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Operations Research in Sports Analytics

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ABSTRACT

The primary objective of this paper is to analyse the application of operations research in the field of sports with the help of quantitative and decision-making techniques. The paper arrives at its conclusions after reviewing different research papers in sports such as Cricket and Formula 1. It discovers that there are some typical applications and elements in the field of sports but there are some significantly different applications in various sports like cricket and F1 racing. The main similarity is that both of these sports has used Operations Research to optimize a critical success attribute. So be it the process of switching out tires in a Formula One race or a strategy to minimize travel time while scheduling inter-city matches, Operation research techniques have been beneficial. This secondary study indicates that Operations Research can undoubtedly enhance a player's performance during a sport and help uncover the perfect output matrix in a professional organization. However, it also elaborates that the full scope of betterment is greatly dependent on the identification of the accurate matrix in the first place, as well as the application of the efficient tools and appropriate techniques.

Keywords— Simulation, Pit stop timings, Tire changing technique, Scheduling, Optimization, DLM method, WASP technique, Player's valuation

1. INTRODUCTION AND OVERVIEW

Operational research is the use of analytical models and procedures to improve the efficiency of decision-making. We will look at how Operation Study is used in the Sports industry in this research paper. The two sports we have focused on are: Formula one and Cricket. In Formula 1, studying the simulation models, pit stop strategies and tire requirements are important areas where operations research play a huge role. In cricket, we have focused on the three most important decision-making factors: Duckworth Lewis method, WASP technique and Players valuation model.

The use of quantitative approaches and research in sports has undergone a significant development. Intuition and gut feelings are no longer used to make decisions and strategies; instead, mathematical models that solve complicated problems in seconds are used. Optimize the pit crew's location and equipment, resulting in ergonomic behavior when changing tires or refueling. We can also find the optimal "path" to drive on taking into consideration all the curves. A strong programmer that optimizes everything for a single race might provide the driver an advantage in terms of when it's best to overtake, when it's best to make planned stops, and so on. (Stavropoulos, 2018)

The main goals are to find key studies that have looked at how operations research has been applied to certain sports and athletic activities. Second, to investigate the use of Operations Research in Formula One racing, with a focus on reducing the time required to change tires. Finally, consider how Operations Research is applied to cricket (scheduling inter-city matches plus strategies).

The advancement of technology has made it possible to improve performance. With research, feats that seemed impossible have become mere standards now. (Bekker, 2009)

2. LITERATURE REVIEW

Operations Research has proven to be extremely beneficial in sports. Many of the tactical decisions made by athletes in these events are quantitatively analyzed to produce the best possible results for the contenders. In this paper we cover the two sports having highest expenditure and highest revenue: Formula one and Cricket. F1 is the highest level of professional single-seat, open-wheel, and open-cockpit motor racing. Cricket is the national summer sport of England, and it is now famous worldwide, and even more so in Australia, India, Pakistan, the West Indies, and the United Kingdom.

Formula one relies heavily on simulation techniques. It's used in a variety of ways in Formula One. A simulator is a huge computer that's the size of a studio apartment. It features a comprehensive array of hydraulics that supply or simulate every motion throughout the race, allowing race teams and drivers to learn circuits ahead of time, as well as assess and test new parts or changes to their cars. To save critical seconds, new engine parts or wing designs must be evaluated regularly. All racing teams have moved to virtual simulations to save time and money since the enforcement of practice sessions per team. When weather conditions prevent drivers from testing their cars, race simulators provide an opportunity for them to practice and understand tracks. The design of race tactics by running hundreds of active simulation models concurrently before and during races has been the most important usage of simulation technology in Formula One.

Experts claim that races are won in the factory rather than on the track. To forecast and improve performance, Formula One teams collect massive volumes of data. During a race weekend, the Red Bull Racing team has sixty engineers in the pit box and thirty engineers in England. Within 300 milliseconds, data from the current race reaches the engineers in England, who use it to run simulations throughout the race or alter the racing strategy whenever a tire change or an overtaking opportunity happens. Race strategy decisions can assist Formula One team's plan and evaluate their plans and can be vital in winning a race. Several policies have been amended or suggested as a result of the use of modelling techniques, including as the restriction on refueling during the race and the adoption of drag reduction systems in particular areas of the track. (Bekker, 2009)

In 2016, a new simulation model was created that takes into consideration the most significant regulatory changes, such as the safety car and drag reduction system. These models can also take into account unexpected events during the race and devise a new race strategy on the fly. Based on lap time data from races in 2016, the newly developed model in 2016 additionally describes the impact of fuel usage and tire deterioration on lap time. In addition, the simulation model accounts for factors such as car mixing at the start of the race, pit stops, overtaking maneuvers, safety car situations, and driver retirements.

