National Basketball Association (NBA) and 3-pointers

Final Project, DECS-922: *Data Exploration*, Winter 2019

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1 Introduction

In the 2018-2019 NBA regular season, we observed births of many new 3 pointers records. For example, Klay Thompson from the Golden State Warriors, made 14 3-pointers in Chicago last October. (link) James Harden, a key player from the Houston Rockets who is known for being deadly at making three pointers, created a record of second longest 30-point games streak, 32 games, in last February. This is the first record change after 1962. (link) Also, Klay Thompson mentioned earlier succeeded 10 consecutive 3-pointers in last Jan. (link)

These observations made us interested in looking this phenomenon further, especially whether they are exceptions to the normal or they represent a shifting trend in how teams play in the NBA. Thus, we would like to answer the following questions to gain a better understanding how three pointer shooting has evolved since 1986 while taking into considerations of dimensions such as teams' standings, player age, other scoring methods in the game and a few other factors.

1.1 Methodology

To conduct the necessary analysis, we used detailed historical data from the nbastatR package. (link) This is a comprehensive open-source package that has additional tools to analyze the NBA data. Through some initial testing, we found that not all the tools are effective at helping us understand the questions regarding the three point shooting trend in the NBA and some of the additional functions in the NBA package are duplicated. However, we found the dataset to be helpful and sufficient to conduct the proposed research.

For additional data such as histrical standings and salary information, that are not included in nbastatR package, we downloaded CSV files from Basketball-Reference.com (link)

The data from nbastatR (`dataGameLogsPlayer` & `dataGameLogsTeam`) contain all the variables available so we trimmed the data by selecting relevant variables for analysis of each question.

1.2 Key questions

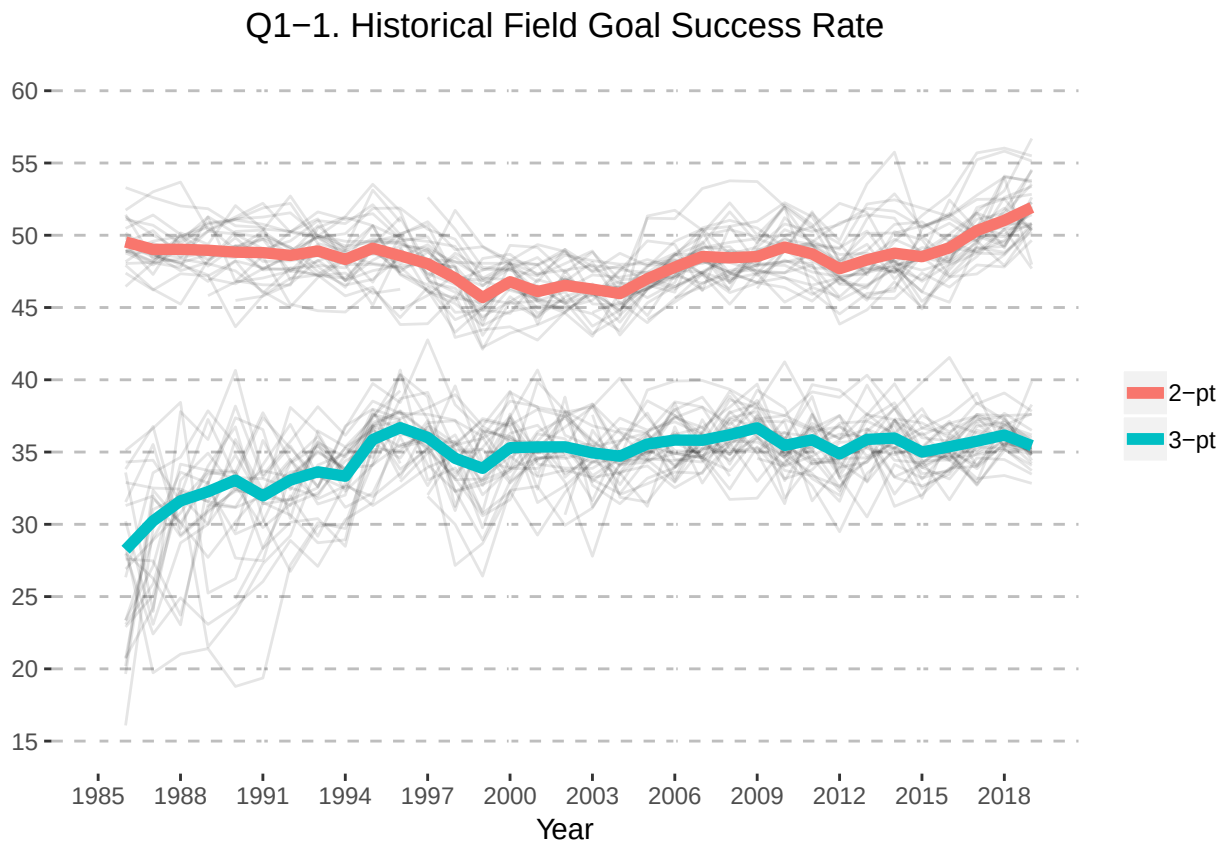
- It seems that players are getting better at making 3-pointers than 10 or 20 years ago (both on average across the league and also top 3-pointer shooters vs. top 3-pointer shooters) Is it true?
- Teams with more 3-pointers tend to be the better performing teams?
- Are there any relationship between players' ages and 3-pointers?
- Players who are good at 3-pointers are also good at 2-pointers or free throws?
- Players with high salaries are good at 3-pointers?
- We want to analyze whether players can drastically improve their three point shooting skills over time or the skill is rather something people are born with.
- Show the 3-pointer statistics geographically based on players' hometowns. Maybe this help illustrates the different basketball playing style across different regions, both domestic and international.
- We would like to explore the importance of three point shooters in a given team by measuring the share of the team's total salary over time.
- What are the expected average points of 3-pointers and 2-pointers?
- If the expected average point from 3-pointers is getting higher than that of 2-pointers, how should each team's strategy chang?

