Statistica Applicata - Italian Journal of Applied Statistics Vol. 35 (1)
doi.org/10.26398/IJAS.0035-003

WHEN IS 2 BETTER THAN 3 IN BASKETBALL?

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Abstract *A recent trend in basketball is that teams are taking more shots outside of the three-point line and fewer shots inside. This is an advantage since the expected number of points scored, in general, is slightly higher for three-point shots. Through simulations, this paper shows that there are game situations where a strategy of taking fewer three-point attempts at the expense of more two-point attempts will improve the probability of winning the game.*

Keywords: *Simulation Coaching Strategy Sports.*

1. INTRODUCTION

The National Basketball Association (NBA) is continuously evolving over time. A recent trend involves teams attempting an increasing number of three-point field goals (Rocha da Silva and Rodrigues, 2021), based on analytics showing this to be a superior strategy in terms of maximizing the expected number of points scored per possession.

Skinner and Goldman (2017) pointed out, from a theoretical perspective, that it may be beneficial in certain situations to aim for two-point shots instead of three-point shots, even if the latter leads to higher expected points. Since two-point shots are converted more frequently, they lead to lower variance in the total score at the expense of potentially lower expected values.

In this paper we examine the following question using real-world data: are there realistic situations that frequently appear in NBA games where teams would benefit from tilting their shot selection strategy in favor of taking more two-point attempts? We answer this question using simulations, while deriving simple guidelines that may be followed by basketball coaches to guide their teams towards increased sporting success.

For almost seventy years, researchers have proposed that coaches can use scientific methods to make improvements in the way that their teams perform

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(Wright, 2009). An early example in basketball was the use of statistical models to evaluate players with adjusted plus-minus ratings (Winston, 2009), which has since evolved into ever more complex and powerful models (Engelmann, 2017), and has been adopted within a range of different sports (Hvattum, 2019).

Nikolaidis (2015) suggested that basketball teams can improve their decision-making processes significantly by choosing to employ statistical analysis of basketball data. In a recent review, Terner and Franks (2021) focused on research that models the performance of players and teams, while also discussing different sources of data and related software tools for data retrieval. Recent advances in this field involve using detailed tracking data (Bornn et al., 2017), but there is still much insight that can be gained also with simpler data sources, such as box scores.

An important concept in the analysis of basketball is the idea of possessions (Kubatko et al., 2007). A given possession begins when a team gains control of the ball, and lasts until the team no longer has control. Possessions can thus end after converting a shot, after missing a shot leading to a defensive rebound, or after a turnover. Since the end of one possession is followed by the beginning of a new possession by the other team, the two teams involved in a game always have approximately the same number of possessions.

The four-factor model of Oliver (2004) is a seminal work within basketball analytics. It proposes that the offensive rating of a team decomposes into four distinct qualities: the effective field goal percentage, the turnover percentage, the offensive rebound percentage, and the free throw attempt rate. Improving these areas of play, a team can improve its win percentage. Cecchin (2022) used structural equations modelling to validate the four-factor model, finding that the four factors are relevant in explaining teams' winning ability. When analyzing high-level European basketball, Charamis et al. (2022) found a slightly better model for win percentages, using a true shooting percentage instead of the effective field goal percentage and the free throw attempt rate.

Annis (2006) analyzed optimal end-game strategy, finding that intentionally fouling is a better strategy than playing tight defense to protect a small lead at the end of a game. McFarlane (2019) used logistic regression to find win probabilities and then created an end-of-game tactics metric to evaluate on-court decisions. One application of this is to find the time at which intentionally fouling becomes the optimal tactic for a given score differential. Christmann et al. (2018) used video-analysis to investigate offensive play types in the final two minutes of 115 close NBA games. Findings included that coaches should instruct their teams to

attempt transition play whenever possible, and that for set plays more complex play types are more effective.

