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Addressing opposition quality in basketball performance evaluation

Rui Dong[a], Bizhen Lian[a], Shaoliang Zhang[b], Mingxin Zhang[c], Sirius Z.Y. Huang[d] and Peter O'Donoghue[d]

[a]China Basketball College, Beijing Sport University Beijing, China; [b]Division of Physical Education and Sport Sciences, Tsinghua University, Beijing, China; [c]Faculty of Physical Education and Training, Shanghai University of Sport, Shanghai, China; [d]Cardiff School of Sport, Cardiff Metropolitan University, Cardiff, UK

ABSTRACT
The aim of this research was twofold: (i) to explain the relationships between basketball indicators and opposition quality; and (ii) to utilise regression models in the evaluation of basketball team performances that account for opposition quality. Opposition quality was represented in absolute terms without considering a team's own quality (OQ) and relative terms as the difference between the quality of a team and their opponents (RQ). Game-related indicators of all the 92 games of the Basketball World Cup 2019 were analysed. Regression analysis was used to model performance indicators in terms of OQ and RQ. Correlations between opposition quality and basketball indicators were statistically low in both terms. However, higher correlations were found between assists, two-point field goal accuracy, defensive rebounds and RQ. Two-point field goal attempts (2 PA) exhibited a negative relationship considering opposition quality. Most of the variables showed higher correlations with RQ than OQ. Offensive rebounds and personal fouls were influenced more by OQ than by RQ. Subsequently, teams over-performing or under-performing when addressing opposition quality could be recognised. This allowed trends in performance and consistency of performance to be evaluated. Evaluation scores were more consistent in absolute terms rather than relative terms.

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Basketball indicators; opposition quality; performance evaluation

1. Introduction

Competition in team sports involves interaction between players and teams. Interacting Performances Theory states that the process and outcome of sports performance can be influenced by the quality and type of opposition (O'Donoghue, 2009). For this reason, coaches and performance analysts should highlight the strengths and the weaknesses of each opposing team and player when deciding on tactics. Much performance analysis research into opposition effect has classified opponents as "strong" or "weak" based on their progress within a specific tournament, win/loss records or tournament rankings (Hook & Hughes, 2001; Hughes & Churchill, 2005; Nevill & Holder, 1999; Sampaio & Janeira, 2003; Zhang et al., 2019, 2017). However, a criticism of this approach is that

CONTACT Mingxin Zhang zhangmingxin@sus.edu.cn Faculty of Physical Education and Training Shanghai University of Sport Shanghai 200438 China

teams within such broad groups (top half or bottom half of a league, for example) may not be of similar quality (O'Donoghue & Cullinane, 2011). In many sports, there is a smoother increase in team quality as we go from the bottom of the league to the top. Cullinane and O'Donoghue (2011) investigated performances of a semi-professional rugby league team and noticed that some performance indicator values changed gradually as opposition quality increased or decreased, rather than producing a "plateauing" effect. In women's singles tennis, O'Donoghue et al. (2008) used the same decile norms to evaluate matches against opponents ranked from 1 to 20 in the World. This risks an evaluation overestimating a performance against the world number 20 and underestimating a performance against the world number 1.

In basketball, performance indicators have been found to discriminate between the winning and losing teams within matches; these include two-and-three point field goals (Çene, 2018; Gómez et al., 2008; Ibáñez et al., 2008), free throws (Conte et al., 2018; Csataljay et al., 2009; Kozar et al., 1994), defensive rebounds (Ibáñez et al., 2003; Sampaio et al., 2004; Trninic et al., 2002; Zhang et al., 2019, 2018a) and assists (Ibáñez et al., 2008; Puente et al., 2015; Zhang et al., 2019). Other game-related statistics such as turnovers (Sampaio et al., 2010; Teramoto & Cross, 2010; Zhang et al., 2019), blocked shots (Gómez et al., 2015; Zhang et al., 2019, 2018b) and personal fouls (Gómez et al., 2016; Leicht et al., 2017a) have also been found to distinguish between winning and losing teams. It is important to mention that some studies above did not take the margin of victory into account, however. The margin of victory has been found to be fundamental to interpret performance indicators discriminating winning and losing performances (Lupo & Tessitore, 2016). Behind these studies, the approaches (traditional linear or non-linear data analysis techniques) are widely used to demonstrate relationships between basketball match indicators and match outcome. However, most of these techniques do not take opposition quality into consideration. A single player's or team's performance will vary from game to game with the opponent effects being recognised as the largest source of variance in sports performance (Hughes & Bartlett, 2004; McGarry & Franks, 1994). Additionally, although the effect of opposition quality has been recognised in basketball performance (Gómez et al., 2016; Sampaio et al., 2010; Zhang et al., 2019, 2018b), analysis methods still suffer the limitation of classifying broad groups with respect to team quality.