2 Team level questions

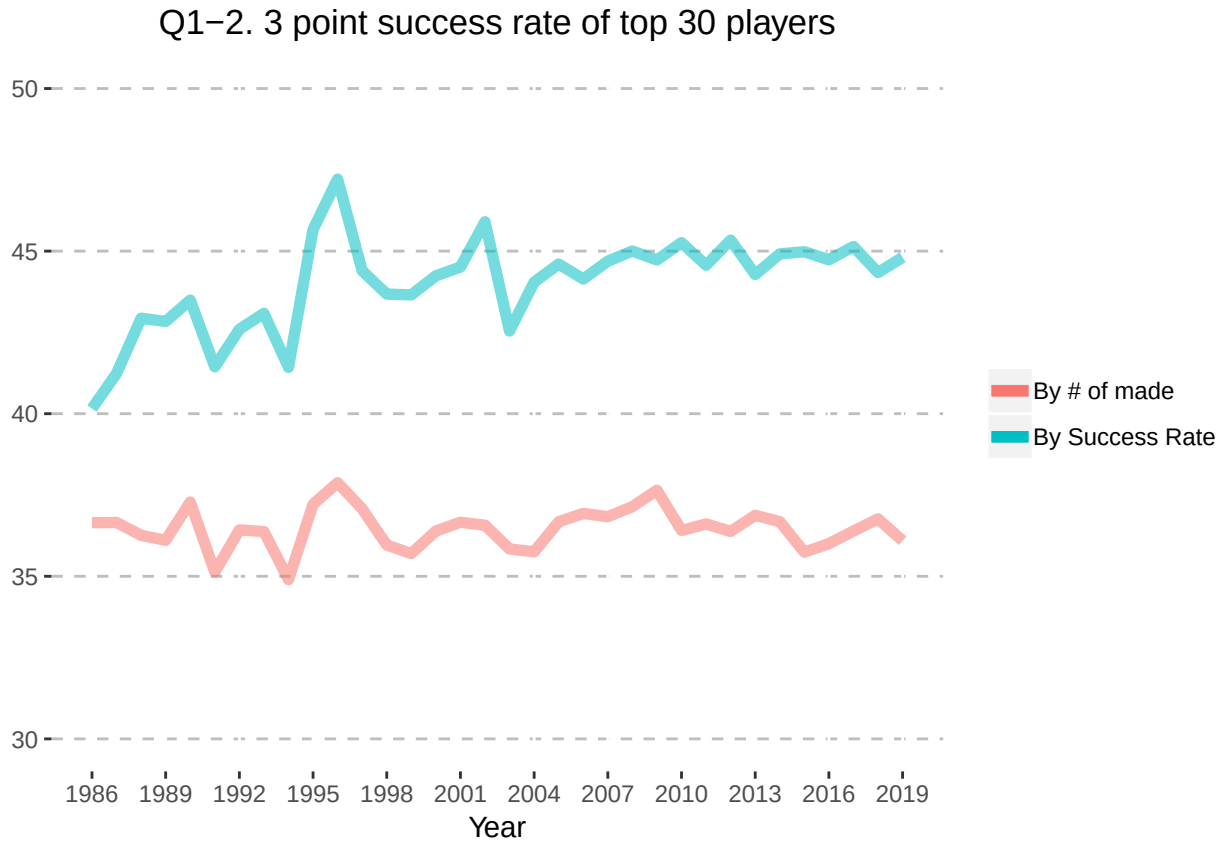
- **Q1. It seems that players are getting better at making 3-pointers than 20 years ago (both on average and also top 3-pointer shooters vs. top 3-pointer shooters) Is it true?**

Yes, the success rate of 3-point field goal has been increased by about 9% since 1986.

Based on the chart 1 in the report, from 1986 to recent years, the average team in the NBA has improved their three pointer success rate, which is calculated by dividing the number of three pointers made by the number of three pointers attempted in each regular season. With that said, however, the success ratio has stayed largely flat since 1998, likely to the fact that the rules regarding three pointers have not changed and players on average have reached a plateau in terms of the three pointers success rate.



Equally interesting, instead of team average, if we were to look at the top 30 three point shooters in the league by success rate or by number of three pointers made, according to chart 2, the main driver behind their improved contribution to the total points score by their team is through the improvement of their three pointer success rate. Similar to the trend we saw among teams earlier, top three point shooters also improved their success rate over the time period that we specified here.



