

APPLICATION OF OPERATIONS RESEARCH IN MAXIMIZATION OF MATCHDAY REVENUE OF PREMIER LEAGUE CLUBS

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Abstract

Football is the most viewed sport in the world and the most viewed domestic league is the English Premier League which consists of 20 top tier British clubs. To stay afloat, these clubs need to maximize their profits and use them optimally. This paper aims to maximize the matchday revenue with ticket sales and thereby maximize profits by using the operations research technique of simplex. The analysis was conducted for the 4 historically biggest clubs in the league which are Manchester United, Liverpool, Chelsea, and Arsenal. The model created maximizes matchday revenue. It can be used for all sports teams and is not restricted to football clubs alone. However, this model only takes into account ticket sales and no other matchday purchases like food, beverages and merchandise.

Keywords: Football, Operations Research, Premier League, Revenue, Stadium, Maximization

Introduction

The English Premier League (EPL) is often referred to simply as the Premier League. According to an Ernst & Young study it is the largest and most popular football league in the whole world, having over 1.3 billion fans globally. The numbers speak for themselves, with the Premier League earning 1.1 billion pounds in 2016 alone from broadcast exports. It supports over 100,000 jobs and has 97% stadium utilization on average, which is the highest of any league

globally. The study states that revenue earned by football clubs in the English Premier League is divided into 3 different main streams: broadcasting, commercial and matchday. The money earned from the television rights of the matches is broadcasting revenue. Commercial revenue includes money they earn from promotions, advertising, merchandise, and product licensing. Matchday revenue includes all the revenue from ticket sales, and in-game purchases like food and beverages at games played in the home stadium of the club. According to the study the Premier League earns over 1.5 billion pounds a

year from commercial revenue and 2.8 billion pounds from broadcast revenue. Each of these streams is equally important to the clubs and all clubs aim at maximizing all of their revenue streams. The substantial revenues earned make Premier League clubs some of the richest globally, with a fascinating financial structure (Ernst & Young, 2019).

Simplex method is a linear programming technique that is used to solve a problem when there are more than 2 variables involved and multiple constraints are required to be satisfied. It makes use of slack variables, tableaux, and pivot variables. By using the simplex method one can obtain the optimal solution and fulfill the necessary constraints and acquire the maximum or minimum objective function which is written down as the “Z” value. However, in order to use the simplex method, it is essential that the linear programming model be in standard form such that one can add slack variables to the constraints.

The simplex technique of Operations Research is used in a plethora of fields in football alone. It can be used to maximize all kinds of revenue streams and profits earned not only by various clubs but by the league itself. Moreover, it can be used in the minimization of various costs incurred by these parties. By assigning different variables and formulating a maximization function, the simplex technique can be easily used to achieve answers which are optimal even if there are constraints on the maximization function. Therefore, it can be concluded that simplex is especially useful in the optimization of finances when it comes to football. It is preferred over the graphical method since in the practical world, the number of variables usually exceeds 2 which cannot be solved using the

graphical method of linear programming since it is virtually impossible as there are not enough axes.

The topic we chose involves the creation of a model whose objective is the maximization of the matchday revenue from ticket sales of the historically biggest Premier League teams. We have taken this topic because of the decline in the past year in the football industry. Since there was an economic downturn all around the world due to the Covid-19 pandemic, and because all of us are very passionate about football, we wanted to come up with a solution to have football matches with spectators inside the stadium with appropriate Covid measures. While doing our research we noticed that there were not too many existing research papers relating to maximizing match day revenues or any football related papers that used simplex. Furthermore, there weren't any papers that analyzed the different revenue streams for football clubs and especially for Premier League clubs nor did they use OR techniques for analysis of matchday revenues for Premier League clubs. When looking at data published by the clubs, they did not specify the capacity per stand for each year. Existing research primarily consists of qualitative analysis talking about the factors affecting profitability and finances. This research can be applied to other sports leagues to maximize not only matchday or ticket sales but to other revenue streams like for broadcasting revenues or for merchandise revenues. Furthermore, it can be applied to business in which one can track average worker turnover and how many different product ranges are made and how much of a particular type of product can be made. For example, for a manufacturing company the average worker turnover for different products can be put in the objective function, the variables are the products,

and the constraints can be the demand and supply for the respective products. This use in particular can be used when it comes to merchandising. Through our research, we have created a model which allows football clubs to decide how they should allocate seats to the spectators based on the number of seats in each stand and the average price of the tickets per stand.

Our objective is to maximize the matchday revenue with ticket sales using simplex for four of the historically biggest clubs in the English Premier League: Manchester United, Liverpool, Arsenal and Chelsea. The study was conducted based around the Covid-19 guidelines that were put in place with respect to match attendance for spectators during the last 2 match days of the 2020-2021 English Premier League Season. These guidelines stated that the stadium could have a maximum of 25% capacity or 10,000 spectators-whichever was higher.

Literature Review

According to a study in 2015 by Rodrigo in the WritePass Journal clubs in the English Premier League have unconventional business operations; despite being limited liability companies, they comply with the same rules and regulations as any other limited liability company. They prefer debt to equity, which is later invested into players in the form of human capital formation. In 2010, Manchester United had a debt of £716 million; Arsenal had £297 million, and Liverpool had a debt of £237 million. The debt for these clubs may be high because when clubs get too large, they may become inefficient in handling finances and operations where they experience diminishing

returns to scale. Despite this, club revenue has been growing consistently over the years through sponsorship agreements, stadium ticket sales, merchandise sales, domestic and international TV rights, amongst others (Rodrigo, 2015).