Consider a basketball match between two teams A and B. A defeats B by a score of 65–40 which we will refer to as the raw score. However, we wish to evaluate this performance considering how well a team might be expected to perform in such a match. An average result for teams playing against Team B might be 55–45; hence, the raw point difference for Team A is greater than the average point difference of teams in general when playing Team B. We will refer to the difference between these point differences as the opposition quality-adjusted score (+15 = 25–10). Team A might also wish to evaluate their performance in terms of their own ability as well as that of the opponent. In other words, they wish to know how well a team of Team A's quality would be expected to do against Team B. The answer to this could be that one would expect a team of Team A's quality to defeat a team of Team B's quality by 60–40. Thus, the raw point difference is 5 points higher than the expected point difference (+5 = 25–20). We will refer to this as the relative quality-adjusted score. This paper proposes to evaluate performance indicators in international basketball matches addressing opposition quality and relative quality.

This paper aims to use a more continuous representation of team and opposition quality using regression analysis. This allows elite basketball performance to be evaluated addressing opposition quality and relative quality, using a finer grain approach to identify strengths and weaknesses of performances against given opponents.

2. Method

2.1. Research design

This research is composed of two parts. The first part determines the relationships between performance indicators, opposition quality and relative quality. Regression models determine expected indicator values given team and opposition quality. The second part combines actual and expected performance so that performance indicators can be interpreted addressing opposition and relative quality. Trends in performance are presented accounting for selected performance indicators.

2.2. Sample and variables

This study was a retrospective analysis of publically available data from the official FIBA Basketball website (http://www.fiba.basketball/basketballworldcup/2019/teamstats). Each of the 92 matches involved two team performances. Therefore, a sample of 184 team performances were used in the current research. Each performance was represented by 16 game-related indicators from the official box score. These variables are defined in Table 1. In order to identify the relationships between the frequency of shooting performances and opposition quality, attempts and made were used (FT, 2FG and 3FG) whilst previous studies mostly prefered made and missed. In addition, a team's quality is represented by the team's World ranking points according to FIBA Rankings System at the time of the tournament. Relative quality (RQ) between the two teams contesting a match is the difference between two teams' world ranking points, while opposition quality (OQ) is the opponent's world ranking points. The study was approved by the Research Ethics Committee of the School of Sport and Health Sciences at Cardiff Metropolitan University.

2.3. Data reliability

In order to evaluate the reliability of the data, video recordings of 10 randomly selected games were observed together by two experienced basketball analysts. The results were compared to those collected from the official website, and perfect agreement (ICC = 1.0) was obtained for two- and three-point field goals (attempts made and accuracy), free throws (attempts made and accuracy), offensive and defensive rebounds, assists, steals, blocked shots, and turnovers. A slightly lower but very acceptable level of agreement (ICC = 0.90) was obtained for the personal fouls. All other performance indicators were derived from these indicators.

Table 1. Variables from the official box score.

Variables	Definitions
FTA – free throw attempt	The number of free throws that a player or team has attempted
FTM – free throw made	The number of free throws that a player or team has made
FT% – free throw accuracy	The percentage of free throw attempts that a player or team has made
2 PA – two-point field goals attempt	The number of two-point field goals that a player or team has attempted
2PM – two-point field goals made	The number of two-point field goals that a player or team has made
2P% – two-point field goals accuracy	The percentage of two-point field goal attempts that a player or team makes
3 PA – three-point field goals attempt	The number of three-point field goals that a player or team has attempted
3PM – three-point field goals made	The number of three-point field goals that a player or team has made
3P% – three-point field goals accuracy	The percentage of three-point field goal attempts that a player or team makes
OREB – offensive rebounds	The number of rebounds a player or team has collected while they were on offence
DREB – defensive rebounds	The number of rebounds a player or team has collected while they were on defence
AST – assists	The number of passes that lead directly to a made basket (such passes are usually the penultimate pass before a successful shot)
STL – steals	The number of times a defensive player or team takes the ball from a player on offence, causing a turnover
TOV – turnovers	A turnover occurs when the player or team on offence loses the ball to the other team's defence
BLK – blocks	A block is where a defensive player blocks a shot attempt by an opposing offensive player, hence blocking their chance to score
PF – personal fouls	The number of personal fouls that a player or team committed

