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BASEBALL: DEFENSE OR NO?

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Abstract. Defense wins championships, or so they say. How do baseball organizations find the right defenders to win games? FanGraphs has published a series of metrics that teams throughout Major Leage Baseball use to quantify players' fielding prowess. Baseball analysts use Wins Above Replacement, WAR, to predict who should be the league most valuable player, MVP. This uses defensive metrics to quantify how many runs the player produces when the team wins. The paper will discuss the metrics that already exist, and the technology that has been developed to analyze these metrics and other measurements of a player's defensive skills.

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1. Introduction

Baseball sabermetrics is a huge research field in statistical analysis. Defense is a big part of the game; anyone that is familiar with the sport will understand its significance. It has become a huge part of how many teams nowadays become World Series champions: just look at the 2016 Chicago Cubs and more recently the 2017 Houston Astros. Organizations throughout Major League Baseball have hired mathematicians to develop metrics to predict how a season should develop for the team.

The most common example used when explaining Sabermetrics is the 2002 Oakland Athletics. Most people know the story of "Moneyball," when the A's were the worst team in the league at the end of July, but Billy Bean, former player and General Manager at this time, made some key trades to help the team succeed at a cheaper price. This then led to a 27-game win streak, and eventually the team found themselves the playoffs where they eventually lost in the American League Championship Series. What most fans don't understand is the A's were not the only team, at this time, using statistical analysis to help field a team, but they were the most aggressive and successful with their studies.

This is also not the earliest account of statistical analysis in baseball. With a rich and long history in the United States, dating back to Civil War times, baseball has consistently been the most gambled-upon sport in the country. Many people place bets on games, individual performances, or overall season results. To bet on the right teams or players, most would devise their own tests to find the likeliest candidates [2]. The history of Sabermetrics shows how people unintentionally discovered the now modern way to watch and play the sport of baseball.

2. What Already Exists?

Throughout the history of baseball, many statistics have been developed and are now considered a basic part of today's game. The most familiar statistics: batting average, fielding percentage, win/save ratio; contain a lot of hidden information that the common baseball fan might not realize [3]. Then statistics were developed that combined multiple different basic statistics. For example, On-base Plus Slugging (OPS) is exactly what it says, it is the percentage of the times a batter get on base and the slugging percentage added together. This is supposed to provide a more accurate number than batting average when quantifying an individual batter [1].

Statistics like this have recently dominated how people view individual players. Statisticians argued how the OPS is the next best thing for baseball, and how the Defensive Independent Pitching Statistic should help determine whether a pitcher should win the Cy Young Award, pitcher of the year [1]. These arguments eventually led to Sabermetricians producing new metrics in order predict award winners.

2.1. **WAR.**

Wins Above Replacement (WAR) is a metric to measure a player's total worth to his team [5]. It is designed to predict the Most Valuable Player each year in baseball. It claims to measure the number of games a player helps his team win in comparison to an average player replacing him in the lineup. The formula for WAR is:

$$\mathrm{WAR} = \frac{1}{\mathrm{RunsPerWin}} \begin{pmatrix} \mathrm{BattingRuns} & + & \mathrm{BaserunningRuns} \\ + \ \mathrm{FieldingRuns} & + & \mathrm{PositonalAdjustment} \\ + \ \mathrm{LeagueAdjustment} & + & \mathrm{ReplacementRuns} \end{pmatrix}$$

Batting Runs refers to the expected number of runs the team scores given the player has a plate appearance. Baserunning Runs is the expected number of runs the player produces by his baserunning skills, for example by stealing bases. Fielding Runs are how many runs the player saves from the plays he makes in the field. Positional Adjustment shows how many runs he saves on average by a positional shift. League Adjustment accounts for situations where the player is traded to a different team in the middle of the season; how many runs did he save after the trade was done? Replacement Runs is from a substitution made in the middle of a game; were there more runs saved before or after the switch? Runs Per Win is simply the average number of runs the team he plays for scores when they win.

2.2. **DEF.**

Most of the statistics involved in the WAR calculation are based on offensive performance: how does a player help his team score runs? Only two are based on defensive performance: Fielding Runs and Positional Adjustment. Combined, this two comprise the Defensive Runs Above Average (DEF) statistic. Fielding Runs represents how many opposing runs a player prevents from scoring as compared to the an "average" player in his position. Positional Adjustment is a value based on the player's position, chosen to allow comparisons between players in different positions.