Operational researchers create mathematical models that decipher information such as relative track positions, fuel consumption, tire wear, and weather conditions, among other things. These computer models may run millions of scenarios at the same time to determine the most successful tactics. This helps team leaders to assess the relative risks of each approach and choose the best course of action. Finding the best timing to come in and change your tires, as well as the amount of time spent at pit stops, is critical. Operations research determines the ideal time for a pit stop based on various factors like weather, competition blunders, and pit lane overcrowding. (Stavropoulos, 2018)

Formula One is a calendar event with races taking place in a variety of locations and weather conditions. In this case, operations research is required; for example, if the temperature is particularly high on race day, the tire pressure should be reduced. The micro-allocation of work to each crew member has resulted in a significant reduction in pit stop times. Because these jobs are assigned and practiced often, time has been drastically reduced. This again demonstrates how efficient work allocation saves time. (Walthert, M, 2018).

One of the most important contributions of operations research to Cricket was the Duckworth and Lewis Method. This method calculates the outcomes of matches that are halted due to weather circumstances (cricket cannot be played in rain or severe weather), is one of operations research's most important contributions to cricket. Using mathematics to help in administering the sport was novel and difficult for a few people and an anathema to others. Although many journalists still enjoy making disparaging comments about the method, there's general acceptance of its superiority over all other methods that are tried. (FC Duckworth, 2004)

Operations research also plays a huge role on the Winning and Score predicting (WASP) technique of cricket. The batting-first estimation evaluate the total score at the end of the innings as a function of the number of balls and wickets remaining with the batting team. The second innings forecast predicts the chances of each team winning by taking into account the number of balls remaining, wickets lost, runs scored till the latest ball, and the target score set the batting first team. Projected score or the required run-rate will not qualitatively show the actual representation as they fail to take into the account the quality of the batting team and the quality of the bowling attack. WASP is an excellent quantitative parameter.

All in all, the WASP is a really good quantitative indicator of the flow of a cricket match, but fails terribly as a predictor when it comes to assessing the qualitative results. It takes into account numerous statistics and quantitative data required to predict the outcome of the match, but leaves out other demographics such as pitch and weather, historical records of the batsman and the bowler,

etc. Analyzing players' performance is also of immense importance in this sport. There are numerous methods of analyzing a player's performance. 3 methods of valuation of players are - (a) Performance Based Index, (b) Hedonic Pricing, (c) Ordinary Least Square Regression Technique

- (a) In the Performance-Based Index- This model enables the franchises to determine which player need to be bought and which ought to be bought out.
- (b) Hedonic Pricing-Within the hedonic pricing model, the charge and assessment of a player are calculated based on internal and outside factors. From the players' factor of view, inner elements are their on-discipline overall performance elements and external factors quantity to their off-area performance factors and values.
- (c) Ordinary Least Sq. Regression Technique Value

The dependent variables used in this Ordinary Least Square Regression technique, cover a variety of performance factors (such as batting and bowling averages)

- Experience
- Strike rates
- All-rounders
- Icon Players

3. METHODOLOGY

We have analyzed various research papers pertaining to Operations Research, Application of Operations Research in the Sports Industry and specific papers. Our paper focusses on two specific sports. These are the two highest expenditure and highest revenue generating sports: Formula 1 and Cricket. We have covered detail analysis of the application of operations research in Cricket and Formula 1 racing. We have conducted the research on specific factors what were most affected by operations research in both the sports. In Formula 1, studying the simulation models, pit stop strategies and tire requirements are important areas where operations research play a huge role. In cricket, we have focused on the three most important decision-making factors: Duckworth Lewis method, WASP technique and Player's valuation model. Other elements that affected and filtered our study included the use of Operations Research to schedule matches, various strategies for determining the batting order, and ways to reduce player tiredness and travel time, among others. We had a goal about understanding how Operations Research has improved the outcomes in the selected sports. We also looked at important aspects of distinction in operations research's use in the sports we picked.

