

APPLICATION OF DIFFERENT OPERATIONS RESEARCH TECHNIQUES IN VARIOUS SPORTS

Aarushi Aggarwal^{*1}, Aaryan Daga^{*2}, Aaryan Agarwal^{*3}, Aaryan Sarada^{*4},
Anoushka Sanghvi^{*5}

^{*1,2,3,4,5}Student, SVKM's Narsee Monjee Institute Of Management Studies, Mumbai, Maharashtra, India.

ABSTRACT

The purpose of this research paper is to look at the use of operations research in the sector of sports and gaming using quantitative and decision-making approaches. It arrived at its conclusions by reviewing numerous study articles in sports such as cricket, football, F1 racing, and casinos. The similarity is that each of these sports has utilised Operations Research to optimise a critical success element. Operations research approaches are utilised in field sports to schedule inter-city matches with the goal of minimising travel time. This secondary research suggests that Operations Research may undoubtedly increase sport performance and the main output matrix in sports organisation.

Keywords: Scheduling, Forecasting, Operations Research Tactics And Strategies, VAR, DRS.

I. INTRODUCTION

According to a recent Kearney analysis of sports clubs, leagues, and federations, the global sports business is worth between \$480 and \$620 billion. Infrastructure building, sporting equipment, licenced items, and live athletic events are all examples of this (Kearney, n.d.)

With such high stakes, it's no surprise that utilising data and/or models to make better judgments is a hot topic. Many sports leagues across the globe have substantial economic implications, making the sports economy a significant element of the broader economy. Many logistical and financial difficulties arise during sporting events, such as tournament preparation, club management, marketing strategies, and security concerns, to mention a few. (Prusty M., 2017)

Every decision made by a team, its managers or its players, from picking a golf club to deciding if a football match will take place at home or away from home, OR is involved to some extent. (Wright, 2009) Needless to say, Each tournament requires a lot of organizing, planning, execution because of the importance a sport has in a country. For example, The Tokyo Olympics this year was executed smoothly without many obstacles. We are affirmative that OR played a humongous hand in this. We will look at how Operation Study is used in the Sports and Gaming business in this research paper. As we all know, Sports are an important aspect of everyone's lives, young and old, all around the world. One wrong decision made by the team or team managers can be extremely expensive and cost the team the championship cup. Hence, different sports and their teams started using OR to make more accurate decisions and formulate the right tactics and strategies. Throughout the year, numerous contests involving various teams and places take place. This year, the IPL, even though cut short, was followed by the Euro finals and then the Tokyo Olympics. These Championships and Competitions are a huge deal for the country and its citizens as it is a matter of pride and respect. Each of these events involves much preparation and strategy, both in terms of the organisation and the sport itself. For example, when organizing inter-city, inter-team matches with players from all over the world, Operation Research methodologies will be used to decrease player travel time, fatigue, or to work on a budget/timetable, among other things. In this research paper, we will observe how different Operation Research studies are used in various sports like football, cricket, baseball, F1 etc. Using techniques like dynamic programming, linear programming, integer programming, VAR, optimization techniques are few of the many techniques used in sports. We will primarily analyse how these various sports use OR scheduling, forecasting and coming up with tactics and strategies.

II. LITERATURE REVIEW

In a recent operational research literature, the scheduling of sport contests has received considerable attention. (Urban & Russell, 2003). Temporarily restricted and temporarily easy issues in the sport league may be split into two types. The plan horizon in a time-strict instance includes the minimal number of times necessary to

schedule all the games (thus known as rounds), which means that each side must play exactly one game per round. It is believed that tournaments according to this design are compact. In time-relaxed cases, however, the number of rounds needed for all games is more than the number of minimum rounds required. Not every team is necessarily involved in every round in this circumstance, therefore, clubs may have certain stretches without a game. (Kendalla, Knustb, & Ribeiro, 2010)

Gambling is a major activity that takes place in all sports. Different kinds of OR models must be used within bookmakers' organization. These methods are regarded as highly confidential. However, some studies are available to the public. (Wright M. , 2009) To illustrate, four researches applied multivariate time series analysis to predict the outcomes of three football matches in the English Premier League. The model's success was determined by its ability to forecast the outcome of three dependent binary variables in the final 10 games of the season: win, lose, or draw. With a success percentage of nine out of ten for Winning, eight out of ten for Losing, and nine out of ten for Drawing, multivariate ARIMA properly predicted the outcome. Undoubtedly, multivariate time series analysis seems like a promising way to forecast the winners of any championships. (Yiannakis, Selby, Douvis, & Han, 2006)

Without a doubt, betting/ gambling in sports is an important characteristic in sports and gaming. Spectators, fans, managers and basically anyone attached to the sports team can gamble during or before the match. Certainly, several bookmaker organizations must be using tools to make predictions in order to gain profits. (Wright M. , 2009)