- **Q2. Teams with more 3-pointers tend to be the better performing teams?**

We ran regressions on the team standings during the regular seasons by three pointer success rate and two pointer success rate. If team has a lower standings, in another word, smaller number for its ranking position, it is ranked closer to the top so the better team. Unsurprisingly, the regressions showed that independent variables three pointer success rate and two pointer success rate all have negative coefficients and they are statistically significant at 5%. This means when the three pointer and two pointer success rates increase, the teams tend to have smaller numbers as their rankings, i.e., better rankings.

Table 1: Ranking with 3-pointer success rate

term	estimate	std.error	statistic	p.value
(Intercept)	32.6295	2.7198	12.00	0
pctfg3	-0.5177	0.0787	-6.58	0

Table 2: Ranking with 2-pointer success rate

term	estimate	std.error	statistic	p.value
(Intercept)	107.039	4.9650	21.56	0
pctfg2	-1.907	0.1026	-18.59	0

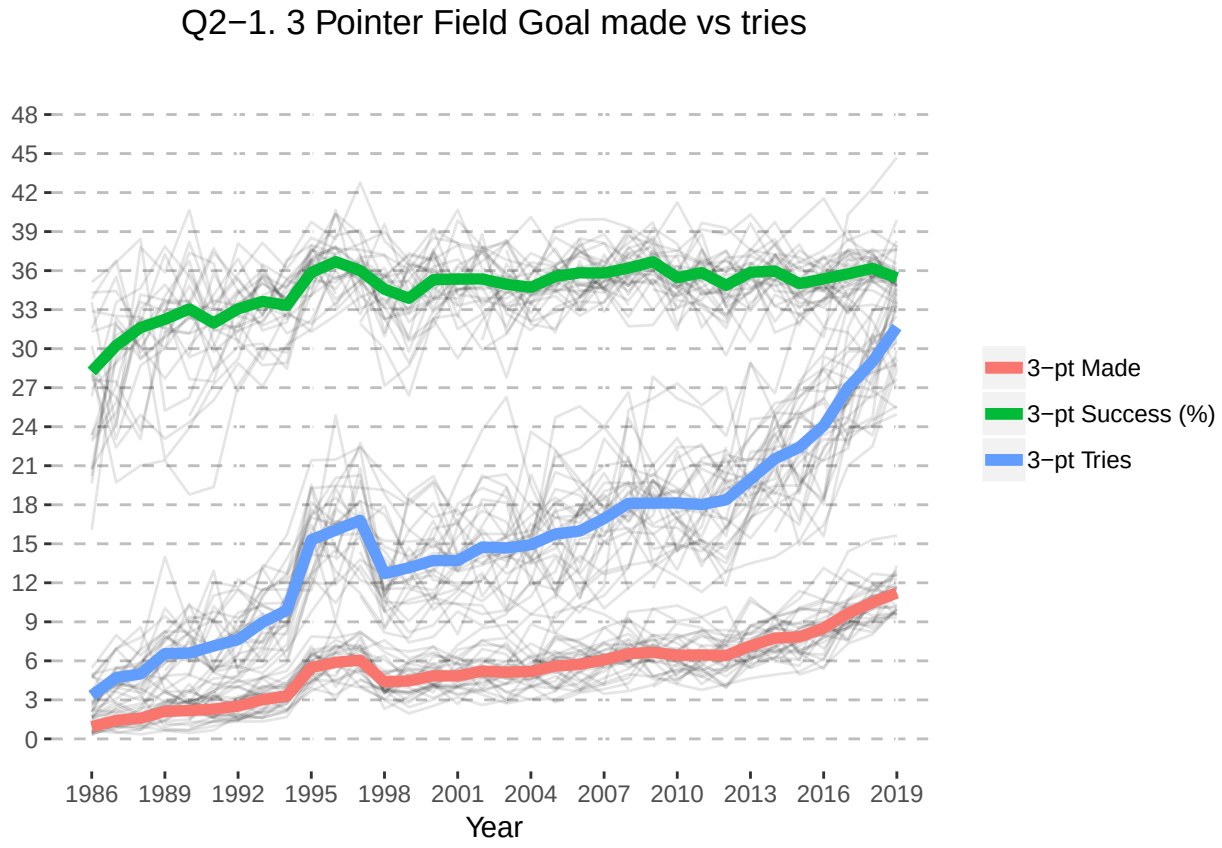
Table 3: Ranking with 3-pointer & 2-pointer success rate

