

Salary Determination of a Free Agent in the National Basketball Association

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Abstract:

In this paper, we consider both statistical and financial factors that determine a free agent NBA player's salary. By looking at a player's production from the previous season and the NBA team's financial situation, our results are consistent with our hypothesis that the three point shot and free throws are the two major significant statistics that determine how much a free agent will make in their next season. From an NBA teams' financial perspective, it is significant to note that players who decide to switch teams make less money, which is in line with the NBA's CBA. Different economic articles discuss salary determination in the NBA, however, those sources are outdated due to major changes in the style of play in the NBA. Using these variables to create our model based on 2018 and 2019 NBA player statistics and salaries and 2019 team revenue, we found that the three point shot and free throws are important statistical factors that determine a player's salary. We will further explain our overall theory and model below.

Introduction:

The National Basketball Association (NBA) is continually growing both in terms of popularity and revenue. Former commissioner David Stern has done so by broadening the competitive league internationally. NBA teams have been playing preseason and regular season games in countries like China, Mexico, England, and many other countries for over 40 years. Broadening out internationally significantly increased the amount of revenue the NBA made thanks to the television contracts. Eventually, in 2016, the NBA signed a 9 year, \$24 billion television contract that caused a significant increase in league revenue. An increase in league revenue allows players to get an increase in their yearly salaries. Around the same time that the

new television contract was signed, the NBA began adapting to a new style of basketball started by the Golden State Warriors. Their system emphasized shooting more 3 point shots efficiently, as well as significantly improved efficiency in free-throws. Their small ball lineup has led to analysts calling this time “the era of the guards” since they are the ones mainly responsible for shooting three pointers traditionally. When determining an NBA player’s salary, player performance and team revenue are the broad variables to analyze. Therefore, our model will show NBA salary as our dependent variable and field goal percentage, free throw percentage, three point percentage, rebounds, assists, steals, blocks, turnovers, and NBA team revenue will be our independent variable. An independent variable from the team revenue aspect to analyze is if switching teams has an impact on player salary since the NBA’s CBA suggests that is the case. Since the NBA is in “the era of the guards”, we also have an independent variable for a player’s position to see if being a guard has a significant impact on a player’s salary. Looking deeper at position impact on salary, since shooting guards are traditionally known to shoot the most three pointers, we have shooting guards as an independent variable as well. We plan on using ESPN as our source for players’ salaries, basketballreference.com to get data on players’ stats, and statistica.com to record team revenues. We found two relevant pieces of literature on salary determination for free agent players that we made sure to review before making our decisions on the model. The first article was written by Sigler and Compton in the Sports Journal. They came up with a regression model to predict a players’ salary, mainly focusing on the statistical side. The other article was written by Jason Huang, who also came up with a regression model to predict a players’ salary, but Huang was more focused on analyzing complex statistics, not many casual fans and even analysts fully understand. The variables both used in their models and their

approaches for conducting their research helped us throughout our process to produce a simpler and more updated version of these two articles.

Relevant Literature Review:

A piece of literature that has already analyzed a topic similar to this is the article *NBA Players' Pay and Performance: What Counts?* published in "The Sports Journal" written by Kevin Sigler and William Compton, professors in finance in the Cameron School of Business of UNC Wilmington. In their study, they determined significant statistics that determine an NBA player's salary. They analyze points a player scores, how long a player has been in the league, a player's field goal percentage, made three pointers, rebounds, assists, blocks, personal fouls, and PER (player efficiency rating). Their hypothesis was more focused on the three point shot and PER will be statistically significant. After gathering the statistics from all 540 players in the NBA from the 2017-2018 season and conducting the regression analysis, they were able to conclude that points, experience, rebounds, assists, and fouls are the statistically significant variables for determining an NBA players' salary. They wanted to see if newly important statistics like the three point shot and PER have a significant impact on salary determination, but the results showed that this was not the case. They looked at the three point shot more specifically because they understood that teams over the years went from rarely shooting three pointers to making it the primary focus of any offense. For our research, we include statistics similar to Sigler and Compton, however, we are re-evaluating the three point shot hypothesis and adding a revenue variable to fully account for the demand for a player from a team's perspective.