The number of three-point and two-point attempts made has occasionally been studied in the scientific literature. Csataljay et al. (2009) analyzed games from the European Basketball Championship of 2007 and found that winning teams had a higher conversion rate for three-point attempts, while having fewer three-point attempts. Ibáñez et al. (2008) studied the Spanish Basketball League, finding no statistically significant differences between the best and the worst teams when it comes to successful, nor unsuccessful, two-point and three-point attempts.

This contrasts with analysis of modern era NBA games: Rocha da Silva and Rodrigues (2021) observed that between 2014 and 2019 three-point attempts and conversions had a positive effect on the performance of teams, while two-point conversions started to be a negative factor and then turned into a non-factor. Mandić et al. (2019) compared statistics from the NBA and the Euroleague between 2000 and 2017. They found that the number of three-point attempts in the NBA had almost doubled in the examined time period, while the number of three-point attempts in the Euroleague had increased by a much smaller magnitude. Fichman and O'Brien (2019) split the court into 11 zones, and used game theory to find optimal mixed strategies for which zones to use when making shots. They concluded that NBA is headed for a future with a higher number of three-point attempts, with an equilibrium analysis suggesting on average 62.1% two-point shots and 37.9% three-point shots.

The remainder of this paper is structured as follows. In Section 2 we describe the data used to find appropriate inputs to our simulations. Section 3 presents our simulation framework. Results and analyses are given in Section 4, followed by conclusions in Section 5.

2. DATA

The main source of data is `https://www.basketball-reference.com`. We extracted team statistics per 100 possessions for seven seasons of the NBA, from 2015/2016 to 2021/2022. These statistics are based on 82 games for each of 30 teams, except for the 2019/2020 and 2020/2021 seasons when fewer games were played due to an epidemic infectious disease. We thus focus on regular season games, and exclude the play-offs. The attributes extracted include the number of three-point field goal attempts (3PA), the number of two-point field goal attempts (2PA), the three-point field goal percentage (3P%), and the two-point field goal percentage (2P%). Table 1 summarizes the number of two-point

Table 1: Descriptive statistics from seven recent seasons of the NBA, reporting the number of two-point attempts and the number of three-point attempts per 100 possessions for different teams. Data source: basketball-reference.com

	2PA			3PA		
Season	Min.	Avg.	Max.	Min.	Avg.	Max.
2015/2016	53.5	62.7	70.2	16.4	24.9	31.5
2016/2017	46.7	60.2	68.5	22.1	27.8	40.1
2017/2018	42.8	58.3	66.0	23.3	29.6	43.2
2018/2019	42.6	56.8	63.8	25.2	31.8	46.0
2019/2020	43.3	54.2	61.4	28.0	33.7	43.4
2020/2021	45.6	53.9	62.1	27.7	34.7	43.5
2021/2022	47.1	53.6	61.2	29.3	35.6	41.4

attempts and three-point attempts for different teams, while Table 2 shows the corresponding conversion rates.

The team-based statistics show that there has been an evolution in shot strategies in the NBA over the span of these seven seasons. The number of two-point attempts has declined, while the number of three-point attempts has increased, in particular when considering the average across teams. While the conversion rates for three-point shots have been relatively stable across time, the conversion rates for two-point shots have improved.

In the following, we focus in particular on the 2018/2019 regular season, which was the last season prior to the playing schedules being interrupted due to pandemic-induced restrictions. Figure 1 shows the number of field goal attempts of each type per 100 possessions for each of the teams in the 2018/2019 regular season. Naturally, teams with many three-point attempts have, in general, fewer two-point attempts and vice versa. The outlier with the highest 3PA is the Houston Rockets, with 46 three-point attempts per 100 possessions. The field goal percentages per team are illustrated in Figure 2. The conversion percentages vary from 33% to 39% for three-point attempts and from 48% to 57% for two-point attempts.

