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# Exploring the Impacts of Salary Allocation on Team Performance

## **Abstract**

Study of salary has been an increasingly important area in professional sports literature. In particular, salary allocation can be a significant factor of team performance in NBA, given credit to the wisdom of team managers. This paper seeks to extend the scope of existing research on basketball by investigating on how salary allocation affected team performance and exploring other factors that lead to team success. Our findings indicate a moderate correlation between salary allocation and team performance, while average Player Efficiency Rating is a more crucial factor of team performance in comparison.

## **Keywords**

Basketball, Salary Allocation, Player Efficiency Rating (PER), Superstar Effect, Golden State Warriors

## **Disciplines**

Applied Statistics | Business Analytics | Sports Management | Sports Studies | Statistical Models

# Exploring the Impact of Salary Allocation on NBA Team Performance

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## Abstract

Study of salary has been an increasingly important area in professional sports literature. In particular, salary allocation can be a significant factor of team performance in NBA, given credit to the wisdom of team managers. This paper seeks to extend the scope of existing research on basketball by investigating on how salary allocation affected team performance and exploring other factors that lead to team success. Our findings indicate a moderate correlation between salary allocation and team performance, while average Player Efficiency Rating is a more crucial factor of team performance in comparison.

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## Disciplines

Sports | Basketball | National Basketball Association (NBA) | Salary and Team Performance Analysis

## 1. Introduction

There has been an increasing research interest in the relations between salary allocation and team success in professional sports over the years. A number of researchers have investigated on whether the amount of salary impacted the team success, measured by different metrics ranging from team revenue to winning percentage. Research has indicated a positive correlation between the team payroll and team success. These research studies encompass multiple sports such as basketball, football, baseball and ice hockey, with a focus on the four major professional leagues in the United States and Canada.

Over the past several years, the salary cap in National Basketball Association (NBA) has been increasing drastically, with a further projected increase after the league signed a gigantic nine-year, \$24-billion TV-deal this year.<sup>1</sup> Evident from the changes from the 2015-2016 season to the 2016-2017 season, the salary cap rose from \$70 million to \$94 million by a whopping \$24 million while the luxury tax limit also increased from \$85 million to \$113 million by \$28 million, an even larger amount at.<sup>2</sup> This trend, known as the ‘Superstar Effect’, creates further opportunities for teams to sign multiple superstars to compete for championships: the best example comes from the former Oklahoma City Thunder superstar small forward Kevin Durant, who was able to sign with the Golden State Warriors in the 2016 off-season because of the increase in the salary cap and Warriors superstar Stephen Curry’s surprisingly low four-year, \$44-million contract that took his previous ankle injuries into consideration.<sup>3</sup> Later, with four NBA All-Stars in their starting lineup, the 2017 Warriors were considered as the most talented team in the NBA history and was described as a

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<sup>1</sup> Prada, 2014

<sup>2</sup> Zillgitt, 2017

<sup>3</sup> Badenhausen, 2017

'juggernaut' by Forbes Magazine contributor Vincent Crank,<sup>4</sup> crowning the Larry O'Brien trophy after finishing the playoffs with a historic 16-1 run in 2017.

Seeing the significance of salary in professional basketball leagues on team success, this paper will take a statistical approach to investigate on the relationship between the allocation of salary in an NBA team and team success, measured mainly by the winning percentage out of 82 games during the regular season. While advancing to the playoffs and accomplishing a championship are also good indicators of team performance, we choose the team winning percentage during the regular season because team performance is more consistent during this time span compared with post-season playoffs where winning is highly affected by external factors such as home court advantage.

According to recent basketball research conducted by Larry Coon in 2017, the correlation between team payroll and regular season wins is very strong. For the 2010-11 NBA season, the correlation coefficient<sup>1</sup> between team payroll and regular season wins was 0.53<sup>5</sup> ----- high enough to conclude that teams with deep roster have been able to achieve success simply by spending more money on talent, at least to some extent. Although the recent correlation coefficient for the 2016~2017 season declined to 0.35<sup>3</sup>, this statistical result still demonstrated a moderate correlation between the two.