4. FINDINGS AND ANALYSIS

4.1 Formula One

A race plan is just as crucial to the teams as mechanics, aerodynamics, engine power and the driver. Through the data collected by thousands and millions of scenarios there are race strategies decisions made weeks prior and even during the race. (SPURGEON, 2008).

In a Formula One race pit stops are essential. A team can potentially gain or lose a good amount of time depending on their pit stop. F1 drivers can go faster between pit stops by pausing and making improvements to the car during a pit stop, thereby surpassing the time it took them to make the stops in the first place. Pit stops must therefore be planned carefully. (F1 strategy and pit stops, n.d.) Various factors like weather conditions, human error and over-crowding in the pit lane are main variables that affect the most planned pit stops. Optimum pit stops timing and number of laps covered before each stop is derived by continuous and in-depth operations research and analysis.

Mathematic models analyse relative track locations, fuel consumption, tire wear, weather conditions, and a variety of other parameters on a continuous basis. For example, in a racing circuit where overtaking is difficult, pit stop and race tire tactics are more important. There are 3 types of tires:

1. Hard – High Durability but slower speed
2. Medium –Durability and speed is equal
3. Soft –Low durability but high speed

Type of Tire (Status of tire)	Time compared to Optimal time (per lap)
Soft (new)	0s
Soft (Worn)	-1s
Medium (new)	-0.4s
Medium (old)	-1.4s
Hard (new)	-0.7s
Hard (old)	-1.7s
Pit stop	-2

On an average, the driver would lose around 1 second per lap once the wheels have reached a worn-out state. But each pit stop add up to the time. As a result, the optimal race time needs to be a fine balance between the two. (Whittle, 2012) To form a pit stop tire strategy, a simulation model is developed. A few seconds in the race are also of extreme importance which can be saved by multiple factors which are identified by time saving stimulations that are run before and during the race. In each race there are stimulations

running continuously to help find the driver an advantage. The significance of a pit stop in a formula one race has pushed people to constantly develop technology and increase the use of operations research in formula one. This led to pit stops being reduced to just 2 or 3 seconds from minute long pit stops.

The micro allocation of jobs to each of the crew member significantly improves the pit stop timing. The jobs are allocated and practiced over and over again resulting in dramatically reduced time while ensuring error free performance.

One more important factor to consider is the positioning of the car at a given time compare to its competitors. Average time to overtake is always being calculated. To determine the number of positions lost or gained by each driver as a result of each change of tires and pit stop, an empirical distribution function is drawn. This results in development of an overtaking model which calculates the cumulative lap time difference between each pair of drivers on the track. The best chance to overtake any of the competitors is determined by this model. (Sulsters, 2018)

This is a classic example of the use of game theory – the part of mathematics that is involved in strategic decision making. The model does the complex task of trading off between different factors using the state-of-the-art computers and ultra-powerful software. (F1 strategy and pit stops, n.d.)

4.2 Cricket

4.2.1 Duckworth-Lewis method

Duckworth-Lewis method is one of the greatest contributions by Operations Research to Cricket. It was related to the calculations of scores any particular match which is interrupted due to weather conditions. This method is dependent on some resources namely wickets and overs left. The optimal score is formulated taking all combinations into consideration that is fair to both teams. (Hemant Sangwan, 2015). An example showing the calculation of the score is given below taking into the reference the resources availability percentages that is universally available.

Example:

Team 1 has scored 300 runs from 50 overs and in the second innings, Team 2 lost 7 wickets and scoring 180 runs in 30 overs. Play is dropped due to rain. A decision for the winner is required.

Team 1's innings was not interrupted, so the percentage of resource accessible is	100%.
Team 2's innings: resource % accessible at start of innings	100%
After 30overs Team 2 has 20overs left and has lost 7wickets. From universal table, resource% left at suspension of play =	25.2%
As play is dropped all this remaining resource are lost. Hence resource % available for Team 2's innings =	$100 - 25.2 = 74.8\%$
Due to rain, Team 2 had fewer resources than Team 1, therefore their objective had to be decreased by ratio of resources.	$46/100$
Team 1 scored 300, so Team 2's 'target' is $300 \times 74.8/100 = 224.4 =$	225

As no play will be carried on, the winner is to be decided on the basis of exceeding the target. As the Team 2 has scored 180 runs and according to D/L method the runs should be 225. So, Team 1 has won the match by 3 wickets.

4.2.2 Wasp in Cricket

The WASP (Winning and Scoring Predictor) is a tool used in limited over cricket matches to find out the probability of the first batting team's final score or the team batting second's chances of winning.