Another literature review that was conducted similar to this one was done by Jason Huang from the University of Pennsylvania overseen by an advisor under affiliation with the Joseph Wharton Scholars. Instead of looking at individual offensive and defensive statistics,

Huang analyzes the significance of more complex statistics. He looks at win-shares and real plus-minus, sophisticated analytical ratings that reflect the overall impact of an NBA player. He hypothesizes that general managers not focusing on these statistics are making poor choices in allocating their salary cap and are more focused on analyzing offensive statistics. After conducting multiple regression analyses with the other common basketball stats like points, defensive rebounds, and turnovers during the 2013-2014 and the 2014-2015 seasons, Huang concluded that both win-shares and real plus-minus are statistically significant. However, team owners are not compensating their players based on statistics usually associated with winning. This article is important to our research because Huang conducts a process similar to ours by analyzing both win contribution and revenue perspective. However, his data is outdated due to the change in the style of basketball mentioned earlier and his hypothesis is different since he is focusing on general managers making poor decisions instead of predicting how much a player should make.

Economic Theory:

To create an accurate model that estimates an NBA player's salary, it is important to analyze the demand for that player from the team's perspective. To break this down, the demand for a player stems from the player's productivity, in other words, win contribution, and team revenue, how much money the team has to spend. Looking at the player's productivity theoretically, the more productively efficient and higher win contribution a player has, the player will earn more money in his contract. To measure a player's productivity, we account for both simple offensive and defensive statistics. We expect that as offensive and defensive productivity increases, the player's salary should increase since that player should be in high demand. It is obvious that the more points a player scores, the more value they bring to the team. However, since teams are more focused nowadays on shooting three pointers and free throws, we break

down scoring into field goal percentage, a player's overall scoring efficiency, three point percentage, a player's three point scoring efficiency, and free throw percentage, the player's efficiency at making free throws. Players scoring at an efficient rate increases the chance of the team winning. The expectation for all these variables is that every time each is increased by a percent, the player should have a salary increase. Rebounding is another important statistic to analyze because it helps either secure the ball for the team to start an offensive possession or keep an offensive possession alive. Minimizing the amount of time spent on defense will improve a team's chance of winning. As rebounds increase by one, a player's salary should increase since rebounds display a player having a positive impact on the court. Assists are an offensive statistics, which is defined as a player passing the ball to a teammate that leads to a score. The more scoring a team does, the higher the chance of the team winning. Since this is showing offensive production, as assists increase by one, a player's salary should increase since assists are another important aspect of the offense. Steals are a defensive measure that significantly impacts a player's productivity on the court. This is when a player on the defensive ends takes the ball away from the offensive team legally. Allowing the team to have more offensive possessions increases the probability of the team winning. As a player's steals count increases by one, a player's salary should increase. Blocks are another defensive statistic that helps analyze a player's productivity. A block occurs when the offensive team attempts a field goal, but the defensive team blocks the shot away from the basket. This is an important statistic because blocking minimizes the scoring of the opposing team. If the opposing team scores fewer points, then the probability of the blocker's team increases. Thus, the expectation is that as blocks increase by 1, the higher the player's salary. Turnovers are an offensive statistics that measures a player's productivity, but negatively. Turnovers are identified as when an offensive

player loses possession causing the other team to be on offense. The more a player loses the ball on offense, the probability of their team winning decreases since they have fewer chances to score. The expectation is that as turnovers increase, the player's salary will decrease since more turnovers hurt the team.

Since the NBA is in "the era of the guards", we analyze if this is true by measuring if the position of a player impacts their salary. With this understanding, the expectation is that guards will receive more money since traditionally, they can shoot the three point shot and free throws more efficiently than the other position. To break down the guard position even further, of the point guard and shooting guard, the shooting guard is traditionally known as the specialized shooter, hence the name shooting guard. Compared to the guard and the other position, the expectation is that shooting guards make the most money since the NBA has adapted toward their style of play: efficient three point and free throw shooting.

Theoretically from a revenue perspective, the higher the team's revenue is, everything else held constant, the team can spend more money on players. With this in mind, the expectation is that as team revenue increases, a player's salary should increase since the team can spend for a player of demand. Since the players being analyzed are free agents, players have the option to leave their team. Assuming the free agent player moves to a team with high revenue, the initial expectation is that moving to a team with higher revenue will increase a player's salary. However, due to the NBA's CBA, moving to a new team decreases the maximum amount of money the team can offer. With this in mind, the actual expectation is that if a player moves to a new team, their salary will decrease. With all the variables and their expected impact on a player's salary mentioned, the model and analysis are discussed in the next section.