This paper takes one step further to investigate on the impacts of the salary on NBA teams, specifically on how the allocation of the salary affected the performance of these teams during the regular season across different years. Furthermore, this paper goes beyond salary distribution to investigate on other key factors that affect team success on the basketball. Section 2 of the paper explores how data is cleaned and organized. Section 3 synthesizes the analysis of Section 2 and constructs a model on the team performance by using the winning percentage of the team during the regular season as a key metric.

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<sup>4</sup> Frank, 2017

<sup>5</sup> Coon, 2017

## 2. Data and Methodology

In this section, we discuss how the data about the team performance and salary of players is scraped from the Internet and cleaned. We then process data to explore the correlation between the salary distribution and team performance. Through several stages of analysis, we choose to investigate additional factors that affect the team performance along with the salary distribution.

### 2.1 Data Scraping and Cleaning

Since the winning percentage of NBA teams during the regular season is the most direct measure of team performance, we extracted the data on the number of wins for all 30 NBA teams during five regular seasons from 2012 to 2017 due to a steady increase in salary cap from 2011 and omitted the 2011-2012 season because it was shortened to 66 games. Because all teams play 82 games during the regular season, the winning percentage can be calculated by the formula:

$$\text{Team Winning Percentage} = \frac{\text{No. of Wins in a Season}}{82}$$

In order to measure the salary distribution of NBA teams, we have to first get the data about the salary of every single player for all 30 NBA teams from 2012 to 2017. We choose to use data from a website called Basketball Reference because it takes into account the movement of players during trades and signings of free agents in the middle of the season. After scraping the data with R, we have 150 columns of data representing the salary breakdown of 30 teams during the past five regular seasons.

To measure the salary distribution in a team, we use three different metrics: standard deviation, Gini Coefficient and Robin Hood Coefficient. The standard deviation measures how much the salary of each player in the team deviates from the mean. Gini Coefficient and Robin Hood Coefficient, in comparison with standard deviation, are more general measurements of dispersion because they are invariant of scale and are bounded by  $[0, 1]$ . While these two metrics are commonly

used to measure the income inequality of countries at a macroeconomic level, they can also be used in the measurement of wealth inequality<sup>6</sup> such as salary distribution in this context. However, these two coefficients also possess certain limitations: the two coefficients will have a downward bias on the measurement of salary distribution because the data size for each team during a season is very small, ranging from 13 to 28 players. This leads to an underestimation of salary inequality in a team, thus affecting the correlation between salary distribution and team winning percentage.

## 2.2 Finding Correlation

After calculating the Gini Coefficient and Robin Hood Coefficient of all 30 NBA teams across the past five seasons, we run a correlation test between the team winning percentage and these three metrics of salary distribution including the standard deviation of salary with Python. Before doing so, we first standardize the salary distribution and team winning percentage data with the following formula:

$$\text{Standardized } x = \frac{x - E(x)}{\sigma}$$

Measure of Salary Distribution	Correlation with Team Winning Percentage
Standard Deviation	0.309
Gini Coefficient	0.035
Robin Hood Coefficient	0.100

Table 1: Correlation with Team Winning Percentage for Different Measures of Salary Distribution

According to **Table 1**, we find the highest correlation with team winning percentage in the standard deviation of salary at 0.309, which is also demonstrated in **Figure 1** below when a regression is run against these variables. Though a correlation coefficient of higher than 0.4 is usually required to indicate a strong statistical significance between two variables, a coefficient of 0.309 at least demonstrates a moderate correlation between the standard deviation of salary and the team

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<sup>6</sup> Gini, 1936

winning percentage. The intuition behind this might be that the more unequal salary allocation to players in the same team means that there might be more stars in the team that can contribute tremendously more than average players to the team with their high caliber. As a reward to their talent, a significantly higher salary is given to these players than their teammates with average skills. Due to the Superstar Effect, teams that are composed of players with different levels of talent tend to win more games compared with those equipped with players of same levels of talent.