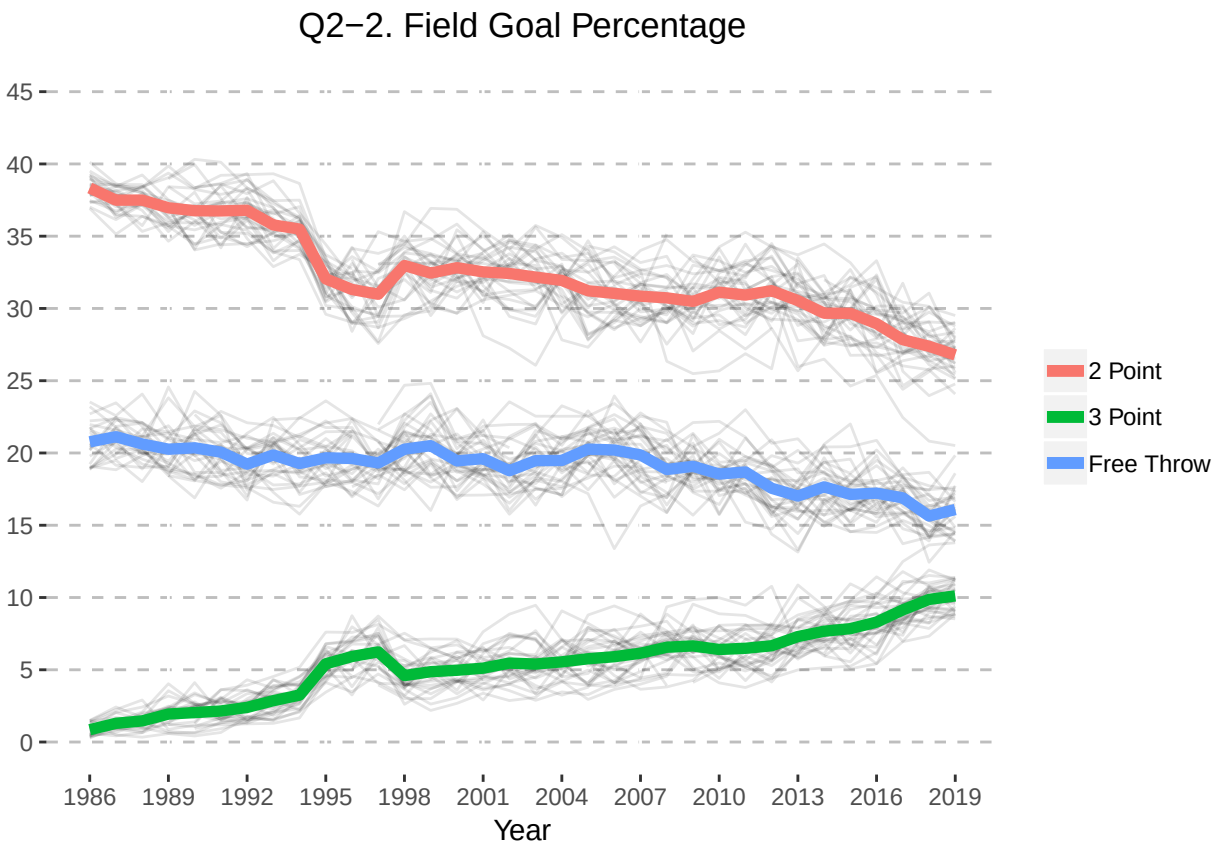
term	estimate	std.error	statistic	p.value
(Intercept)	113.7368	5.1490	22.089	0
pctfg3	-0.3049	0.0694	-4.395	0
pctfg2	-1.8284	0.1031	-17.727	0

Table 4: Regression of 3-pointer & 2-pointer success rate

term	estimate	std.error	statistic	p.value
(Intercept)	21.9658	2.2869	9.605	0
pctfg2	0.2572	0.0472	5.445	0

However, as two pointers still contributed to a larger share of the total points scored by a given team than three pointers do. The absolute value of the coefficient on two point success rate is larger than that of three point success rate. This is not surprising because improving the same percentage of success rate in two point shooting and three point shooting means that the former will have a larger impact on improving the team's ranking than the latter does.




Q2−2. Field Goal Percentage
45
40
35
30
25
20
15
10
5
0
1986
1989
1992
1995
1998
2001
2004
2007
2010
2013
2016
2019
Year
2 Point
3 Point
Free Throw

The expected points from each shot tell another interesting story.

The expected points of 2-point shots in 1986 was `fgyear$pctfg2[1986-1985]/100 * 2` = 0.9907
The expected points of 3-point shots in 1986 was `fgyear$pctfg3[1986-1985]/100 * 3` = 0.8472