2.4. Statistical analysis

In the current investigation, relative quality is represented by the difference between a team's and an opponent's world ranking points. Opposition quality, on the other hand, is represented by the opposition's world ranking points. The statistical approach to model the effect of opposition quality and relative quality on performance indicators uses the following steps:

Step 1: The strength of relationships between RQ and each game-related indicator was determined using Pearson's correlation coefficient. The relationship between OQ and each game-related indicator was determined in the same manner.

Step 2: The curve fitting function of IBM SPSS (IBM Corporation, Somers, New York, USA) determined the type of relationship between each indicator and RQ as well as OQ. Based on the statistical significance of the models, different regression models were selected when modelling the effect of RQ and OQ. These models were used to calculate the predicted values for each indicator in each match. After that, the residuals were calculated and the standard deviation (SD_{res}) of these residuals was determined for each model. The residuals are the differences between the actual and predicted values for the performance indicators. The residuals represent how much better or worse the performer has done than predicted according to the given model (O'Donoghue, 2012). The residuals were tested for normality and homoscedasticity which are assumptions of regression modelling (O'Donoghue, 2012). Normality was checked using a series of Kolmogorov–Smirnov tests. Skewness and kurtosis can be tested using z_{Skew} and z_{Kurt} where residuals are not normally distributed ($p < 0.05$). Homoscedasticity is the tendency for the magnitude of residuals to increase as predicted values increase. This was tested by

correlating the predicted values with the absolute values of the residuals. Where a positive correlation of greater than +0.25 (Pearson's *r*) was found there was deemed to be a "shotgun" effect with the residuals.

Step 3: Each distribution of residuals was used to determine a percentage score for each performance indicator that addressed RQ or OQ depending on the model. This utilised the NORMDIST function of Microsoft Excel to give the probability of any other residual value being below the residual value for the given match. This probability was multiplied by 100 to obtain a percentage evaluation score (%ES) for the given performance indicator.

%ES is used to evaluate the match performance by quantifying where a performance is located with respect to other teams when addressing opposition or relative quality. However, this could only be done with the proposed method if the residual values are normally distributed and homoscedastic. Where residuals failed to satisfy either of these assumptions, an alternative approach was used to determine %ES. This used percentile norms from the actual distribution of residual values.

3. Result

3.1. Correlation and application of models

3.1.1. Correlation

Table 2 shows the strength of the relationship between the independent variables (RQ and OQ) and the 16 performance indicators. Assists, defensive rebounds and two-point field goal accuracy had the strongest correlations with RQ; all being positive correlations. None of the performance indicators had absolute correlations above 0.4 with OQ.

3.1.2. Modelling

According to the relationship between performance indicators, opposition and relative quality, it is clear that most of the variables showed weak correlations. In order to

Table 2. Relationships between basketball game-related indicators and opposition quality.

Indicators	Relative quality	Opposition quality
2 PA	−0.117	+0.040
2PM	+0.347	−0.241
2P%	+0.497	−0.316
3 PA	+0.215	−0.123
3PM	+0.391	−0.285
3P%	+0.342	−0.256
FTA	+0.170	+0.004
FTM	+0.187	+0.007
FT%	+0.093	+0.021
AST	+0.595	−0.361
OREB	+0.050	−0.154
DREB	+0.478	−0.189
STL	+0.212	−0.215
BLK	+0.303	−0.223
TOV	−0.261	+0.044
PF	−0.199	+0.308

Table 3. Model parameters and assumption tests for indicator of AST.

	Relative quality	Opposition quality
Regression equation	18.418 + 0.018*RQ	25.525–0.014*OQ
Residual normality	0.028*	0.200
Residual homoscedasticity (r)	0.056	0.147
SD_{res}	4.517	5.239

"*" in the normality means the distribution of given residual is not normal ($p < .05$).

highlight the most significant results, AST was selected for analysis addressing opposition and relative quality, as it was the most highly correlated variable with RQ and OQ.

