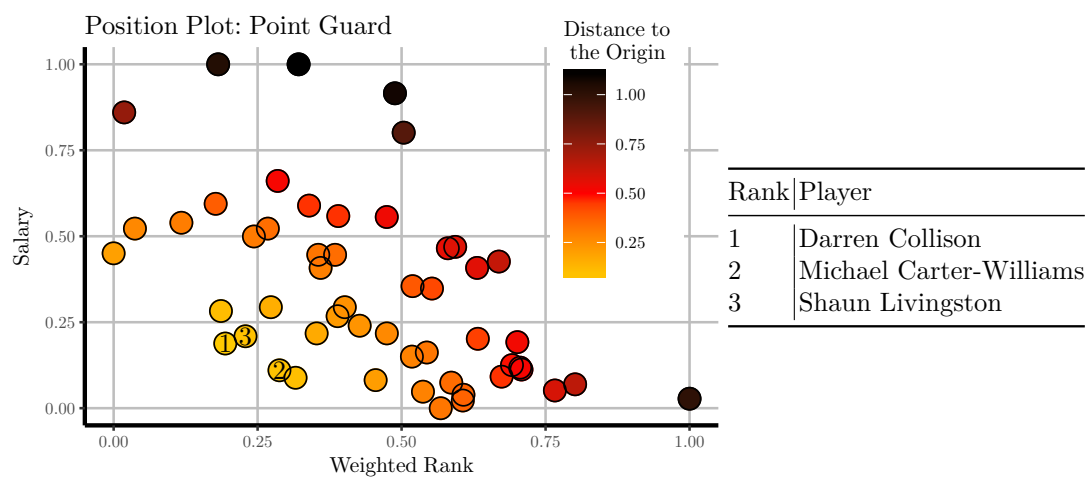
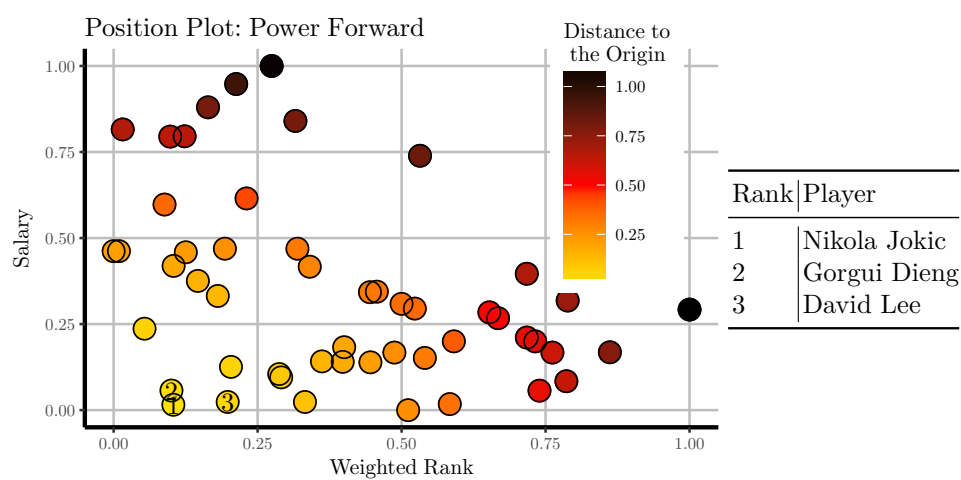
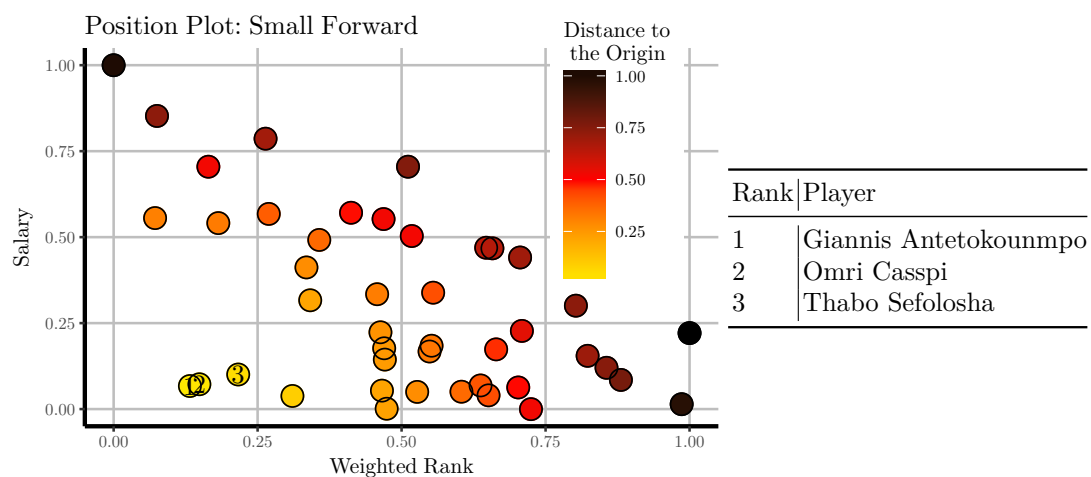
	Center	Small Forward	Power Forward
First pick	Zaza Pachulia	Giannis Antetokounmpo	Nikola Jokic
Second pick	Karl-Anthony Towns	Omri Casspi	Gorgui Dieng