WASP predicts it results based on two parameters-

1. The final score of the team batting first based on players' past records and venue details.
2. The result of the match based on venue and the teams' past results.

WASP also uses the current match scenario, batting conditions and the ground record; these things change with short intervals of time. For e.g., In a match between India and Sri Lanka, WASP would consider India's past performances with Sri Lanka, and the batting conditions to assess India's chances of winning. If India were playing a less powerful team, say Afghanistan (someone whose past results against India weren't in their favor), WASP would increase India's chances of winning accordingly.

4.2.3 Valuation of players in Indian Premier League

- Players sign up for a bid and set their initial price, and they go for the most expensive franchise offered to them.
- During 2018 IPL season, India's national team captain Virat Kohli got paid 2.5 million dollars, while former Indian captain MS Dhoni got 2.2 million dollars.
- In IPL under 19 age players have also been auctioned around 450,000 dollars and 600,000 dollars for one Indian premier league season. The head coach also earn around 5 lakh dollars to 1 million dollar per season.
- It can be helpful to understand that which method is more realistic to evaluate the real value of a player. It would also help the team owner to decide which player is too kept and which is too eliminated.
- Helpful for players to realize their value and how much are they getting paid for their services. It also help to understand are the players overvalued or undervalued.

- It also brings attention towards that non cricketing aspect are also as important as cricketing aspects.

5. LIMITATIONS

We confronted a couple of issues when we were finding research papers for the strategy used for holding a sport effectively and efficiently in terms of decreasing travel time, depletion and making the sport popular or playing domestic matches on the end of the week etc. We also thought if we had more clarity and know how about the subject through which we could use the techniques and understand them more clearly and if possible, could give suggestion of alterations on the techniques. Although we think Operations Research in Sports has a huge area of application and due to some of the limitations, it could decrease the optimality in this industry.

6. RECOMMENDATIONS

After such an in-depth research and analysis of the use of operations research in sports, there are few future research directions stated by us.

- In a Formula One race there are many things that have to be taken into consideration like the type of tires, the time taken at pit stops, and how they use stimulations to their benefit. Even though there has been a lot of progress in the time taken at a pit stop there is always room for improvement.
- The crew's allocation can be more efficient by practicing various situations and learning how to improvise on the spot in case of any issue. The stimulation model helps the driver find an advantage over his competitors. They can also appoint a team to look at the races of its top competitors to understand their technique of racing and how they make their decisions. This can benefit the driver as knowing the competitor's way of racing can help the driver outsmart its competition.
- Operations Research can assist IPL franchise owners to make informed decisions regarding the valuations of cricketers. A sudden outburst in form results in the players' perceived value to rise and fall. Improvements can help franchise owners make informed decisions.
- The WASP can be improved by adding changes to the structure of the algorithm. Supposedly, if the normal flow of the match is disrupted in any way, WASP doesn't have the ability to alter itself. If it can be developed according to it, it can overcome major flaws and provide better results.
- The Duckworth-Lewis method does not take into consideration the latest matches and relies heavily on historic data. So, when it delivers the revised calculations, the data used to arrive at to it isn't according to recent trends. If it can be altered to give conclusions based on recent results, it can be fairer to the teams.

7. CONCLUSION

Operations Research has significantly improved and refined the sports business. As it is a flexible concept, it can be applied to any circumstance. In Formula one, the significance of a pit stop has pushed people to constantly develop technology. This led to pit stops being reduced to just 2 or 3 seconds from minute long pit stops. Few seconds in the race are also of extreme importance which can be saved by multiple factors, the micro allocation of jobs to each of the crew member significantly improves the pit stop timing.

In Cricket, Duckworth-Lewis method developed with the use of Operation Research is used to solve the challenge of defining targets for an interrupted cricket match due to weather conditions. It is also used in evaluating value of players in IPL using combination of AHP-ANN, Ordinary least sq. regression technique, Hedonic pricing, and performance-based index. These assist the bidder to invest the most appropriate money for the player as per his skills. Winning and Scoring Predictor is a tool used in limited over cricket matches to find out the probability of opening batting team's final score or the team batting second's chances of winning. Unique algorithms help to determine the best and most efficient approach to solve a situation. Operations Research examines everything and comes up with the best solution. This brings us out to the conclusion that how advantageous the application of operation research is to the sports industry.

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