Regression coefficients and residual test results are displayed in Table 3. Curve estimation revealed that the most significant models for AST were linear models. The regression equations were used to determine predicted values for AST based on RQ and OQ in each match. Kolmogorov-Smirnov tests revealed that the residuals for AST failed to satisfy the assumption of normality ($p < 0.05$) for the model in terms of relative quality. Therefore, it was necessary to determine percentile norms for AST, by using the COUNTIF function in Excel within the calculation of the probability of randomly chosen residuals being below the given residual value. This was expressed as a percentage to give %ES for evaluation. When addressing OQ alone, the Kolmogorov-Smirnov test revealed that the residual values for AST were sufficiently normal ($p > 0.05$). The homoscedasticity test revealed no shotgun effect between the predicted values and absolute residual values ($r < +0.25$). Consequently, the standard deviation of the residual values for AST when addressing OQ could be used when determining %ES with NORMDIST function in Excel.

3.2. Team performance addressing opposition quality

As mentioned above, the percentage evaluation score (%ES) reflected how well teams performed considering the opposition and relative quality. Therefore, teams with higher %ES achieved more assists than expected for the given opposition or relative quality.

In Figure 1, the %ES for AST performance is presented for each team using their set of performances in the world cup. This allows performance to be evaluated addressing team and opposition quality instead of merely comparing the average of actual values for the given performance indicator. OQ represents the percentage of performances against the given quality of opponent where lower values are observed for AST. RQ, on the other hand, represents the percentage of performances where the teams have the same difference in quality as the teams in the given match where lower values are observed for AST. In each case, values above 50% for %ES reveal the team has achieved more assists than predicted. The error bars in Figure 1 show the consistency or inconsistency of teams' AST performances when addressing AQ and OQ.

Figure 1 shows that New Zealand and Serbia were the teams who exceeded expectations for AST the most when considering the opposition and relative quality. These two teams were also very consistent across their matches in the world cup in performing better than expected for this performance indicator. In contrast, Angola, the Philippines and Jordan had the lowest %ES scores showing their AST values were below expected to

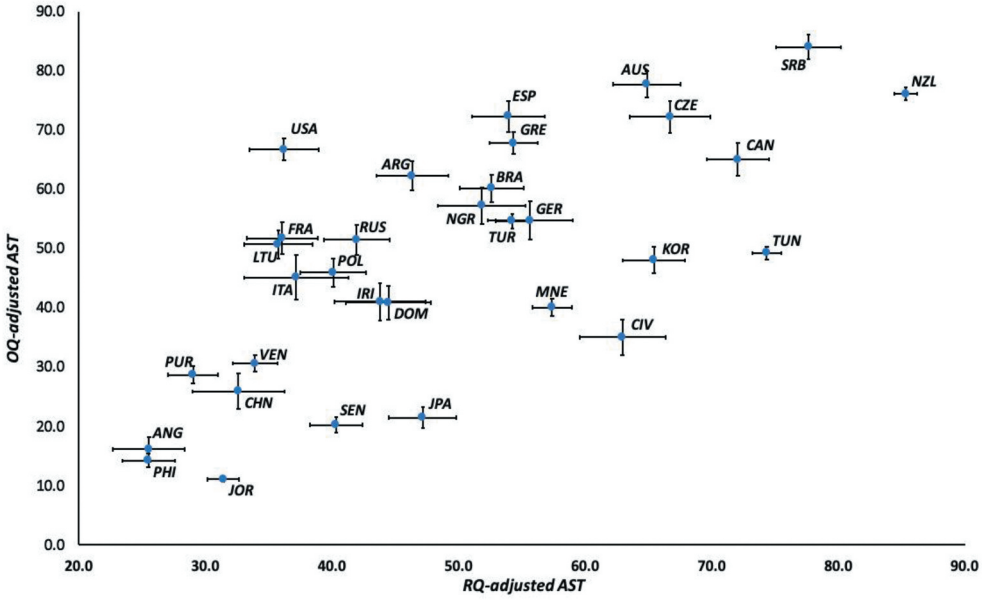

Figure 1. RQ-adjusted and OQ-adjusted performances for each team during the matches of 2019 Basketball World Cup. Error bar represented SD/10.

a greater extent than other teams. However, Angola's AST performances were not as consistently below expectation as Jordan's or the Philippines'. Italy was the most inconsistent performing team for AST when considering both RQ and OQ. There is an interesting comparison between Germany and Turkey who had similar %ES scores when considering RQ and OQ effect. However, Turkey's performances were more consistent than Germany's in both respects.