When looking at the number of attempts and the conversion rates, an important observation is that the conversion rates do not vary to a large degree with the number of attempts. This is illustrated for three-point field goals in Figure 3, and similar relationships were found for attempts and conversions of two-point field

Table 2: Descriptive statistics from seven recent seasons of the NBA, reporting the conversion rates for two-point attempts and three-point attempts for different teams. Data source: basketball-reference.com

	2P%			3P%		
Season	Min.	Avg.	Max.	Min.	Avg.	Max.
2015/2016	45.4 %	49.2 %	52.8 %	31.7 %	35.3 %	41.6 %
2016/2017	47.3 %	50.4 %	55.7 %	32.7 %	35.7 %	39.1 %
2017/2018	47.8 %	51.1 %	56.0 %	33.4 %	36.2 %	39.1 %
2018/2019	47.9 %	52.0 %	56.5 %	32.9 %	35.6 %	39.2 %
2019/2020	48.9 %	52.4 %	56.7 %	33.3 %	35.8 %	38.0 %
2020/2021	47.6 %	53.1 %	56.5 %	33.6 %	36.6 %	41.1 %
2021/2022	49.7 %	53.3 %	57.5 %	32.3 %	35.4 %	37.9 %

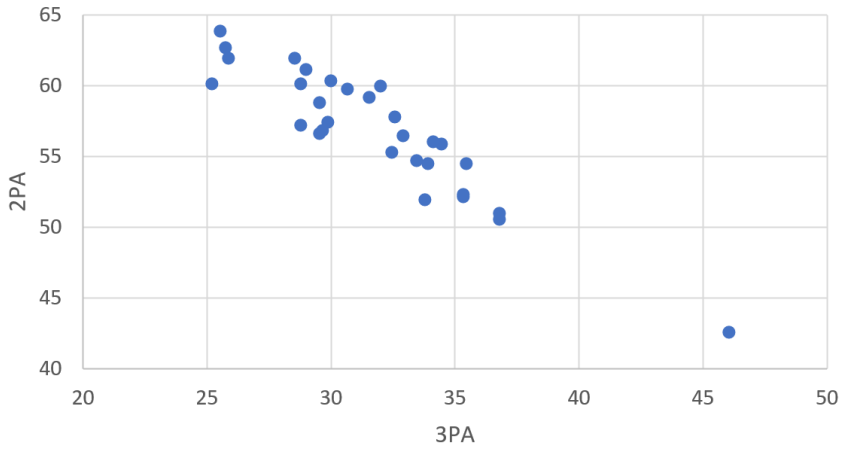

Figure 1: Number of two-point and three-point attempts per 100 possessions for each of the 30 teams participating in the 2018/2019 season. Data source: basketball-reference.com

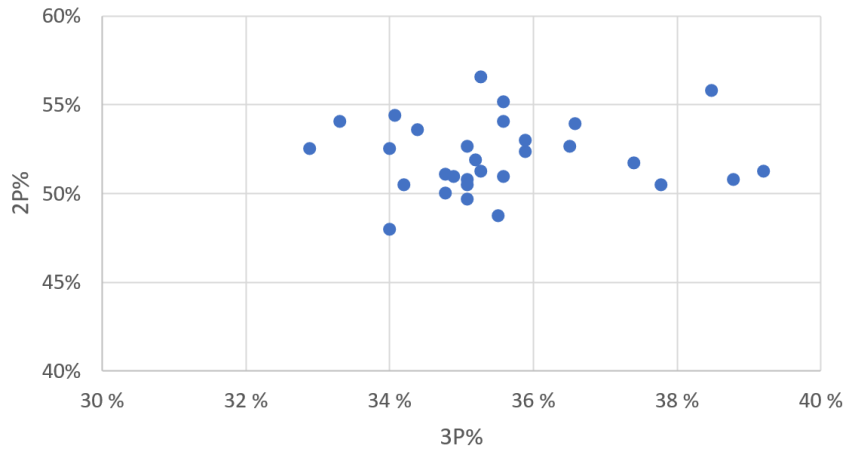

Figure 2: Field goal percentages for two-point and three-point attempts for each team in the 2018/2019 season. Data source: basketball-reference.com

goals.