This paper used OR techniques to predict the match outcomes in tennis. They used statistical data provided by the ATP (Association of Tennis Professionals) to determine the tennis serving statistics when the two competitors, Roddick and El Aynaoui, met. These numbers are then entered into a spread sheet model to forecast other match outcomes, such as the length of the game and the likelihood of either player winning. (Barnett & Clarke, 2005)

Similarly, OR was also used to predict the medal count of various countries in the Tokyo 2020 Olympics. A research paper tried to study the impact of the Covid-19 pandemic on the medal distribution in the Olympics. They applied Random Forest, a machine learning procedure applied to get answers for regression and classification problems. This included learning models such as regression learners, neural networks, and boosting algorithms etc. This model proved better than all other forecasting models used to predict outcomes in 2012 and 2016. (Schlembach, Schmidt, Schreyer, & Wunderlich, December 2020)

In a lot of ways, managing a sports team is very similar to running a business. Effective strategies and planning can improve profit, performance, and make the overall operations much more effortless. Similarly, strategies play a huge role in determining how a team performs. A well-thought-out strategy has the ability to improve Performance and maintain coordination between the players. Another important aspect is analysis. Strategies can be formed by analyzing past data. This helps the team management to understand what they need to work upon.

In the article, 'A Study on the application of Operation Research in Sports and Sports Management', (Prusty M. , 2017), we learn about the various tactics and strategy formulations carried out in different sports with the help of Operations Research. In baseball, a simulation model was used by (Freeze, 1974) to decide the most optimum batting order. A decision support system was created by (Boon and Sierksma, 2003) to display the contributions made by each player. This not only helped the team managers in team selection, but also assisted them in the buying process of new players. (Scarf and Grehan, 2005), with the help of Operations Research, decided the most suitable route that would be chosen while cycling.

Another such method used is Linear Programming in Football. This method is used to determine whether a team should run or pass. (Wright M. , 2009), in his article, '50 years of OR in sport', describes the different ways in which Operations Research is helpful in different sports. A few examples of this are the use of Dynamic Programming in ice hockey (to determine when to substitute an outfield player for a goalkeeper), and in weightlifting (what weights to choose). A few other techniques consist of various types of statistical and optimization techniques that are used in real time during a game. However, there are a number of strategic

decisions that need to be taken in between two games, or even two seasons. Examples of these are the removal of managers. In certain cases, different forms of statistical and optimization techniques are used together.

There are many popular sports in today's world for example: cricket, football, hockey etc. All of them use Operation research in one way or the other but football uses it the most. A football club needs to perform financially and sports wise also. They need to buy players according to their needs and preferences. (Ed Woodward-Manchester United). In other sports like swimming, archery, kabaddi, volleyball etc. players can be judged by the number of points scored and points given. However, in football, scoring goals is not the only aspect which a club wants. (Shatoya SA 2019) Of course, a defensive midfielder will have very less goals scored when compared with a striker. However, the need of a defensive midfielder is never understated. Similarly, a keeper will have very few or zero goal chances created in the match but that doesn't mean he is not an important player. Thus, just by looking at facts and stats of the player, a club cannot make its decision. (Jose Mourinho 2017)

Hence OR became an important aspect of football. Before buying any player, Football clubs contact their OR team and ask them whether the player is suitable for their club or not and that whether he fulfils the gap in their system or not. Afterward, OR team usually judges the player based on their chemistry with existing players and his game play according to the club's need. Other than that, they keep in mind the financial aspects and how well will the player get welcomed by the fans. (CAY S.B,2012) Football club is just not a club, it's a business as well. Thus, owners nowadays are employing more and more of OR TEAM to recruit more players suitable for their club. In the same way, OR plays an important role in cricket. The most important role of OR in cricket is to help determine the batting and bowling order of the team.

Elite players like Virat Kohli, Williamson etc. can play well at any batting position. However, this is not the case for every player. Usually, players have a fixed batting position which they prefer and they cannot perform well in other positions (Sunil Gavaskar-Extra Innings,2020), for example, when Rohit Sharma used to play down the order, his average was not even 30 (cricbuzz -player profile), and now for the past few years, when he is allowed to open, he averages around 45 (cricbuzz-player profile) every match. Thus, OR becomes very important here.

For example, the average of an elite player as an opener is 50 and as a one down is 60, and an average of another Normal player as an opener is 20 and as a one down player is 45, the OR team would suggest the coach to keep the normal player at one down position and the elite player at opening even though the average of elite player as an opener is less than as one down. This happens because the normal player cannot open properly hence the elite player has to adjust accordingly. (Mahela Jayawardene 2018-On Surya Kumar)

This was just an example of two players but a national cricket team, while deciding their order has to keep in mind tons of players. This is why OR becomes very handy here.