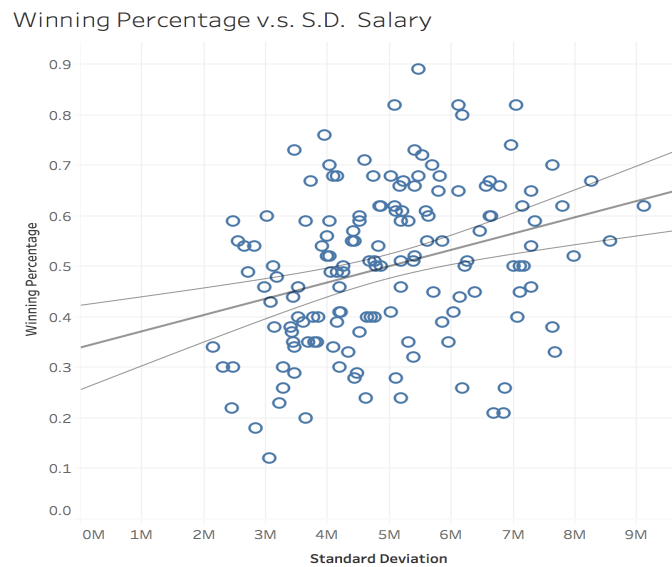


Figure 1. Least Squared Regression of Team Winning Percentage on Standard Deviation of Salary

Simultaneously, we find from the table that there is not a significant correlation between the team winning percentage and the other two metrics, namely the Gini Coefficient and Robin Hood Coefficient of the salary data. This can be partially explained by the underestimation of the salary distribution under the calculation of these two metrics, given the small population in the data. Another reason could be that these two metrics are invariant to scale, while the standard deviation metric takes into account the values of the salary.

Overall, the data indicates that the correlation between salary distribution and team performance is not very significant. This hints that the amount of salary given to players cannot directly reflect the player talent that determines his or her performance at games. Because the salary floor for a team is



84.73 million and the team payroll is required to go beyond this number, mediocre players have a high chance of getting high salary at teams at bad locations that cannot attract star players during free agency like Charlotte Hornets. Overpaying these players, though creating an incentive for these players to practice harder, cannot improve the quality of these players instantaneously and therefore does not affect the team winning percentage. After realizing that the effectiveness of uneven salary distribution is contingent upon player quality in a team, we decide to look into existing advanced metrics that may directly impact the team performance, namely the Player Efficiency Rating.

### **2.3 Exploring Player Efficiency Rating**

Player Efficiency Rating (PER) is an advanced metric that measures the quality of an NBA player holistically. The calculation of PER is based on a complex formula that sums up positive performance metrics such as points, rebounds and assists and subtracts negative performance metrics such as turnovers and personal fouls with assigned coefficients. PER is a comprehensive measure of the value of a single player as it takes into account the all-around performance of players on the court. According to the PER data posted by Basketball Reference in 2016, former legend Michael Jordan and current superstar LeBron James are sitting at the top two spots on the all-time PER leaderboard, with a total rating of 27.91 and 27.65<sup>7</sup> respectively.

Based on the Superstar Effect, it is then intuitive to reason that there is a strong positive correlation between the standard deviation of PER among players in a team and the team winning percentage. Thus, a similar correlation was run between the team winning percentage and the three afore-mentioned metrics of PER spread, namely the standard deviation, Gini Coefficient and Robin Hood Coefficient. In addition to measuring the dispersion of PER, an additional correlation was run on the average PER.

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<sup>7</sup> Basketball Reference

Measure of PER	Correlation with Team Winning Percentage
Standard Deviation	0.175
Gini Coefficient	0.146
Robin Hood Coefficient	-0.009
Average	0.287

Table 2: Correlation with Team Winning Percentage for Different Measures of PER

According to **Table 2**, we find that neither the Gini Coefficient nor the Robin Hood Coefficient of PER has a significant correlation with team winning percentage. However, since the correlation coefficient between the standard deviation of PER and team winning percentage is close to 0.2, there is at least a weak correlation between the two, likely due to the superstar effect. The metric with the highest correlation coefficient 0.287 is average PER, which shows that the average player quality in a team is in some ways more important than a widespread player quality in a team with superstars especially during an 82-game regular season. The bench players play a substantial amount of time during games and thus are crucial to the team performance. This observation means that a non-superstar team with a consistent player quality in both the starting lineup and the substituting lineup is more likely to win compared with a superstar team with a high standard deviation of PER where bench players have low ratings and perform significantly worse than their superstar teammates.