To elaborate on these relationships, we ran simple linear regressions with the conversion rates as dependent variables and the number of attempts as independent variables, using team observations from all seven seasons in the data set. When 3P% is regressed on 3PA, the regression coefficient is very close to zero, but statistically significant with a P-value of 0.035. The coefficient implies that the conversion rate for three-point shots increases by 0.04 percentage points for each additional attempt per 100 possessions, which is very low. For 2P% regressed on 2PA, the regression coefficient of 2PA implies a decrease of 0.28 percentage points in the conversion rate per additional attempt per 100 possessions, and the coefficient is highly significant with a P-value that is essentially 0. However, including additional independent variables, such as free throw conversion rates and total points scored per 100 possessions, is associated with a reduction in the magnitude of the regression coefficient of 2PA.

We can expect that the number of free throw attempts depends on the shot selection strategy, since a player fouled within the three-point line is awarded two free throws, whereas a player fouled outside of the three-point line is awarded three free throws. Using the full data set with 280 team observations, we regressed the number of free throw attempts per 100 possessions on the number of two-point attempts and three-point attempts, respectively. We find that two-point attempts are not significant at explaining the number of free throw attempts, with

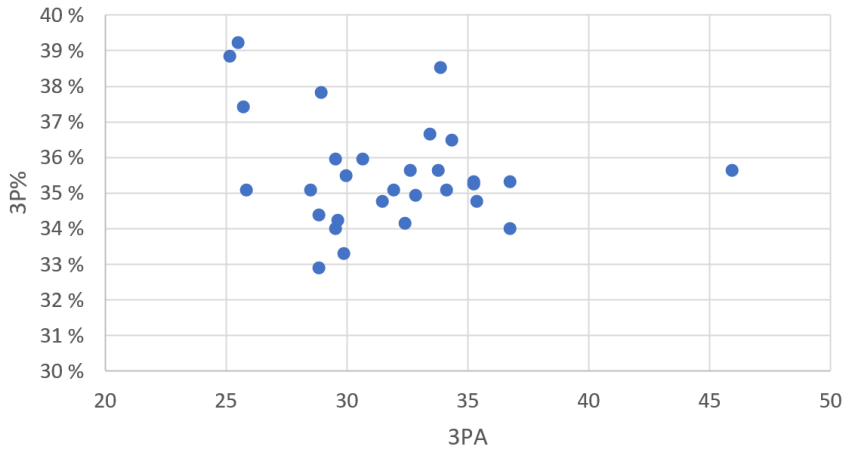

Figure 3: For three-point field goals, the relationship between attempts and conversion rates for each team in the 2018/2019 season. Data source: basketball-reference.com

a P-value of 0.31, whereas three-point attempts are significant with a P-value of 0.003. The regression coefficient of 3PA indicates that the number of free throw attempts decreases by 0.08 for each three-point shot attempted. Overall, there is no evidence of a strong relationship between free throw attempts and the number of two-point or three-point attempts.

3. EXPERIMENTAL SETUP

To compare the effect of different shot selection strategies, or in other words the effect of teams choosing to make more two-point attempts at the expense of three-point attempts, we use discrete-event simulation. The simulation takes as input the values of 3PA, 2PA, 3P%, and 2P% for each of two teams. In addition, it takes as input the current point difference and the number of remaining possessions per team. Considering the number of possessions remaining is a simplification, since in reality there is a game clock that determines how long the game lasts, and the number of possessions is unknown a priori. However, defining the remainder of a game through the number of remaining possessions per team makes the results easy to interpret.

The simulation then considers each remaining possession and, according to the given shot selection probabilities, randomly determines that the possession

Table 3: Alternatives explored for shot selection strategies

Style	2PA	3PA
Two-point focus	63.9%	25.5%
Balanced	57.1%	32.0%
Three-point focus	42.6%	46.0%

ends with a three-point shot, a two-point shot, or no shot. Then, if a shot is taken, according to the given shot conversion probabilities we draw whether the shot is successful, and then adjust the point difference. The simulation does not consider free throws.