Empirical Model:

In this model, we include twelve explanatory variables. Below is the model we used to determine the salary of a free agent NBA player:

$$\text{Salary} = S_1 + S_2 (\text{FG\%}) + S_3 (\text{FT\%}) + S_4 (\text{3PT\%}) + S_5 (\text{REB}) + S_6 (\text{AST}) + S_7 (\text{STL}) + S_8 (\text{BLK}) - S_9 (\text{TOV}) - S_{10} (\text{POS}) - S_{11} (\text{SG}) - S_{12} (\text{DEC}) + S_{13} (\text{REV}) + \varepsilon$$

The S's represent the coefficient of determination for each variable in the regression output. For the FG% (field goal percentage), FT% (free throw percentage), and 3PT% (three point percentage) variables, those values were inserted into the equation as decimals from the dataset. REB (rebounds), AST (assists), STL (steals), BLK (blocks), and TOV (turnovers) values will be inserted as-is from the dataset. These variables are represented as dummy variables: POS, SG, and DEC. The POS (position) variable creates a distinction between guards and forwards. For this model, 0 represents guards and 1 represents forwards. If the player is a forward, we predict that they will make less money than a guard would. The SG (shooting guard) variable identifies free agents that are listed as shooting guards. In this model, 0 represents players listed as shooting guards and 1 represents all the other positions. We predict that players of other positions will make less money than shooting guards. Finally, the DEC (decision) variable represents a free agent's decision to move to a new team. 0 represents the free agent resigning with his original team and 1 represents the free agent signing with a new team. We expect that if a player signs with a new team, they will make less money than if they stayed with their original team.

Data:

We will not analyze a free agent coming off an injury (eg. DeMarcus Cousins tearing his achilles in 2018, the year he was a free agent). Factoring out free agents coming off injuries is

the best way to create an all else equal field for all the free agents, the best way to isolate the impact of all the variables. There were a few sources that were used to gather the total set of data points to create this model. The free agent players that were analyzed were from the 2018 and 2019 class. Using basketball-reference.com, the players' statistics were gathered from the previous season, which in this case would be from the 2017-2018 season for the 2018 class and the 2018-2019 season for the 2019 class. This website also listed each free agent player's official position. All the player productivity variables used in this model are averages for the 2017-2018 and the 2018-2019 season. The data collected for team revenue was listed on statista.com and we analyzed team revenue as of 2019. To record if a player switches teams or not, we used the website spotrack.com to make our data accurate. We used the official ESPN website to record each player's salary. Another aspect to note about this model is that the values REV (revenue) and the salary have been adjusted to eliminate skew results. A skew is present in the salaries because the superstar players tend to earn the majority of the money. Similarly, revenue is skewed because large market teams tend to receive the most revenue since they have more potential people to broadcast to. To eliminate the skews in our model, we took the natural log of the salaries and the revenues.

Econometric Investigation:

Here is the descriptive statistics table for the 2018 and 2019 NBA free agents. This include player productivity statistics, position, free agency decision, adjusted team revenue, and adjusted salary:

	Adjusted Salary	FG%	FT%	3PT%	REB	AST	STL	BLK	TOV	POS	SG	DEC	Adjusted Revenue
Count	106	106	106	106	106	106	106	106	106	106	106	106	106
Mean	15.90294249	0.472235849	0.775679245	0.317018868	4.943396226	2.645283019	0.833018868	0.514150943	1.469811321	0.575471698	0.773584906	0.603773585	19.52359036
SD	0.849162509	0.06322425	0.084191228	0.111882164	2.351413713	1.851266918	0.376632118	0.408816801	0.705916468	0.496619299	0.420498998	0.491436093	0.211339151
Min	14.22934124	0.367	0.543	0	1.2	0.5	0.2	0	0.4	0	0	0	19.22715661
Max	17.4562234	0.652	0.919	0.455	13.1	9.1	2	2.2	4.2	1	1	1	19.97248954

Below are the regression statistics for our model.

Regression Statistics	
Multiple R	0.725199535
R Square	0.525914366
Adjusted R Square	0.464742026
Standard Error	0.621258558
Observations	106

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	14.91274499	6.00522962	2.483293053	0.01480894	2.987549119	26.83794087	2.987549119	26.83794087
FG%	1.38380015	1.544936105	0.89570057	0.372725243	-1.684136771	4.451737071	-1.684136771	4.451737071
3P%	1.768793909	0.782916053	2.25923827	0.026204267	0.214077791	3.323510028	0.214077791	3.323510028
FT%	2.297610474	0.869078125	2.64373295	0.009623842	0.571793557	4.02342739	0.571793557	4.02342739
REB	0.09423966	0.043556578	2.163614873	0.033056808	0.007744928	0.180734393	0.007744928	0.180734393
AST	0.086577585	0.071082976	1.217979185	0.22631298	-0.054579118	0.227734288	-0.054579118	0.227734288
STL	0.618838462	0.202191094	3.060661332	0.002886509	0.217327021	1.020349903	0.217327021	1.020349903
BLK	0.173880573	0.21347439	0.814526617	0.417424196	-0.250037259	0.597798404	-0.250037259	0.597798404
TOV	0.129734013	0.148876237	0.871421896	0.385767874	-0.165904689	0.425372714	-0.165904689	0.425372714
Position	0.071771094	0.264572754	0.271271673	0.786783314	-0.453617961	0.597160148	-0.453617961	0.597160148
Shooting Guards	0.031951973	0.232095954	0.137667084	0.890801157	-0.428944592	0.492848539	-0.428944592	0.492848539
Decision	-0.348145679	0.131673166	-2.644013878	0.009616428	-0.609622492	-0.086668867	-0.609622492	-0.086668867
Adjusted Revenue	-0.171716708	0.302946876	-0.566821188	0.57220119	-0.77309165	0.429875748	-0.77309165	0.429875748