III. RESEARCH OBJECTIVES

The broad topic of our research paper is the Use of Operations Research in Sports. In light of the broad topic we worked on the following sub topics

1. To analyse how Operations Research is used in Cricket
2. The use of Operations Research in Formula 1
3. Use of Forecasting as an operations research technique in Basketball
4. The Basic use of OR in Football
5. The Application of VAR in Football and DRS in Cricket.

IV. RESEARCH METHODOLOGY

The key intention to write this paper was to understand the Importance of Operations Research in different sports. Information on this has been collected from various journal articles, newspapers, and online websites. The use of OR in sports like Cricket, Football and F1 has been studied. In addition, the use of Operations Research in different functions like Scheduling, Forecasting and Strategizing has also been covered. Qualitative analysis has been carried out to write this paper.

V. APPLICATION OF OPERATION RESEARCH IN VARIOUS SPORTS

Use of OR in cricket:

In cricket, scheduling is a big element of operations research. Depending on the size of the event, match scheduling might range from simple to complicated. When there are more than fifteen teams in a tournament and it is an inter-city competition, these issues become more difficult to solve. Match scheduling can reach optimality based on what is prioritized, such as reducing player travel time (travelling tournament dilemma), reducing player fatigue, or increasing ticket income. They may plan a match over the weekend where they know people would go out and buy, particularly since they want to step out on the weekend, such as in Mumbai. There are always a few constraints when it comes to scheduling matches. Some are due to game constraints; for example, in the IPL, a major match (Mumbai versus Punjab) will be scheduled on a weekend so that everyone can attend. Some venues may not be accessible on a specific day, and regulations like the IPL's limit on the number of home and away games may apply. Factorization and Minimum breaks are another strategy they employ to attain maximum audience pleasure. This implies that after an away game, they return home rather than continuing on to the next site since the audience at home does not have to wait as long to see their regional team play, and so they assure regular revenue from home games.

Use of OR in Formula 1:

Operations research is used extensively in Formula 1, from deciding on the various strategies of the race to the working of the car itself. It is also used to analyse the revenue of the sport, to understand the track positions, fuel consumption, and also the weather and track conditions. (Sulsters, 2018). Operations Research also plays a huge role in simulation techniques. It emulates most real-life events like overtaking procedures, driver retirements, accidents, car breakdowns and pit stop during a race. This helps the team managers to form their strategies and make important decisions that directly affect the race results. (Bekker & Lotz, 2017). The simulation also helps sports equipment manufacturers to improvise on their products by seeing and analyzing how the drivers respond to different situations. Manufacturers can use this data to improve the quality of the equipment to withstand extreme conditions. Numerous simulations are run to find any competitive advantage. When it comes to deciding on pit stops, thousands of layouts are analyzed simultaneously to find the most appropriate strategies. It also provides alternative strategies which further helps the management to decide on the most appropriate one. It also helps in calculating the seconds spent in the pit lane and deciding the lap and parts that are to be changed. (Stavropoulos, 2018). Furthermore, it is extremely vital to figure out when and how much fuel should be filled to ensure that the car is at par with its rivals, if not faster.

OR in Basketball

For more than 50 years, OR has been an integral part of sports in making analytical decisions for complex as well as trivial situations.

Decision making may be based either on manager's intuition or on analytical and objective reasoning. A basketball court can be considered as an indicative field where these decisions can lead to critical outcomes.

During a match, each shot attempt can be treated as a sub-game. A player has to make a decision whether to shoot or pass. OR is used to compare the expected payoff of shooting the ball against that of passing it, a model is prepared on which the players' shooting decisions are investigated and their accuracy is analyzed. (Nourollahi & Kourosh Eshghi, 2012)

Another application of OR is analyzing the sweet spots. The objective is to estimate players' worth through evaluating their respective performance area and estimating shots per game which is then run through an algorithm to select an optimal basketball line up that maximizes total field goals per game along with court coverage. Forecasting is used for evaluating the players through data aggregation and mining. Other applications include implementing a fitness and conditioning program for Basketball Players. Injury prevention, mitigation and First Aid. (Nikolaidis, 2013)

Use of OR in Football:

Football, also known as soccer in the United States of America and Canada, is the most popular sport in the world with a whooping fan base of over 4 billion people! Due to the sports sentimental and emotional value and unimaginable budgets, one wrong decision can cost a team and its players heavy losses. Hence, many OR

techniques have been studied and used for scheduling matches, devising strategies and creating team formations, deciding referees etc. (Durán, Guajardo, & Wolf-Yadlin, 2012)

OR has successfully been used for scheduling five tournaments in the Chilean professional soccer league. Using an integer Linear Programming model, all the geographical constraints are met to decide when and where a match is to be held. This model was a hit as it even considered the fact that a home game should not be scheduled at the time of a major event happening in the city. (Salles, Hora, Júnior, Santos, & Shimoya, 2019)

A study by Pena and Touchette applied network theory and different centrality measures to determine the importance and popularity of players in a game, and the cost of removing them. Using OR, they devised passing strategies for teams and this study is beneficial for coaches to formulate their game plan. (Peña & Touchette, 2012)

Use of OR in Football, VAR

VAR in football is also playing a very important role in today's footballing world.