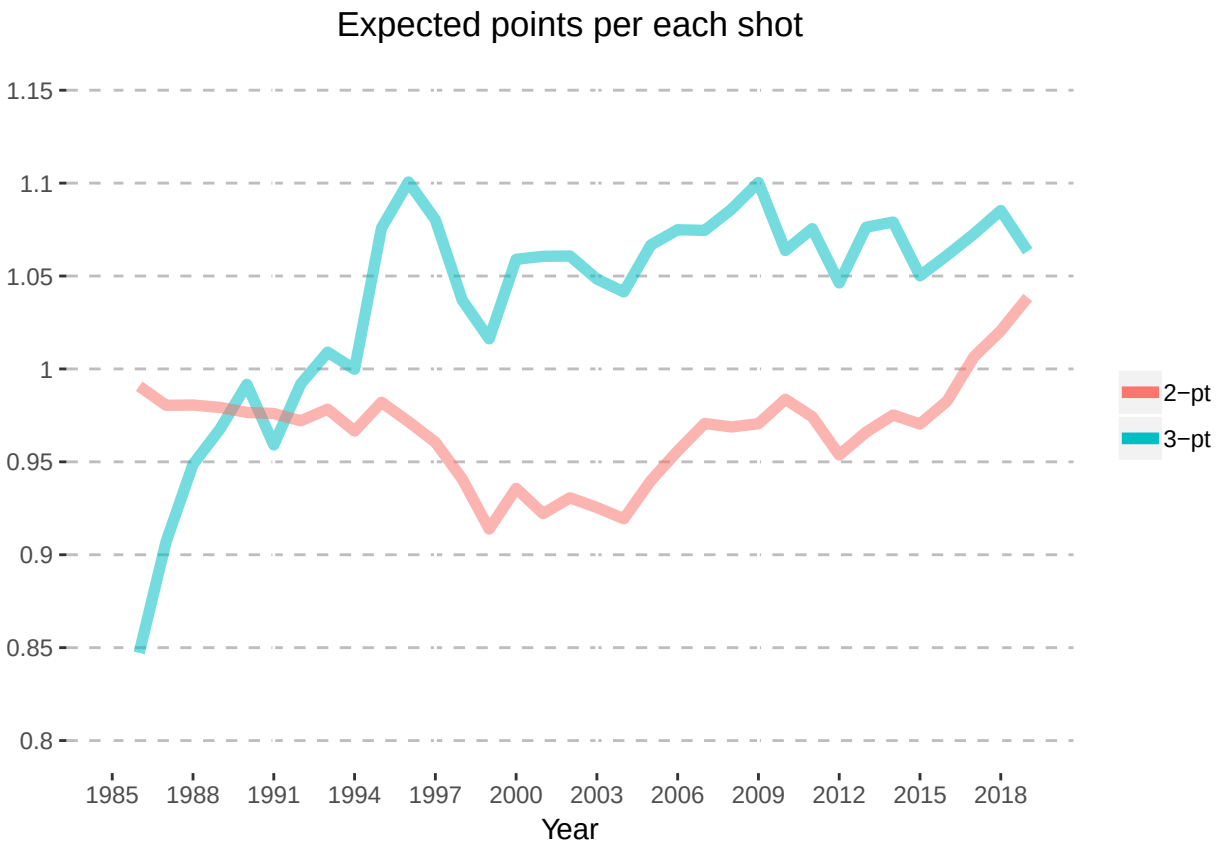
The expected points of 2-point shots in 2019 was `fgyear$pctfg2[2019-1985]/100 * 2` = 1.0385
The expected points of 3-point shots in 2019 was `fgyear$pctfg3[2019-1985]/100 * 3` = 1.0633

Teams started to focus on 3-point shots after its first introduction in 1979, because the expected points of 3-point shots are higher than that of 2-point shots since early 90's.

Looking back, three-pointer's debut, in the 1979-80 season, was inauspicious.(link)

There are many reasons for the rise of the 3-point shot, but one may simply be math. It took a while, but coaches finally stopped listening to the traditionalist naysayers and realized that a shot that is worth 50 percent more pays off, even if that shot is a little harder to make.

"Teams have all caught on to the whole points-per-possession argument," Lawrence Frank, the Nets' coach at the time, said in 2009 as the 3 rate began to rapidly increase.



- **Q3. Are there any relationship between players' ages and 3-pointers?**

Really good players are not related with ages/career.
Average players' success rate is increased by 0.4% in one year. Not bad. . . ?

Based on the regression that we ran the three pointer accuracy on a given player's tenure in the NBA, The coefficient is positive and statistically significant at 5%, so we believe as players play longer in the NBA, they tend to have better success rate at shooting three pointers, likely due to continuing training that help improve their three pointer shooting skills and also better understanding of the games and thus know when are the right times to shoot three pointers.

Table 5: 3-pointer Success Rate & Tenure: for players with 2000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	39.5611	0.7195	54.983	0.0000
career	-0.0994	0.0656	-1.514	0.1323

Table 6: 3-pointer Success Rate & Tenure: for players with 1000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	35.428	0.2807	126.194	0.0000
career	0.073	0.0306	2.384	0.0173