When all possessions have been processed, the simulation terminates with a final point difference. However, if the final point difference is 0, extra time is needed to determine a winner. From `http://stats.inpredictable.com/`, we find that the average time per possession is slightly less than 15 seconds. Since overtime in the NBA lasts five minutes, we therefore use 10 possessions per team when simulating the overtime. Should the overtime also end with a draw, another overtime period is started.

Table 3 shows three alternative settings for the shot selection strategy of a team. For the analysis, input numbers are based primarily on the 2018/2019 regular season. The two-point focus strategy is based on the statistics of the team with most two-point attempts in that season, the San Antonio Spurs, while the three-point focus strategy is based on the team with the most three-point attempts, the Houston Rockets. The balanced strategy is based on the average of all the teams in the 2018/2019 season. However, since we want to analyze a situation where two teams have the same expected number of points per possession while following different shot selection strategies, the numbers given in the table are slightly adjusted, so that each strategy is made sure to produce the same expected number of points when executed by a team with an average conversion quality.

Three alternative settings for the quality of teams are reported in Table 4. Here, a good team corresponds to having the maximum conversion rates among all teams in the league for both types of shots considered. Correspondingly, an average team has the average conversion rates, and a bad team has the minimum conversion rates. With the given conversion rates, all three types of teams obtain a higher expected points total when using 3-point shots rather than 2-point shots, with an expected difference in the range of 0.029 to 0.046 points per shot.

Table 4: Alternatives explored for team quality settings

Quality	2P%	3P%
Good	56.5%	39.2%
Average	52.0%	36.0%
Bad	47.9%	32.9%

The experiments take into account a number of remaining possessions per team, ranging from 0 to 30, with a starting point difference between -10 and 10. A focal team, team 1, has a choice between two shot selection strategies: focusing on two-pointers or focusing on three-pointers, whereas the opposing team, team 2, has a fixed average strategy. The motivation behind this is to observe, from the perspective of team 1, what happens when going from a strategy favoring three-point shots to a strategy favoring two-point shots.

For the team quality we consider three alternatives: either both teams are average, and are thus expected to score the same number of points per possession independent of the selected shot strategy, or one of the teams is good and the other team is bad.

For each combination of remaining possessions and point difference we simulate 100,000 games with team 1 having a two-point focus and 100,000 games with team 1 having a three-point focus. We then calculate the difference in the number of wins for team 1, which then is used to conclude which shot selection strategy is to be preferred in a given situation.

4. RESULTS AND ANALYSIS

We start by showing the results for two equally good teams playing against each other in Figure 4. The area of the figure with darker color shows game situations where a preference towards two-point shots leads to more wins than a strategy with more three-point shots. For this setting, it is clear that the two-point focus is beneficial as soon as a team is in the lead, whereas a three-point focus is best when a team is trailing.

Figure 5 shows the corresponding figure when team 1 is better than team 2. In this case the two-point focus strategy is beneficial in more situations: even if the team is trailing by a few points, going for two-point shots can be good. Since the other team is weaker, a less risky strategy is sufficient to maximize the winning