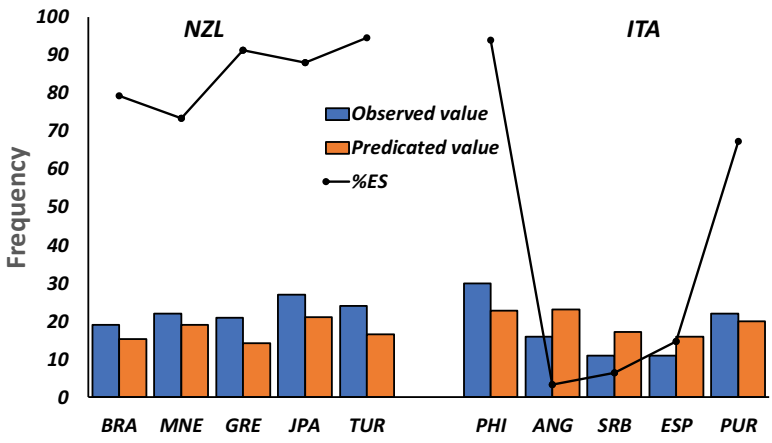

Figure 2. Trends of AST performances for New Zealand and Italy addressing relative quality. Notes: % ES is on a percentage scale.

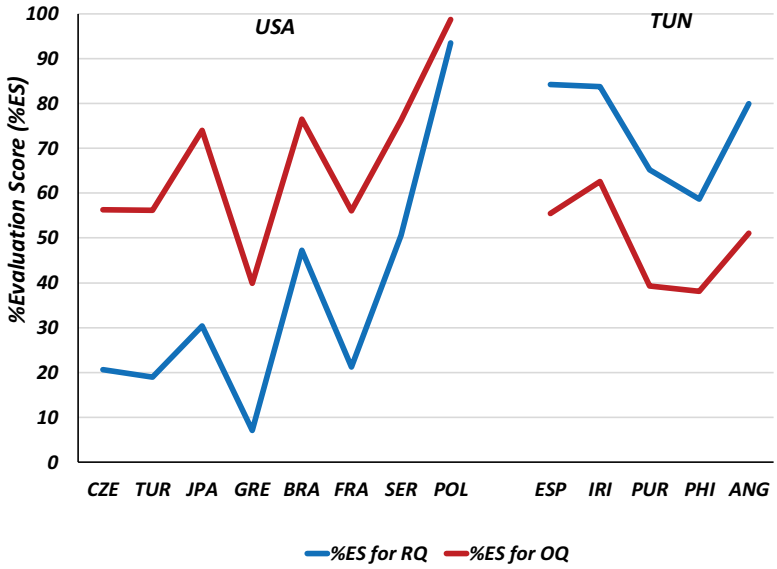

Figure 3. Trends of AST performances for USA and Tunisia in both relative and absolute terms.

Figure 2 shows trends in performances for New Zealand and Italy during the tournament considering the relative quality between them and each opponent. New Zealand consistently produced more assists than predicted, which made their assist performances consistently stay in the top 30% of performances for teams of their quality. In reverse, Italy was very inconsistent from the outset, with their %ES score being up to above 90% in the first game, however, dropped dramatically to less than 10% in the middle. They would have expected to get a similar number of assists against their first two opponents but did much better than expected against the Philippines and much worse than expected against Angola.

Figure 3 shows the %ES addressing opposition quality and relative quality of for the USA and Tunisia. The lines for each %ES score are almost parallel because these are trends for single teams whose own world ranking points do not change during the tournament. The performances of Tunisia are of interest because their assists have been higher than expected considering RQ but lower than expected in given quality of opposition. This means that teams of the same quality as Tunisia would expect to make more assists against the opponents Tunisia faced than Tunisia did. However, when we consider Tunisia's own world ranking points, they performed better than expected for a team of their quality than other teams of the same quality would be expected to against the same opponents. Tunisia's performances were in the top 40% of performances for teams of their quality throughout the tournament when we take relative quality into account. However, the OQ quality model shows that Tunisia's performances were outside the top 40% of performances against their given opponents overall. The opposite is the case for the USA. The USA achieved more assists than over 60% of teams would be expected to achieve against the opponents the USA faced in the tournament. However, when we consider the USA's own world ranking points, the average team of the same quality would be expected to achieve a greater number of assists against the opponents the USA faced.