Table 7: 3-pointer Success Rate & Tenure: for players with 100+ 3-pointers

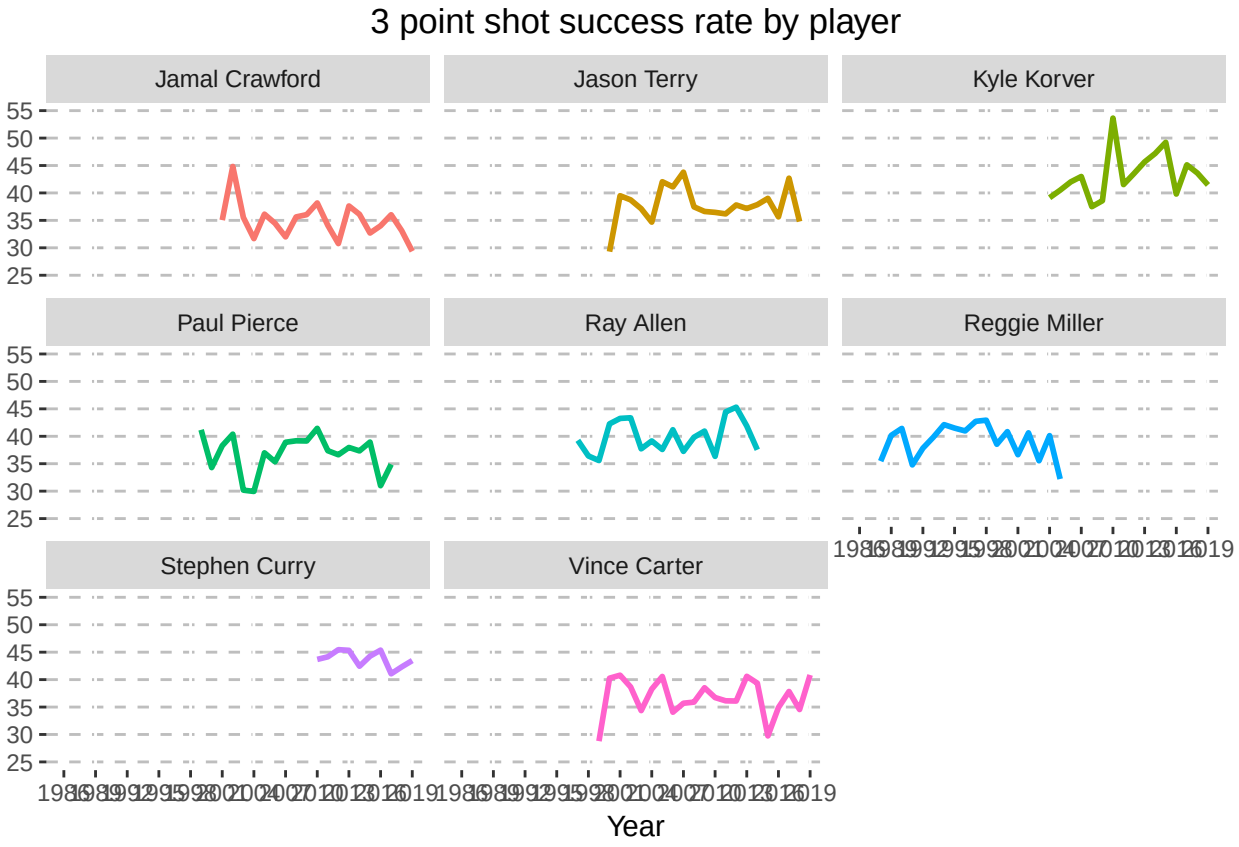
term	estimate	std.error	statistic	p.value
(Intercept)	31.7021	0.2075	152.772	0
career	0.1859	0.0280	6.629	0

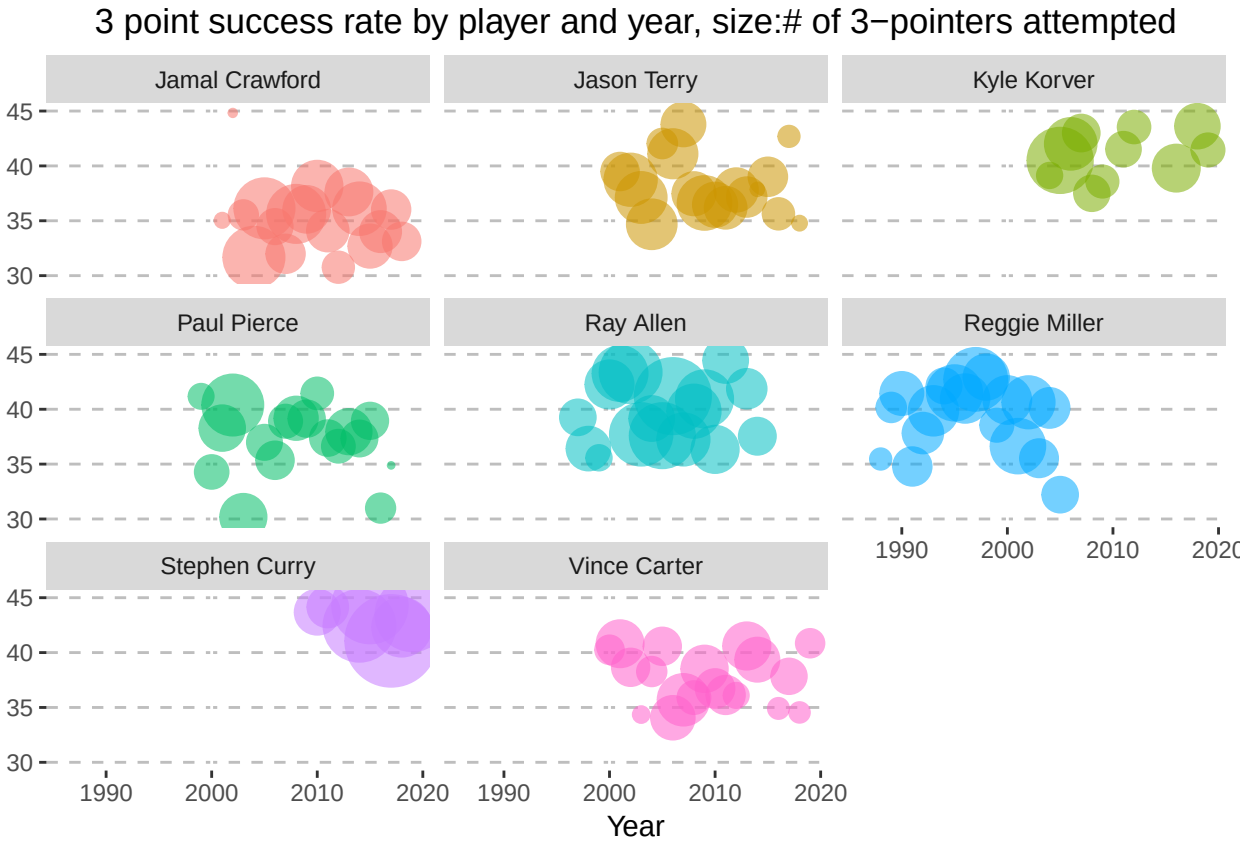
Table 8: 3-pointer Success Rate & Tenure: for all players