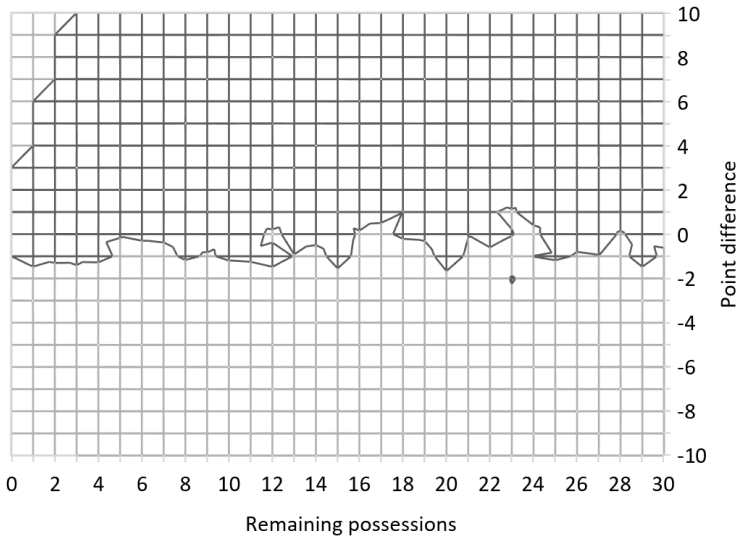

Figure 4: Best strategy for shot selection when two equally good teams play against each other and the second team has an average shot selection strategy, with dark color indicating situations where two-point focus is beneficial

chances.

Finally, Figure 6 illustrates the result for a bad team playing against a good team. In this case, if many possessions are left of the game, it may still be necessary to go for three-point shots when having a slight lead, as the more conservative two-point strategy is not sufficient to defeat the stronger opponent.

The figures conveniently demarcate the situations where a team may benefit from making more two-point attempts and fewer three-point attempts. However, they do not show whether the difference is large enough to warrant coaches to consider the effect. In each of the three situations analyzed, the magnitude of the differences in the number of wins when using either a two-point or a three-point focus is similar.

When taking two-point shots is better, this strategy leads to the team winning around 0.7 percentage points more games than when focusing on three-point shots. When taking three-point shots is better, the team also wins around 0.7 percentage points more of the games. This, however, is on average across all game states within the two regions of each figure.

Looking at the maximum numbers, there are certain states where the number of games won can change by up to 1.5 percentage points, and one example giv-

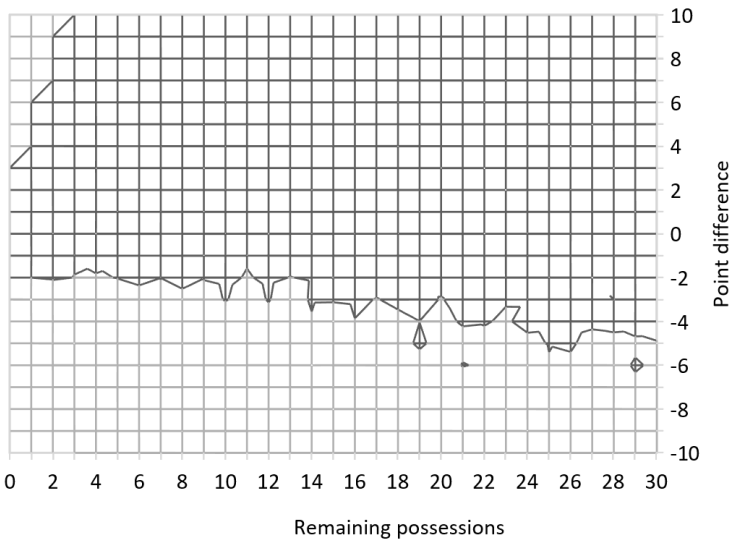

Figure 5: Best strategy for shot selection when a good team plays against a bad team with an average shot distribution, with dark color indicating situations where two-point focus is beneficial