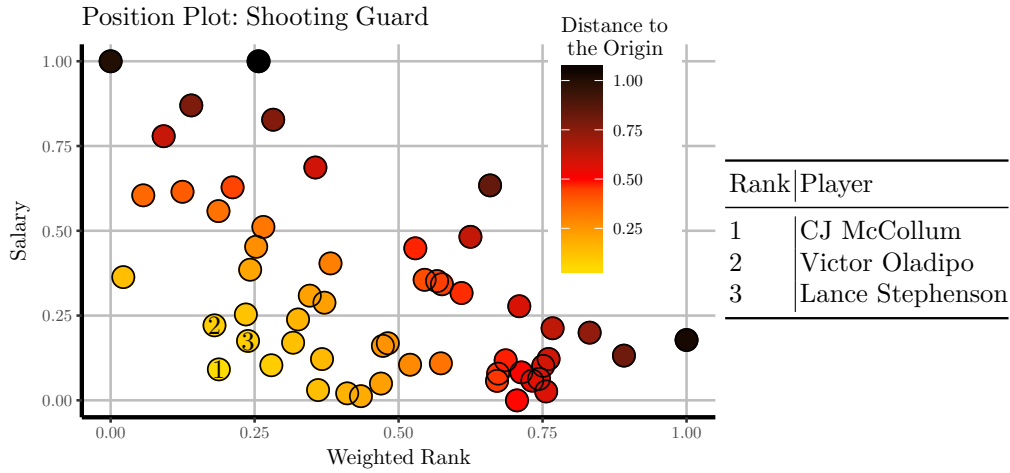
  

	Point Guard	Shooting Guard
First pick	Darren Collison	CJ McCollum
Second pick	Michael Carter-Williams	Lance Stephenson

Table 2: First and second picks for the team based on the selection algorithm







### 3.2 Comparisons to Top NBA Teams

As a means to visualize the favorable and not so favorable shooting areas (so called “sweet” and “unsweet” spots) for each player and for the whole “fantasy team” chosen by our ranking algorithm, we plot the boundaries of an NBA 50 by 47 feet half court based on the official dimensions published by NBA. First, we convert the XY coordinates data into our own coordinates, where we make the center of the whole court the origin and rotate the points in the upper half court around the origin to the lower half court. Thus, we are making the assumption that each of the players will shoot approximately the same on either side of the court. Then, we cut the half court into  $50 \times 47$  squares ( $1 \times 1$  square foot each), and calculate the density of made or missed shots in each square. Finally, we visualize the sweet and unsweet spots for each player chosen by the ranking algorithm. In order to compare the “spots” with other top tier teams, we plot the graphs containing favorable and unfavorable shooting areas for Golden State Warriors and Cleveland Cavaliers top 2 players in for each position based on FGP. For Golden State Warriors this includes Draymond Green, James Michael McAdoo, Andrew Bogut, Marreese Speights, Brandon Rush, Klay Thompson, Shaun Livingston, Stephen Curry, Harrison Barnes, Andre Iguodala. And for Cleveland Cavaliers: Channing Frye, Kevin Love, Timofey Mozgov, Tristan Thompson, Iman Shumpert, J.R. Smith, Kyrie Irving, Matthew Dellavedova, LeBron James, Richard Jefferson. These plots are included below in the Additional Charts section.