There are many subjective judgments that go into these choices. How important is one position defensively over another? How do we determine which plays an average player in a given position could, or should, make? Throughout the years, there have been a series of defensive metrics developed to try to limit the subjectiveness in answering these questions. In particular, many statistics attempt to compare defenders across positions directly, rather

than rely on a Positional Adjustment. These include Ultimate Zone Rating (UZR), Defensive Runs Saved (DRS), and Revised Zone Rating (RZR) [4].

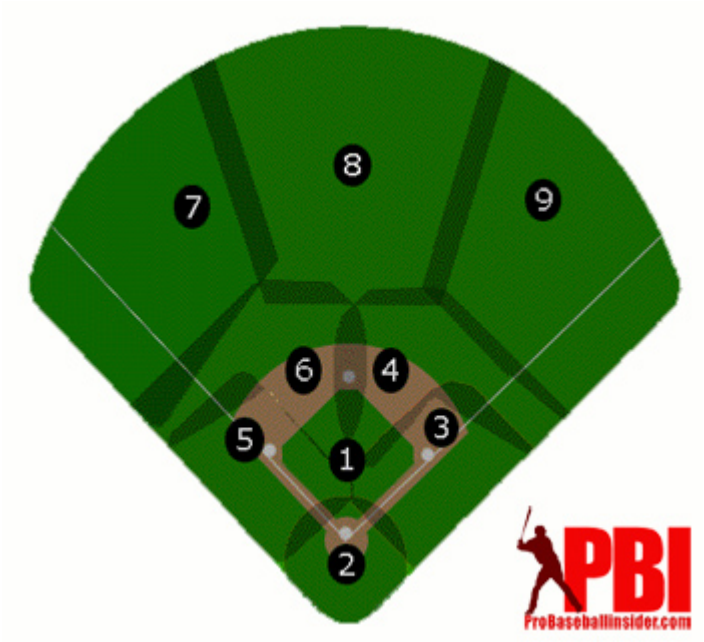
2.3. **UZR.** Ultimate Zone Rating quantifies a player's entire defensive performance by attempting to measure how many runs a defender saved [6]. This statistic indicates the number of runs the player saved or gave up through their defensive plays. Some variables in the algorithm for UZR include: Outfield Arm Runs (ARM), Double-Play Runs (DPR), Range Runs (RngR), and Error Runs (ErrR).

These take into account how many runs above the league average the player saves through their arm strength, by coverting double plays, through their range to make a play, and, counting negatively, the amount of errors they commit. ARM and RngR are difficult to compute and require many qualitative judgments on the part of the assessor; analysts must constantly watch plays to determine what plays were made or could have been made.

These component statistics are then combined through a proprietary formula into a player's UZR statistic [4]. For example, if a player attempts to make a play outside the average player's range, a successful attempt will add a certain fraction of a point to their UZR while a failure will subtract a fraction.

2.4. **DRS.** Defensive Runs Saved is a proprietary statistic with a similar purpose to UZR; its goal is the calculate a player's total defensive worth. By definition, DRS gives a player's defensive prowess a numerical measurement stating how many runs, above an average player's performance, the defender has prevented [6]. How it accomplishes this is very different from UZR, however. First, the variables used to calculate a player's DRS depend on which position(s) the player plays; for example Double Play Runs Saved (rGDP) only counts for second basemen and shortstops. Secondly, the statistics used in DRS only count positive contributions for successful plays. There are no negative penalties for plays that could have been made as in UZR [4]. In this way, DRS attempts to limit the subjectivity of the analyst.

2.5. **RZR.** Revised Zone Rating measures the ratio of balls hit into the player's positional zone that the player converted into an out. RZR uses numbers which are extremely easy to find: Balls In Zone (BIZ), Plays Made, and Out Of Zone Plays Made (OOZ). These are all numbers that are easy to tally and come together to make a better calculation for UZR [4]. The following diagram depicts each position's zone of responsibilty.



3. What's Next?

With this information, the author will attempt to design a brand new defensive metric to replace the defensive part of the WAR algorithm. Then, a user-friendly website will be created so that any player will be able to put in their stats and see what their metrics would be if they were playing in Major League Baseball.

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