### 3. Model

After cleaning the data and running correlation tests between the team winning percentage and different metrics of salary and PER, we come up with a model that best measures the team winning percentage that represents overall team performance. After weighing different metrics and balancing

the statistical significance of variables in the model with the correlation coefficient of the metrics, we choose to run a multiple regression of team winning percentage against the average PER and the Robin Hood Coefficient of salary through Python and find the following function:

$$\text{Team Winning Percentage} = 0.034 + 0.029 * \text{Average PER} + 0.233 * \text{Robin Hood Coefficient of Salary}$$

Although the coefficient of the average PER in the model is very low at 0.029, the metric demonstrates the highest correlation with team winning percentage among all the metrics of PER. Meanwhile, even though it has a slightly lower correlation with team winning percentage than the standard deviation of Salary, the Robin Hood Coefficient of Salary is chosen as a factor in the model because it is more statistically significant due to a higher t-value than the standard deviation and thus fits in the model better.

#### **4. Discussion on Model**

While the model intends to take into account different situations, there are some weaknesses that we need to take into consideration.

First, unlike other professional leagues like NFL and NHL, NBA imposes a “soft” cap on the team salary, offering the opportunity for teams to go beyond the salary cap through different exception rules without paying any luxury taxes. Famous exception rules include the Larry Bird Exception and Mid-Level Exception, where the salary of players signed with these exception contracts are not included the annual team payroll. For instance, the mid-level exception allows teams to sign one player at a specified maximum amount.<sup>8</sup>

Second, the increase in salary cap from 70 to 94 million by 24 million gives teams an edge to sign multiple quality players at reasonable salary levels without compromising the salary of other players. Thus, this policy reduces the impact of salary distribution on team performance and makes the

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<sup>8</sup> Coon, 2017

Robin Hood Coefficient of Salary less significant in the model. This can be shown by the decrease in the correlation coefficient between the team payroll and regular season wins from 0.53 to 0.35 for the 2010~2011 and 2016~2017 season respectively.<sup>3</sup>

Third, teams have different goals. Some teams that aim at contending for playoff spots or even championships are willing to afford luxury taxes. This might lead to the reduction of the Robin Hood Coefficient of Salary while maintaining at a competitive winning percentage of the same team. Ultimately, the correlation between these two variables would be lower and affect the selection of the Robin Hood Coefficient of Salary in the model. At the same time, other teams that aim at tanking to gain high draft picks might intentionally lose games, which artificially reduces the average PER of the team and can bring down the correlation between team winning percentage and average PER.

Last but not least, the model does not take into account the complexity of contracts such as signing star players to a maximum contract. For instance, the salary under the maximum contract is contingent upon how many years the player stays with the team. Ultimately, the model oversimplifies the complexities of different scenarios as it is hard to include the effects of these contracts in the model.

## **5. Conclusion**

This paper finds that, contrary to what numerous sports fans may believe, there is only a moderate correlation between team performance and salary distribution due to the Super Star Effect, where team winning percentage serves as a measure of team performance. Since the salary given to players is contingent upon player caliber and reflects individual player's performance on the court, the average PER, a metric that measures the average efficiency of players in a team during games, seems to be a more significant factor of team performance than salary distribution due to its

stronger correlation with the team winning percentage. A model of team winning percentage is thus built taking into account both the Robin Hood Coefficient of Salary and average PER through multiple regression. The results may give managers of NBA teams some insights to balance between rewarding players with high salaries and keeping up the average caliber of players in the team.

Overall, PER is a better metric than salary when measuring team success on the court. Thus, more investigation should be conducted by adjusting the PER to reflect its true impact on team performance. In addition, certain qualitative variables such as the support of the city and team location are omitted in the research as it is difficult to quantify their impacts on team success. A more in-depth research that focuses on the impact of PER on team success will be conducted in the future.

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