## 4 Conclusions

### 4.1 Applications

Basketball is a spatial sport. The team that contains all well known players that cover every spot in the field with high field goal percentage may become the strongest. However, every team financial manager must take budgets into consideration. In this paper, we evaluate all players in season 2015-2016 by different positions and then rank them by our own ranking algorithm that can be a reference for each team manager that he/she may use it to find players with the best performance-salary ratio. We also define the “sweet” and “unsweet” spots, and present the graphs for better visualization. From the graphs, we can easily identify players’ shooting performance in 1 by 1 foot square. With our method of visualization “sweet” spots and “unsweet” spot, the team coach may use this approach to design both offensive strategies and defensive ones. For the offensive

strategies, the coach could use the visualization to better understand the strength and weakness of the team and train the players accordingly. While for the defensive strategies, the coach can conversely learn the strength of the opponent teams and tell the players to actively defend on the spots. For example, to defend a player, the defensive team can push him to this area and let him shoot, and he will most likely miss the shot.

## 4.2 Discussion

As with most statistical analyses, the main limitation is the data used. While implementing our algorithm we worked under the assumption that the data is complete and is a good reflection of players' strength and weaknesses. The limitations of the data is one of the biggest drawbacks for this research. We are constrained by analyzing only features or qualities of players that can be quantified and collected, such as the number of blocks or free throws made. It would be beneficial for a more indepth analyses to be able to find out other indicators of performance such as number of successful screens or team chemistry. Both of which are without a doubt as important to a team's success as the number of three point shots or slam-dunks scored by individual players. Our team identified the lack of reliable data on the performance of players on defence as one of the biggest weaknesses of our methods and most prospective and interesting direction for new research. The ability to gauge the performance of players on both sides of the court gives future researchers and coaches a more complete picture of both the strengths and weaknesses of teams and players alike.