Our model has an R squared of approximately 0.53, which means that the model explains approximately 53% of the variation in a free agent's salary. Looking at the results, the regression model does support the main hypothesis that three point and free throw shooting are significant factors that increase a player's salary. The model displays a positive coefficient for both variables, meaning the player makes money. And since the p-value for both is less than any of the confidence intervals (1%, 5%, or 10%), it means that the variables are significant. The other significant variables in this model are rebounds, steals, and the decision dummy variable. The

coefficient for each of those variables matched the prediction: both rebounds and steals being positive and decision being negative. This makes sense since rebounding and steals increase the amount of time a team is on offense. The longer a team is on offense, the more likely they score. The more likely they score, the probability of winning the game increases. The decision variable is correct as it is in line with the details of the NBA's CBA. With most regression models come insignificant variables. The most notable insignificant variables are the position and shooting guard dummy variables. The reason for this is that these variables being insignificant proves the hypothesis that guards, more specifically shooting guards make more money. The model shows that the position coefficient says that a player makes more money if they are listed as a forward. It also shows that all the other positions that are not shooting guards make more money. Hence, both disproving the hypothesis. Another notable insignificant variable is turnovers. The reason for this is because the coefficient is positive, implying that as a player's turnovers increase, the player makes more money. Turnovers is a negative statistic that harms a player's productivity and a player does not get rewarded more money with more turnovers. Since the p-value of turnovers is greater than the confidence intervals, turnovers can be ignored regarding having an impact on a player's salary. Although the regression model had many insignificant variables, it proved the main hypothesis that the three point and free throw shots are significant factors that determine a player's salary. According to our results, this is what the average free agent NBA player should make. We calculate this by putting the mean values for each variable into the model. Since we eliminated the skew from the salary and team revenue, the answer the model produces, we raise e to that output to see the actual average salary. The results are down below:

$$\begin{aligned} \text{Predicted Salary}_{\text{Average}} = & 14.9127449 + 1.38380015 (0.472) + 1.768793909 (0.317) + \\ & 2.297601474 (0.776) + 0.09423966 (4.94) + 0.086577585 (2.65) + \end{aligned}$$

$$0.618838462 (0.83) + 0.173880573 (0.51) + 0.129734013 (1.47) + \\ 0.071771094 (0.58) + 0.031951973 (0.77) - 0.348145679 (0.60) - \\ 0.171716708 (19.52359036)$$

$$\text{Predicted Salary}_{\text{Average}} = 15.09235970 \rightarrow e^{15.09235970}$$

$$\text{Predicted Salary}_{\text{Average}} = \$3,585,325$$

According to our model, the average free agent NBA player should make around \$3,585,325.

Sports Economic Policy:

With a regression model created, we wanted to evaluate how accurate the model is at creating a predicted salary. We will do so by picking three different players and inserting their information into our model. Since we had to remove the skew from team revenue and salary by taking the natural log of those values, the solution the model produces will also eliminate the skew. To see what the model actually produces, we raise e to the model's output, doing the reverse of natural log. The three players that will be chosen as test subjects are Danny Green, Kemba Walker, and Trey Lyles. Danny Green is a shooting guard who is a three and D player. This means his role on a team focuses on shooting three pointers and playing defense. Kemba Walker is an all-star point guard who has a very solid all-around game for a player of his position. Trey Lyles is a forward who is not considered a strong three point shooter, but contributes in other statistical categories. The calculation for Danny Green's predicted salary is down below:

$$\text{Predicted Salary}_{\text{Green}} = 14.9127449 + 1.38380015 (0.465) + 1.768793909 (0.455) + \\ 2.297601474 (0.841) + 0.09423966 (4) + 0.086577585 (1.6) + 0.618838462 (0.9) + \\ 0.173880573 (0.7) + 0.129734013 (0.9) + 0.071771094 (0) + 0.031951973 (0) - \\ 0.348145679 (1) - 0.171716708 (19.88855509)$$