term	estimate	std.error	statistic	p.value
(Intercept)	24.0595	0.2520	95.49	0
career	0.4144	0.0378	10.96	0

3 Player level questions

The graphs showing top players' career-long progress of 3-pointer success rate tells that it generally goes up at the begining, and after career-high, goes down at the end of his career. We also wanted to analyze whether players can drastically improve their three point shooting skills over time or the skill is rather something people are borned with. By above regression and below graphs, there is no dramatic increase in 3-pointer success rate. Maybe if we can check the players' data from NCAA or high school league, there might be different insight. However, based on NBA data, no big changes.





Above graph shows more players are trying 3 point shots than before. even though the average success rate is similar.

- **Q4. Players who are good at 3-pointers are also good at 2-pointers or free throws?**

We ran a series of regressions and found that three pointer success rate has a positive and statistically significant relationship with free throw success rate, however, we are not able to draw such conclusions between the three pointer success rate and two pointer success rate.

A couple of factors that could have contributed to this observation. Players in NBA tend to specialize in three pointer shooting vs two pointer shooting. These two specialization often mean that they need to make a trade off between which style of play to focus on at each other's expense. Also, two pointer plays include lay ups and dunks that usually top three point shooters would not do because they tend to play in the peripheral of the court during the game. One can also argue in the NBA, there is a trade off between explosiveness and three point shooting consistency. The explosive quality is important to have do well in the two pointer style play and thus created this lack of positive correlation between three point success rate and two point success rate.

Below are for the players made more than 100 3-pointer shots.

Table 9: 3-pointer success rate & 2-pointer success rate

term	estimate	std.error	statistic	p.value
(Intercept)	33.696	1.752	19.2341	0.0000
pctfg2	0.033	0.040	0.8233	0.4106

Table 10: 3-pointer made & overall shots made

term	estimate	std.error	statistic	p.value
(Intercept)	184.0382	19.5664	9.406	0
fgm	0.1425	0.0062	23.078	0

Table 11: 3-pointer attempted & overall shots attempted

term	estimate	std.error	statistic	p.value
(Intercept)	404.3621	48.0459	8.416	0
fga	0.1966	0.0069	28.613	0

Table 12: 3-pointer attempted with overall shots & free-throws attempted

term	estimate	std.error	statistic	p.value
(Intercept)	275.9537	47.4035	5.821	0
fga	0.3470	0.0172	20.226	0
fta	-0.4553	0.0481	-9.473	0

Table 13: 3-pointer success rate & free-throw success rate

term	estimate	std.error	statistic	p.value
(Intercept)	18.249	1.4223	12.83	0
pctft	0.216	0.0181	11.91	0

Table 14: 2-pointer success rate & free-throw success rate

term	estimate	std.error	statistic	p.value
(Intercept)	41.9230	1.415	29.618	0.0000

term	estimate	std.error	statistic	p.value
pctft	0.0219	0.018	1.214	0.2253

Table 15: 3-pointer success rate with 2-pointer success rate & free-throw success rate

term	estimate	std.error	statistic	p.value
(Intercept)	17.6788	2.0985	8.4244	0.0000
pctfg2	0.0136	0.0368	0.3695	0.7118
pctft	0.2157	0.0182	11.8754	0.0000

When we look at all the players, 2-pointers and 3-pointers are reverse-related. Maybe because of dunk shots?

Table 16: 3-pointer success rate with 2-pointer success rate & free-throw success rate: for all players

term	estimate	std.error	statistic	p.value
(Intercept)	3.6531	2.5237	1.448	0.1479
pctfg2	-0.0441	0.0415	-1.063	0.2881
pctft	0.3293	0.0237	13.894	0.0000

Best players (more than 1,000 career 3-point field goals) are good at 2-pointers as well!!!