## 5 Additional Charts

Sweet and Unsweet Spots of Golden States Warriors 1 sqft

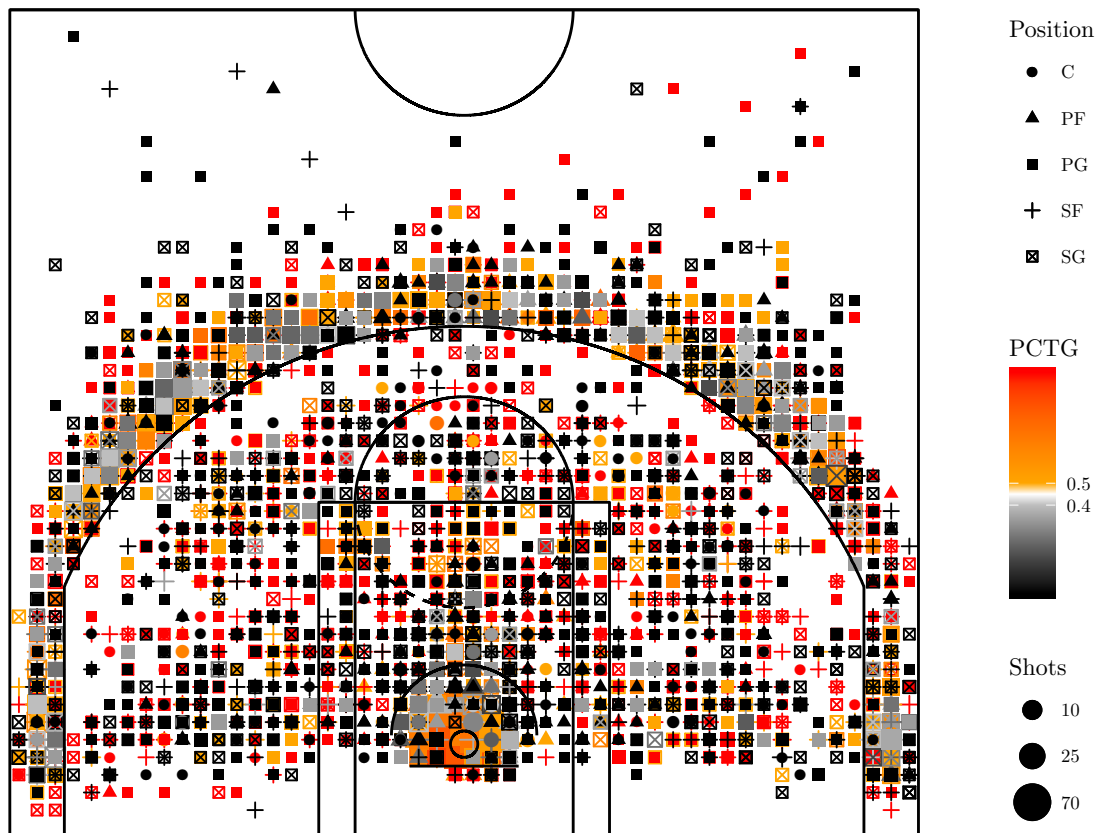


Figure 1: The sweet spots for Golden State Warriors

# Sweet Spots for Cleveland Cavaliers 1 sqft

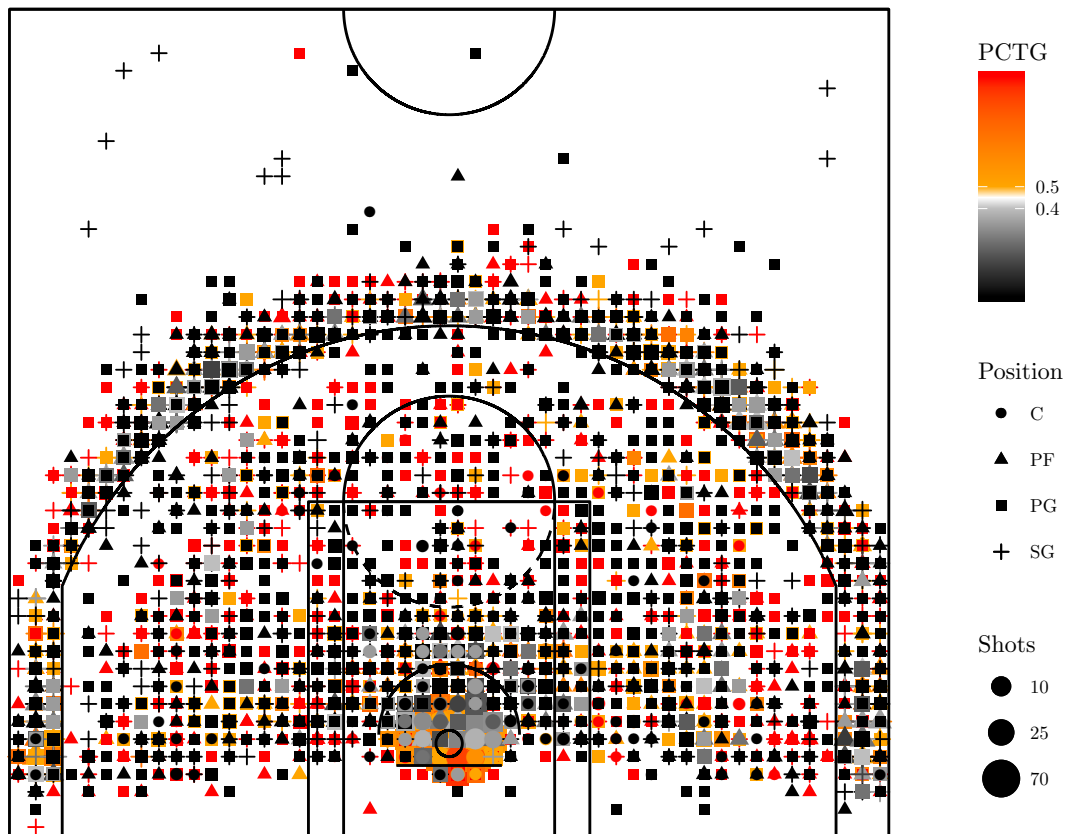