$$\text{Predicted Salary}_{\text{Green}} = 15.84086764 \rightarrow e^{15.84086764}$$

$$\text{Predicted Salary}_{\text{Green}} = \$7,578,817$$

$$\text{Actual Salary}_{\text{Green}} = \$14,634,146$$

For Danny Green, our model's prediction is almost half of what Danny Green actually made. A reason as to why this may be is the year Danny Green became a free agent, he was a key contributor to the Toronto Raptors first championship in franchise history. Since he was so productive, Green could demand more since he knows his value increased. His new team, the Los Angeles Lakers, are a large market team with enough money to give Danny whatever he desires, if not more. This is something that cannot be accounted for in the model. Now we transition into predicting the all-star Kemba Walker's salary. The calculations are down below:

$$\begin{aligned} \text{Predicted Salary}_{\text{Walker}} = & 14.9127449 + 1.38380015 (0.434) + 1.768793909 (0.356) + \\ & 2.297601474 (0.844) + 0.09423966 (4.4) + 0.086577585 (5.9) + 0.618838462 (1.2) + \\ & 0.173880573 (0.4) + 0.129734013 (2.6) + 0.071771094 (0) + 0.031951973 (1) - \\ & 0.348145679 (1) - 0.171716708 (19.53253826) \end{aligned}$$

$$\text{Predicted Salary}_{\text{Walker}} = 16.48685263 \rightarrow e^{16.48685263}$$

$$\text{Predicted Salary}_{\text{Walker}} = \$14,459,362$$

$$\text{Actual Salary}_{\text{Walker}} = \$32,742,000$$

Our model predicted that Walker will make more than half of what his actual salary is. To explain potential reasons as to why this is the case may have to do with the requirements of max contracts according to the NBA's CBA. Incentives for players to increase how much money they make include winning awards like being an all-star, making an all-NBA team, defensive player of the year, and/or MVP. These factors are not accounted for in the model Walker was named an

all-star and named to the all-NBA third team. Knowing his productivity and his accolades for his free agent year, the Boston Celtics, a large market team, were able to give Kemba a bigger max contract according to the CBA rules. Finally, we analyze the model's prediction for Trey Lyles's salary. The calculations for him are down below:

$$\begin{aligned} \text{Predicted Salary}_{Lyles} = & 14.9127449 + 1.38380015 (0.418) + 1.768793909 (0.225) + \\ & 2.297601474 (0.698) + 0.09423966 (3.8) + 0.086577585 (1.4) + 0.618838462 (0.5) + \\ & 0.173880573 (0.4) + 0.129734013 (1.1) + 0.071771094 (1) + 0.031951973 (1) - \\ & 0.348145679 (1) - 0.171716708 (19.46799974) \end{aligned}$$

$$\text{Predicted Salary}_{Lyles} = 14.90647258 \rightarrow e^{14.90647258}$$

$$\text{Predicted Salary}_{Lyles} = \$2,977,137$$

$$\text{Actual Salary}_{Lyles} = \$5,500,000$$

While Trey Lyles did not have the most productive season, there is a possibility as to why Lyles made more compared to our prediction. He was originally a lottery pick by the Denver Nuggets, but there was not enough time for him to play and when he did, he did not produce well. Since lottery picks tend to have a unique talent compared to other draft picks, the San Antonio Spurs are giving Lyles a second chance and a bigger role that will hopefully increase the team's win count. This situational aspect cannot be calculated by any numerical model since it is hard to measure a negotiation that likely happened between Lyles and the Spurs. Overall, our model did not accurately predict players' salaries, but it did show that quality three point and free throw shooters (Danny Green and Kemba Walker) make more money than a player like Trey Lyles.

Conclusion:

Looking at the overall results, our model did support the main hypothesis that three point and free throw shots are significant factors in determining a free agent NBA player's salary. Along with these variables, we predicted that field goal percentage, rebounds, assists, steals, blocks, turnovers, position, player's decision, and team's revenue would be significant factors in determining a player's salary. With our hypothesized variables, the other significant variables include rebounds, steals, and player's decision. While our model supported our hypothesis, it was not a very accurate model in determining a player's salary. To improve this model in the future, we can include more dummy variables. Some can represent the accolades a player has won, which potentially include MVP, Defensive Player of the Year, All-Star, and All-NBA team selection. The NBA CBA supports the fact that players make more money if they win an award from the previous season. The other dummy variable to include is the player who won a championship the year they become a free agent. These are potential factors that can impact a player's salary as seen by the Danny Green and Kemba Walker example.

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