Free term paper on game theory in baseball

Sport & Tourism, Baseball

Introduction

\nSince many kinds of sports are games, it is not surprising that examples from sports are often being used for illustration of classical problems from game theory, while game theory is, also may be applied to improve performance in sports (Chiaporri et al 12). Choice of direction of shots in tennis is often being used for understanding of mixed strategies, and, the other way around, mixed strategy have been used to explain how footballers might decide on where to spot the penalty kicks (and for goalkeepers – how to try to save them). At the same time, chess in itself is a complicated game theory problem (a sequential game), though the variety of scenarios makes it impossible to solve it even for computers, let alone humans; on the other hand, checkers have been solved and therefore ceased to exist as a sport (Lewis, M 63).\nArguably, the most exciting practical implication of game theory in sports is in baseball – one of the most structured, strictly divided into separate analysable episodes major kinds of sports (Chiaporri et al 34). Given this trait of baseball as a game, it is quite natural that to not only members of " the Club" (former players, coaches, pundits etc.) are making key decisions, but also economists and statisticians, as numbers allow to see things that may be not easily apparent for game spectators (Lewis, M 39). While the first comprehensive attempts to introduce statistical analysis are going back to 70s when the first works named " Bill James Baseball Abstracts" by Bill James were published, the believers (if they can be called so) in scientific approach to the game had been effectively kept out of the game and important decision, until Billy Beane became the General Managers of Oakland Athletics in 1998 and revolutionised the way baseball was analysed. He became famous for his use of statistical data, as Oakland A’s, one of the poorest teams in MLB, performed on the level with the richest ones, such as New York Yankees (Chiaporri et al 64). The book “ Moneyball: the Art of Winning an Unfair Game” by Michael Lewis is devoted to the Oakland A’s of early 2000’s – the golden era of Beane’s Moneyball. Among other things, Lewis mentions the full-count situation and refers to it in the following way: “ they are not playing baseball anymore – they are playing game theory”. In this work the full-count situation will be considered from game theory perspective, first as a simultaneous game\n

Problem 1: full-count mixed strategies for pitchers and hitters – simultaneous game

\nRules\nThe aim of a hitter is to reach the base – it can be done i) with a hit (putting the ball in play so that the defender fail to catch it before it bounces and reaching the base before the defending team delivers the ball there); ii) with base-on-balls, or walk (pitcher throws four “ balls” – pitches outside of the strike zone – before collecting three strikes). The aim of a pitcher is to get the hitter out – it can be done in a three ways: i) strikeout (the pitcher collects three strikes before the hitter manages to put the ball in play or to collect four “ balls”). It is important that if hitter swings the bat and misses the ball, it is a strike no matter whether pitcher threw in the strike zone or not (Chiaporri et al 43). The count provides the number of balls and strikes in each particular encounter: e. g. 2-1 means that there are currently two balls and one strike. Full count refers to the count 3-2. A hitter can also foul the ball off, which means making contact but not putting it into play. It counts as a strike, but cannot be the third strike, meaning that a foul ball with counts 0-2, 1-2, 2-2 and 3-2 does not influence the count.\n

The example

\nFor the example, the full-count situation (three balls, two strikes) is being used, and pitcher chooses what pitch to throw. Here are some assumptions to make the game theory problem possible:\n- Pitcher uses one of two pitches: fastball in the strike zone and change-up – one that looks exactly like fastball at release, but then sinks below the strike zone for a ball.\n- Pitcher can disguise change-up so well that hitter cannot produce a better than random guess on whether it is a ball or strike (which is not quite the case in the reality: hitters swing on around 90% full-count strikes and only half full-count balls)\n- Since hitter cannot distinguish whether it is going to be a ball or a strike with better precision than a random guess, and he knows that, it is an equivalent to simultaneous game, where pitcher decides between fastball (strike) and change-up (ball) and hitter decides between swinging and taking\n- It is a zero-sum game: the payoff of hitter is the reverse payoff of pitcher\n- Payoffs are represented by wOBA (weighted on-base average) – a metric that measures weighted value of each possible outcome (walks, singles, doubles, triples, homeruns) against the number of plate appearances. In fact, it is a probabilistic metric.\n- There is a probability that a strike would be called ball (the evidence suggests that more than a third of 3-2 strikes are being called balls, but only 4% of balls are being called strikes)\n- Having swung on the ball, it is possible to produce a hit, however, the probability of doing it is much lower\n- The data on wOBA is taken from Glaser (2010).\n