Figure 2: The sweet spots for Cleveland Cavaliers



## Sweet and Non-sweet Spots of the Fantasy Team 1 sqft

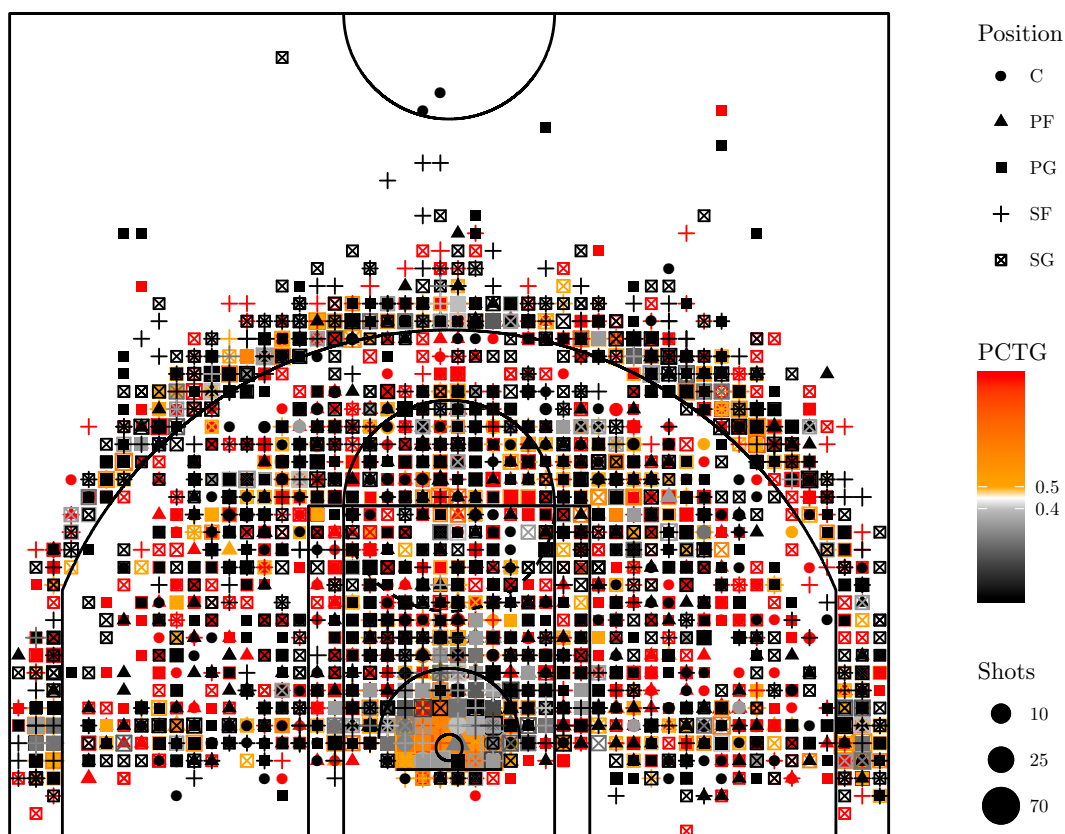


Figure 3: The sweet spots for Fantasy Team

## References

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