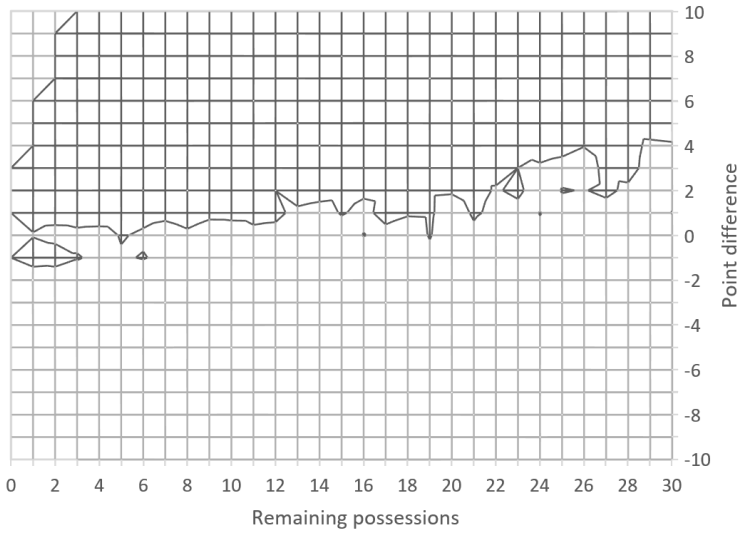

Figure 6: Best strategy for shot selection when a bad team plays against a good team with an average shot distribution, with dark color indicating situations where two-point focus is beneficial

ing a change of 3 percentage points. The latter happens in an extreme situation where each team has a single possession left, the focal team is good and is trailing by three points. In this case, the team must first score on a three-point attempt and then the opponent must fail to score in their attack. The three-point strategy then leads to the team winning 6.9% of their games, compared to 3.8% for the two-point strategy. However, most of the cases with the large difference between strategies are less extreme, such as leading by four points with ten possessions remaining against an evenly matched opponent, where a two-point focus leads to 78.2% wins compared to 76.9% for a three-point focus.

5. CONCLUSIONS

Teams in the NBA use different strategies, leading to different distributions of two-point attempts and three-point attempts. In recent years, the number of three-point attempts has increased, based on observations that this leads to a higher expected number of points per possession.

From a theoretical point of view, it is clear that if two-point attempts and three-point attempts have a similar expected value, the difference in variance may lead to either two-point attempts or three-point attempts being better for maximizing a team's winning chances.

This paper has provided numerical experiments using simulations based on realistic shot selection strategies and conversion percentages. When two equally good teams face each other, a team that is in the lead benefits from increasing the number of two-point attempts at the expense of three-point attempts, while a team that is trailing should prefer to go for more three-point attempts. When one team is better than the other, a similar strategy is useful, but the team can be more conservative, and can prefer two-point attempts even when slightly behind, in particular if there is more time left of the game. On the other hand, a weaker team must be more willing to take risk by predominantly going for three-pointers also when slightly in the lead, assuming that there are many possessions left.

The interpretation of the results rests on several assumptions, thus suggesting some limitations of the analysis. First, free throws have been neglected. Taking into account free throws requires additional information about the probability of being fouled conditional on the selected shot strategy. Second, it is assumed that shot selection strategies do not influence conversion rates. This may be false if the shot selection strategies are very different, such as solely taking two-point attempts, as the defending team can adapt their strategies accordingly. However, the shot selection strategies compared in this study are strategies actually applied

by teams in the 2018/2019 NBA regular season, and the true change in conversion rates when modifying the shot selection accordingly could be relatively small. A third limitation is that the shot selection strategies are assumed to remain fixed throughout the remainder of the game in the simulations. In practice, a team can change strategies dynamically based on the change in point differences.

This study may be extended by considering each of the above limitations. As the shot selection strategies implemented in the NBA are still evolving, future research may investigate whether this evolution leads to different conclusions than when focusing on the strategies applied within the 2018/2019 regular season. In addition, there are some differences between the NBA and other basket leagues, such as the top leagues in Europe. Therefore, using data from other competitions may lead to slightly different results. For example, in Euroleague, the three-point shot line distance is shorter, the number of fouls is higher, and the number of possessions per game is lower (Mandić et al., 2019).

To conclude, this study may provide some balancing inputs to coaches when observing that strategies involving an increased number of three-point attempts become more successful: while three-point focused strategies may lead to better expected scores, certain game situations imply that two-point focused strategies improve the probabilities of winning a game. Our simulations suggest that such game situations are perhaps appearing more frequently than expected: it is not only in rare situations where a team is one point behind and has a single possession left that a two-point attempt may be best, but also in close games where a team is slightly ahead against an evenly matched opponent.

ACKNOWLEDGEMENTS

The authors thank the editor and two anonymous reviewers for their insightful comments, which helped to improve the manuscript.

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