Table 17: 3-pointer success rate with 2-pointer success rate & free-throw success rate: for players with 1000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	3.7572	4.0565	0.9262	0.3565
pctfg2	0.3450	0.0843	4.0937	0.0001
pctft	0.2264	0.0344	6.5772	0.0000

Table 18: 3-pointer success rate with 2-pointer success rate & free-throw success rate: for players with 2000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	-21.5400	20.1466	-1.069	0.3339
pctfg2	0.7987	0.4422	1.806	0.1307
pctft	0.2901	0.2309	1.256	0.2645

- **Q5. Players with high salaries are good at 3-pointers?**

Table 19: Salary vs 3-pointer success rate: for players with 1000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	1.1031	25.9149	0.0426	0.9662

term	estimate	std.error	statistic	p.value
pctfg3	0.5801	0.6901	0.8406	0.4032

Table 20: Salary vs 3-pointer shots made: for players with 1000+ 3-pointers

term	estimate	std.error	statistic	p.value
(Intercept)	16.1141	5.6880	2.833	0.0059
fg3m	0.0046	0.0037	1.229	0.2227

When career success rate of 3-point shots impact the salary statistically significantly, 1%p increase in the rate will increase the salary by $0.58 million. However, It's difficult to say that 3-pointer success rate is the most important factor for one's salary. (2018-2019 season data only)

- **Q5. Geographical analysis based on players' hometown**

Let's show the 3-pointer statistics geographically based on players' hometowns. This might illustrate the different basketball playing style across different region.

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FALSE     clip: on
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FALSE     is_free: function
FALSE     is_linear: function
FALSE     labels: function
FALSE     limits: list
FALSE     modify_scales: function
FALSE     orientation: NULL
FALSE     params: list
FALSE     projection: lagrange
FALSE     range: function
FALSE     render_axis_h: function
FALSE     render_axis_v: function
FALSE     render_bg: function
FALSE     render_fg: function
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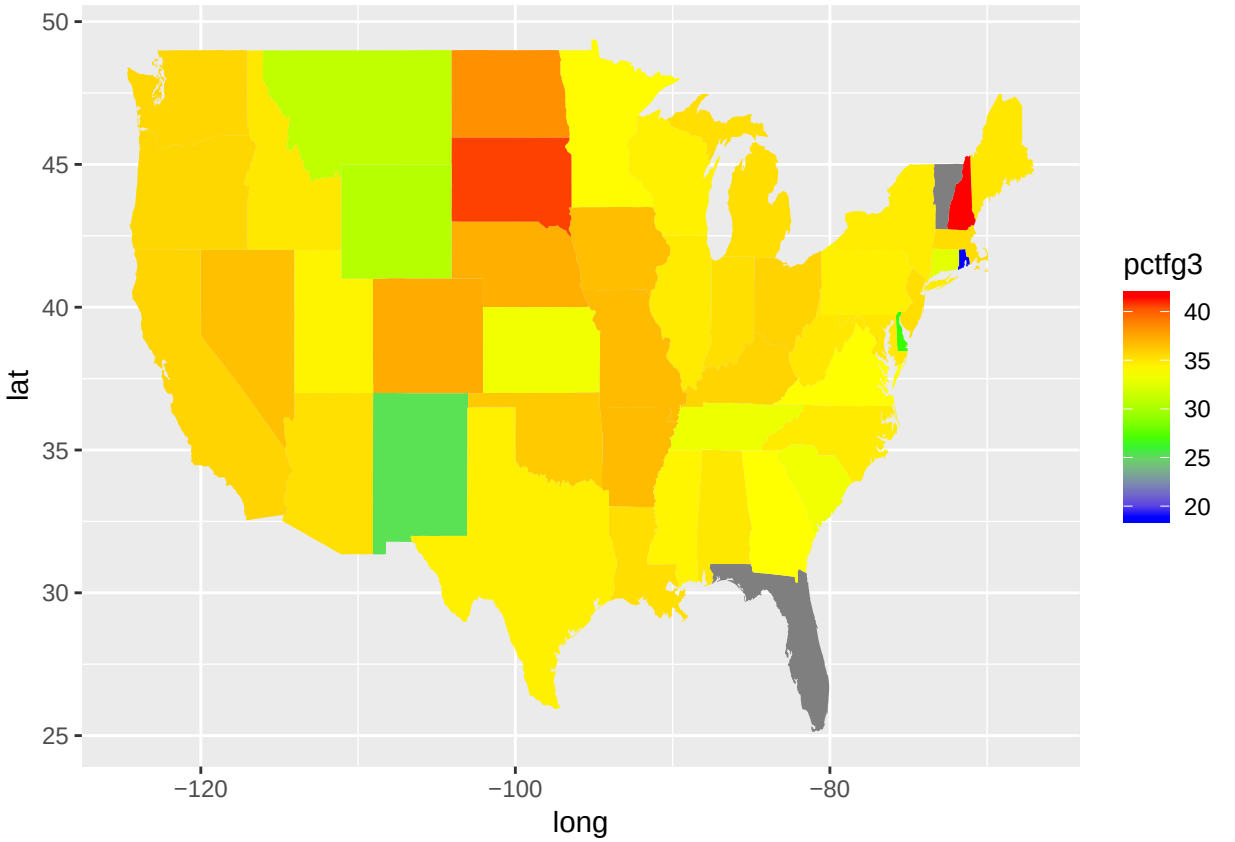

Above map shows that there are a few outliers in the 3-point success rate. We would need additional analysis to find out the implication of this chart. It maybe due to different playing style by region/NCAA team.