Below is the payoff matrix:

\nThere is no dominant strategy for either of players: if pitcher throws strike, hitter would rather swing; if pitcher throws ball, hitter is definitely better to take. The difference in expected wOBA in case of strike between swinging and taking is much smaller than it is between swinging and taking in case of ball, so if hitter knew that pitcher is as likely to throws ball as he is to throw strike, he would obviously opt to take (Chiaporri et al 74). However, pitcher knows that, and hitter knows that pitcher knows that and for that reason situation is more complicated, with both players employing mixed strategies.\nLet the probability of hitter opting to swing be p, and pitcher's probability of throwing a strike be q. The probability of each event is in the table below:\n

In addition, the expected payoffs for the players are the following (pitcher first):

\nFor both strikes and balls pitcher allocates probabilities that would disable hitter from increasing his payoff by choosing either swing or take. So 0. 33p+0. 188(1-p) = 0. 273p+0. 688(1-p) 0. 188+0. 142p= 0. 688-0. 415p\n0. 557p= 0. 5\np= 0. 89\n1-p= 0. 11\n

It is possible to calculate the probabilities the hitter allocates in the same way:

\n0. 33q+0. 273(1-q) = 0. 188q+0. 688(1-q)\n0. 057q+0. 273= 0. 688-0. 5q\n0. 557q= 0. 415\nq= 0. 74\n1-q= 0. 26\nThe example shows that Nash Equilibrium for the game is that pitcher throws 89% of strikes and hitter swings on 74% of pitches.\n

Problem 2: Full-count pitcher vs. hitter sequential game

\nIn this case, it is assumed that the pitcher has two outs at the bottom of the 9th inning with the game tied and bases loaded (Lewis, M 25). The count is full, meaning that the third strike will take the ballgame to extra-innings, while ball four will hand the victory to the opponents. In this example pitcher faces a hitter who can react to the pitch thrown, but cannot perfectly decipher whether it is going to be a strike or a ball. wOBA is irrelevant is this case, as hitter needs to get on base only, for that reason OBP (on-base percentage) is used as an estimation of probability of winning the game for hitter, with 0 standing for the strike-out outcome and 1 – for the outcome when hitter reaches the base and wins the game for his team (Lewis, M 5). Data shows that hitters swing on strikes in 90% of cases and swing on balls in 50% of cases. The purpose of this game is to show the optimal decision for the pitcher on one decisive pitch.\n

The game tree looks the following way:

\nIf pitcher throws ball, hitter will swing in 50% of cases and will take in 50% of case. In case of swing, the probability of getting on base is 0, 18; in case of take – 0, 83, meaning that expected OBP in case of a ball is 0, 505. If pitcher throws a strike, the probability of getting on base is 0. 29 if hitter swings and, surprisingly, higher if hitter takes (it is related to the fact that many of the strikes hitters take are on the borders of the strike zone, with umpires not always getting the calls right). The expected OBP in this case is 0, 3. As the aim of pitcher is to minimize opponent's OBP, the best strategy for him is to throw a strike (Lewis, M 36). However, it should not be taken for granted in the real life, balls are not the same and strikes are not the same.