Using OR techniques VAR decisions like red card, penalty, goal line clearance etc. are taken. We will show how VAR makes these decisions.

They are several VAR referees in the Official box where they check the replays.

If a player denies their opponent a clear goal scoring chance by making a tactical foul, he/she is awarded with a red card (Federico Valverde foul on Morata, during Spanish cup final). Here the intention of the player becomes very important, it is necessary to make sure whether the defender did it on purpose or not.

When a shot is taken by a striker and if the defender is able to clear the ball off the line the VAR is used to see whether the ball has gone over the line or not.

Var is also used for offside purposes, VAR is used to determine whether the player who scored or assisted the goal was offside or not, they do this by seeing replays of the play and making two virtual lines where the defender and the attacker was standing and then these lines are used to make the decision, if the attacker's line is behind the defender's line then the goal is counted otherwise the goal will be disallowed (Raheem sterling's disallowed goal against Spurs in the UCL Semi-final 2018)

VI. CONCLUSION

In Conclusion, we can confidently say that Operations Research plays a huge role in the Sports industry. It has been an integral part for the last 50 years and there is no doubt that the use of Operations Research in Sports is going to increase exponentially in the future. After analyzing the use of Operations Research in various sports like Cricket, Football and F1, it is safe to say that Operations Research helps in almost every aspect of a sports tournament for better decision making. It is used for effective strategy formulation, to schedule various fixtures, and to forecast the outcomes of a tournament. Operations Research evaluates every aspect and gives the most appropriate solution. A team's strategy, based on Operations Research, has a direct relationship on how the team performs. Hence, every decision must be meticulously planned and implemented. With easy access to information, there is a huge amount of data available for every sport, showing almost every possible scenario on a screen that can be analysed in quantitative terms. This trend will continue and Operations Research will be a standard tool in helping players and team managers to plan and play more strategically.

VII. LIMITATIONS

There were a few limitations of use of Operations research in sports and operations research as a whole that we recognised during our research for this paper one of them being Operations research providing a logical solution only for quantifiable problems. However non-quantifiable factors such as emotions and other qualitative factors are not incorporated in O.R. The field of operations research in sports such as formula-one and basketball has not been explored and researched upon to its full potential, therefore the literature review's scope was narrowed down to the available data. The objective of the O.R. is to find out best available solution considering all the factors. However, application of theoretical solutions might not yield plausible outcomes owing to complex qualitative factors that cannot be accounted for. The field of operations research is ever changing . Secondary data that has been collected well in the past may now be out-of-date information that

might offer little value and therefore the relevance of the paper may be subjected accordingly . The research was based on a limited period of 35 to 40 days and the depth of the paper reflects the timeframe.

VIII. RECOMMENDATIONS

In football there's a great deal of complication while giving VAR decisions. One of the most controversial one is ruling off a goal because the player is offside. VAR rules states that if any part of the player's body is ahead of the defender and that the player scores/assists, that goal will be deemed as offside.

Here we feel that the rule of 'any body part' is a bit too vague and that while considering offside only the part of the body which was used to score the goal should be considered and not the whole body because that becomes very harsh on the scorer's point of view.

For example (real life), during the last game of Ronaldo as a Juventus player, he scored an injury time winner only to get it ruled off as offside.

Here Ronaldo scored with his head, however during the build-up of the goal, his hand was offside (head wasn't), thus we recommend that if the part of body which is offside is not used to score the goal and that the part of body which is onside is used to score the goal, then that should be considered as a goal and should not be ruled off.

Similarly, in cricket, after great research and many experiments, a new DRS rule was found which stated that umpires on field call will be overturned (for lbw) if and only if more than 50 percent of the ball is hitting the stumps and anything below 50 percent hitting the stumps will be given as umpire's call only whether it is an out or not out.

Similarly, Sachin Tendulkar, one of the best cricket players in the world raised a point that normally, even if 10 percent or even 1 percent of the ball hits the stump, it will definitely fall and the batsman will be declared as out, this is why the rule of 50 percent was finalized during the research and experimentation.

Hence, we recommend that the rule of umpire's call should be ruled off and that even if 1 percent of the ball is hitting the stumps, the batsman should be declared out irrespective of the umpire's decision.

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