4. Discussion

4.1. Correlation with opposition quality

The results from this study show low correlations between team performance indicators and relative quality and especially opposition quality. From Figure 1, AST, 2P% and DREB were the only three variables showing a moderate relationship with higher correlation coefficients compared to free throw performances and OREB; the lowest in relative terms. This is explained by basketball performance being multi-faceted with some teams being stronger in some areas than others. For example, a team may be stronger defensively than it is offensively. Thus, when ranking teams on performance indicator values, we will not necessarily see the same rankings as rankings based on game and tournament outcomes. AST, 2P% and PF had the highest correlations with opposition quality, but these correlations were much lower than when the performance indicators were correlated with relative quality. This is explained by team performance not only being explained by the quality of the opposition but also by the quality of teams themselves (Cullinane & O'Donoghue, 2011). It is clear that AST and 2P% appear to exhibit the highest correlations in both relative and absolute terms. This is explained by their association with match outcome (Ibáñez et al., 2008). By contrast, Free throw performances revealed no correlation when addressing opposition quality. OREB and TOV exhibited lower correlations with OQ and RQ than expected. This disagrees with findings of Oliver's (2004) four-factor model (Effective field goal percentage, Free throw rate, Offensive rebounds percentage and Turnovers per possession) for determining a team's game result and better understanding a team's strengths and weaknesses. The low correlation for FT% may be explained by no direct opposition defence during free throws. The lower correlations for offensive rebounds may be explained by higher-ranked teams having better shooters, and teams being able to shoot from better positions against lower-ranked opponents. As expected, many correlations with relative quality were positive while correlations with opposition quality were negative. Importantly, 2 PA, TOV and PF displayed a negative relationship with the relative quality but a positive relationship with opposition quality. This could be explained by teams making more 3-point attempts against opponents with lower world rankings and converting more shots whether 2 or 3-point attempts and higher-ranked teams being able to avoid mistakes in the game. Additionally, it can be seen that most of the variables have generally higher correlations with RQ compared to OQ, including DREB, AST and TOV which have the largest differences between their absolute correlations with RQ than OQ. However, OREB and PF performance seemed to be the exception, being affected more by the absolute opponent effect than relative quality.

4.2. Interpretation of team performance

4.2.1. Interpreting AST performance in addressing relative quality

The +0.595 correlation between AST and relative quality means that 35.4% of the variance in this performance indicator is explained by the quality of the two teams contesting the match. Thus, there is more variance in assist performance due to other factors than due to RQ. None-the-less, in evaluating performance we should consider what would be expected for a team of our quality against the given opposition. Attention

can be given to the extent to which a team performs better or worse than expected during squad feedback sessions.

For example, New Zealand consistently performed better than expected considering how much higher-ranked their opponents were. New Zealand made a relatively high number of assists during the pool games against Brazil, Greece and Turkey, despite the disadvantage of RQ of −167.9, −230.9 and −99.1, respectively. New Zealand had the fourth best average observed AST of 22.6 despite being one of the lower-ranked teams in the tournament. In the crucial game defeating Turkey by a single point, New Zealand would have been expected to perform 16.6 assists; however, the actual number was 24, which corresponded to a %ES value of 94% when considering opposition quality. As shown in Figure 2, New Zealand's %ES scores for each match did not go below 70%. One possible explanation of New Zealand's performance trends could be streakiness which has been discussed in basketball (Bar-Eli et al., 2006); the other explanations might be that New Zealand excelled in making successful passes and their given opponents in the matches failed to contest field goals in the defence.

Relative quality should be used when we are comparing a team's performances over a long time period where their own world ranking can change. A further use of relative quality could be to compare whether New Zealand's assists made against Turkey can be considered a better performance than Italy's assists made against Puerto Rico, for example, when we take the quality of the teams into consideration. For example, New Zealand and Italy made the similar number of assists against their opponents, respectively, from Figure 2, if raw values are used, it is hard to determine whether an AST value of 24 is better than that of 22 in the match between Italy and Puerto Rico, nonetheless, this could be done by using %ES scores that New Zealand's %ES of 95% was undoubtedly better than Italy's %ES of 67%.

A surprising finding was that there is greater variability in %ES scores when RQ was addressed than when only OQ was addressed in the predictive models. One might reasonably expect higher predictive accuracy and hence lower variability when both team and opposition quality are addressed. A possible explanation for this is that teams do not always need to do as well as they can play against a given opponent. In Figure 3, the USA performed below expected for a team of their quality against all opponents until their last two matches. These include a draw game against Turkey and a loss against France; the other matches were all won. As the strongest in this tournament, the USA had the greatest advantage of RQ than other teams, however, did not perform excellent actual AST as expected, especially playing against Czech, Greece and France (with their AST performances below the average of all). The explanations might be the USA are well known for their strong isolation offence, they do not need to create opportunities for teammates through passes, or the squad may have been rotated with some players given less court time to avoid the risk of injury to key players.