Some balls are just poorly executed pitches and it is easy for hitters to take them, while strikes in the middle of the strike zone are much more likely to be hit than those to the corners. On the other hand, the latter are more likely to be called balls.\nThe above examples support the case that pitchers should do their best to throw strikes in 3-2 count. However, while the general advice might be useful, pitchers who will confident about the deception of their change-up may be successful using it in the important moment.\n

Problem 3: Mixed strategy and dominance

\nAssume that two baseball players A and B are involved in a competition where each of them is competing to win the game (Lewis, M 17). The two players can adopt various strategies that would give them competitive advantage over the opponent. Player A can adopt strategies A1, A2 and A3 whereas player B can use strategies B1, B2 or B3 in order to compete player A. The pay-off matrix in representing the points the players will gain or lose with each strategy is summarized as below:\nIn the above case, the dominance rule is applied in order to reduce the size of the game matrix. Dominance rule in a game situation occurs where one course of action of a strategy is found to be inferior to the others (Lucey T 65). This course of action is thus said to be dominated. As long as the strategy is dominated, rational players will not play it and it is therefore safely left out of the analysis. Dominance is recognized in this pay-off matrix based on the following criteria:\n- If all elements in a row are less than all the other elements in the other rows, that row is said to be eliminated by others\n- If all elements in the column are greater than all the elements in the other columns, that column is said to be eliminated by others.\nFor Player A, the row for strategy A1 is eliminated by the row for strategies A2 and A3 since it has the lowest row values (Lucey T 66). The column for strategy B1 is also eliminated in the case of player B since its values exceed the values for the other two columns. The revised pay-off matrix is thus expressed as follows:\n

The value of this game is computed as:

\nValue of the game = (0 X 0) - (2-5))/ (0+0)-(2+5)\nValue of the game = -10/-7 = 1. 43\n

Interpretation: Player A has gained 1. 43 points, which have been lost by Player B

\nThe curve for this case can be drawn as below:\nProblem 4: Simultaneous sequential game\nAssume that two baseball players X and Y are involved in a competition where each adopts in order to outdo the other (Lucey T 51). Player X can use various alternatives that include X1, X2 and X3 while player Y can adopt Y1, Y2 or Y3 during the competition. The percentage gain related to the adoption of each of these strategies to compete the other player can be summarised by the pay-off matrix below:\n

Pay-off Matrix (Salary increase in percentage)

\nThe value of P1 will be = (2-1) / (1. 5+2)-(1+1)\nP1 = 1/ (3. 5-2) = 1/1. 5 = 2/3\nP2 = 1-2/3 = 1/3\nQ1 = (2-1)/1. 5 = 2/3\nQ2 = 1-2/3 = 1/3\nPlayer Y will thus play strategy Y1 2/3 of the time while Y2 will be played 1/3 of the time. Player X will play strategy X1 2/3 of the time while X2 1/3 of the time.\nValue of this game = (1. 5 X 2)-(1 X 1)/ (2+1)-(3+6)\nValue of the game = (3-1)/ (3-9) = 2/ -6 = - 0. 33\nInterpretation: Player X will thus lose 0. 33%, which will be gained by Player Y during this competition.\n

Conclusion

\nGame theory concept is thus very applicable among baseball players. This is richly illustrated by the analyses of the scenarios above. It aids in developing the best strategies that would enable a player to outdo the other. Based on its principles and assumptions, players can position themselves rightly to enable them to win as many competitions as possible. Baseball teams would also adopt better strategies to make the best combination of players that would enable them to flourish in their performance.\nA player has a competitive advantage over the opponent in case the opponent is unaware of the strategies he or she uses. Much research should thus be done by a player to study the tactics used by the opponent in order to enhance the chances of winning the game. Game theory was successfully adopted by the renowned boxer Muhammad Ali during his boxing career that made him be champion for long and a force to reckon with. Ali used to spend his time and perform a thorough study of the opponent that enabled him to develop the best strategy in boxing. From the above analyses, baseball players and teams can thus succeed in their career by adopting better strategies.\n

Work Cited

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