4.2.2. Interpreting AST performance using opposition quality

One of the disadvantages of using RQ is that %ES might penalise a team for having a high World ranking (the USA for instance). Addressing opposition quality should be used when we are concerned with how well a team has done against a given opponent without considering their own world ranking points. From Figure 1, Serbia achieved the highest %ES scores for AST performance when considering opposition quality. This could be

because Serbia is particularly successful at making assists compared with other aspects of their game or it could be due to them facing higher-ranked opponents than other teams (of the 32 teams included in the data, Serbia had higher-ranked opponents than all but four other teams in the tournament). Serbia over-performed with the best average actual AST throughout the tournament, no matter whether competing against highly ranked opponents like USA and Spain or against lower-ranked teams like Angola and Philippines.

Opposition quality should be addressed when evaluating team performance within a tournament when their own world ranking points are not going to change. If raw values are used, there is a danger of misidentifying improving performance where there was a high quality of opposition in the previous match. However, according to Tunisia's performance trends shown in Figure 3, the OQ quality model clearly shows Tunisia's performance competing against Spain was much better than that in the last three matches, although the actual AST value was the lowest in the five matches. Opposition quality may also be important if a team wishes to determine what an AST value of 13 against Greece is worth in a match against Spain. This can be done by determining the % ES against Greece and then applying this same %ES score against Spain to determine the AST value that maps onto this from the normal distribution or percentile data.

5. Conclusion

The aim of this paper was to use a fine-grain and regression-based approach in basketball to evaluate performances with respect to team and opposition quality. By using basketball game statistics, opposition quality and relative quality, this has been achieved as follows.

Firstly, the results showed some meaningful correlations between basketball performance indicators and relative quality. Specifically, assists and two-point field goal accuracy were the two variables with higher correlations with relative quality.

Secondly, percentage evaluation score (%ES) was used, allowing relative quality and opposition quality to be assessed when evaluating performances during this world cup. According to the method, New Zealand consistently made more assists than expected while Angola made fewer assists than expected. Serbia had the best AST scores while Jordan had fewer assists than any other team when opposition quality was addressed. Italy was the least consistent team when assists were adjusted for both relative quality and opposition quality. It is also clear that teams like Tunisia, Korea, Cote d'Ivoire, Montenegro and Japan, did much better when we consider the relative quality of the teams in their matches. The USA, Spain, Argentina and France performed fewer assists than one might expect when opposition quality was considered.

6. Direction for future research

The current research attempted to show how this regression approach can be applied in basketball using basic box score indicators when addressing relative quality and opposition quality. The proposed approach for the evaluation of individuals and teams has clear advantages over profiling techniques produced by O'Donoghue (2005, 2008) and James et al. (2005) that fail to address opposition effects. The findings of this study will help to provide basketball coaches and performance analysts with more effective interpretation

of technical and tactical performances, allowing for a better identification of strengths and weaknesses of teams and opponents.

However, there are several limitations and areas for further study. On the one hand, a study could be conducted with larger samples and regression models should take into account much more specific variables that may have higher absolute correlations with opposition quality and relative quality. On the other hand, outstanding relative performance does not always lead to victory. The basketball matches included in this tournament included some where teams won despite performing worse than expected and lost when performing better than expected. This could be explained by specific contextual and planning situations such as the aim of preserving the best players during an "easy game" (where a winning outcome is obvious at the end of the third quarter or even before). These players thus play less time in order to rest before the next more important game. However, other contextual factors such as the margin of victory and venue effect could also be incorporated into these models. Each game has a unique context with coaches needing to interpret evaluation scores considering this context. Therefore, the percentage evaluation score (%ES) used in the current investigation is just one piece of information to be used in the evaluation of team performance. The absolute values of performance indicators and important video and contextual information still be considered for better understanding of basketball coaching and management.

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ORCID

Rui Dong http://orcid.org/0000-0001-5631-6299
Sirius Z.Y. Huang http://orcid.org/0000-0002-1333-7089
Peter O'Donoghue http://orcid.org/0000-0002-9923-9868

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