From studies about finances of the Premier League we learnt that the more successful clubs have better finances due to the prize money they receive and also more fans supporting due to their performance. The higher a club's popularity, the more likely it can increase ticket prices and have better attendance in matches whether they are played at home or away, increasing its matchday revenue. Larger clubs are generally located in larger cities like London, Manchester or Liverpool have larger fan bases leading to more ticket and merchandise sales, leading to high popularity and increased revenue. However, it is known that stadium and facility maintenance and construction costs take up a large portion of a club's costs, which reduces the club's profits over time despite being able to draw in many fans to watch matches. They would also receive more commercial revenue from sponsors who want their name to be affiliated with a top team. This would also attract foreign investors to want to be part of a highly ranked team to enjoy the team's success. Broadcasters would also want to telecast an elite league where the best teams play, so people would like to watch high-quality football (Rodrigo, 2015).

Clubs have a strong relationship with its shareholders and fan base, who are influential in making decisions regarding transfers and retention of key staff like managers. Club managers are primarily responsible for non-financial performance of the club, where they are mainly given non-financial performance objectives by the

board, like finishing in a particular stage or position in a league. In transfers, they have a considerable influence on choosing which player and their bidding and selling price. However, the club board is more focused on the finances where the final decision to pay wages and transfer fees is up to them. This can lead to a dispute between being successful on the field and the club's financial success. Often clubs focus on short term success like winning or getting a top 4 finish in the domestic league or even winning competitions like the FA Cup or the UEFA champions league. This causes them to sign star players who have exorbitant price tags, which only becomes dearer when other clubs are pursuing them (Robinson, 2020).

This makes wages and transfers one of the highest and most crucial costs a team can incur, and these can be given back after some time if a player's transfer value improves from what the player was acquired for. Recently, English players have been priced relatively higher than players from other parts of the world in the Premier League, severely increasing costs for the clubs. Player bargaining also has a significant impact on transfer fees where high bargaining power of players and their agents leads to a surge in their transfer fee. Moreover, clubs may also have a relatively weak position in the transfer market which can also make them pay more for a player (Rodrigo 2015). Top-tier English clubs increased their wage by 11% to £10.6bn in the 2018/2019 season (Perrin, 2020). Players need to be paid well to attract and retain players and being able to maintain the best players would lead to success on and off the pitch. Blanchard and Johnson's EW Concept shows the relation between higher investments and player performance where human capital investments like buying players in

form, could create more significant work incentives, better team performance, leading to higher wage costs being paid off in the long term, since players could be sold for more later. Moreover, the Equity Theory of Arkelof suggests that low player wages serve as a motivation to players to perform better, thereby improving player performance. According to Brynjolfsson, nowadays, social media also impacts player performance as it impacts their focus on game performance, irrespective of the number of wages (Robinson, 2020).

Other studies show that having an optimal schedule reduces television broadcaster operating costs, gain in television subscriptions, increased ticket revenue by increasing fans' interest, and lower travel costs and assuring no team has to travel for a long time back-to-back. It has been used successfully to schedule sports leagues in other countries like volleyball and basketball in Argentina and the South American qualifiers for the 2018 FIFA World Cup. This particular OR technique proves to be very versatile in practical scenarios. An optimal schedule ensures that weak teams avoid playing against the strongest teams back-to-back so that the weaker teams don't get any points for a long time (Alarcón, 2017). This was also seen in a study conducted by Jae Cho, Kenneth Poon, Vaughn Ridings. Here a model was procured to determine a fair schedule for all teams giving each team home and away advantage based on factors such as distance, days between games, etc. These advantages are calculated using a program considering those variables which impact the result of a particular game. The model is based on a theoretical league with ten teams which could be scaled up to 20 teams like in the English Premier League. However, this model does not consider

factors such as days between games, the distance between games, the costs of travelling and certain constraints regarding travel restrictions. These factors add a significant advantage or disadvantage to specific teams and should have been included in the model (Jae Cho, 2013).

After reading all this existing literature, we could clearly see a trend where there was a focus on usage of OR techniques for scheduling. Other studies mainly focused on either optimizing finances as a whole with minimal use of OR techniques or very advanced ones which were tough to comprehend at a graduate level. No existing study focused on a particular club or a particular stream of finance and generalized their findings for the whole Premier League. Hence, in our analysis, we decided to do a club wise analysis for 4 clubs and decided to focus our research on how we could maximize revenue for these clubs. Within revenue, our objective is to focus on the matchday revenue stream of the revenue to be received by Premier League teams primarily focusing on ticket sales with Covid-19 guidelines in place.

Methodology

As mentioned above, our objective for this paper is to maximize matchday revenue from ticket sales for 4 of the biggest Premier League clubs: Arsenal, Chelsea, Liverpool and Manchester United, with Covid restrictions. The Covid-19 guidelines were put in place with respect to match attendance for spectators during the last 2 match days of the 2020-2021 English Premier League Season. These guidelines stated that the stadium could have a maximum of 25% capacity or 10,000 spectators-

whichever was higher. We performed a club wise analysis of how each club could maximize their revenue while respecting the guidelines that were put in place to ensure all the spectators were socially distancing themselves. For this particular problem we took the variables as the stands in the stadium and for the constraint we kept the capacity of each stand between 20-50% of the maximum capacity so that there can be an equal distribution of people in each stand and limited it to 50% to avoid overcrowding in one particular stand. The guidelines stated that only 25% or 10000 people can be seated based on whichever of the two is higher and for our clubs the 25% capacity was higher than 10000. So, the sum of all variables was less than or equal to 25% of the stadium capacity. The prices in the model were procured from an average of the different categories in each tier or stand including hospitality tickets and we subtracted the number of hospitality seats from the stand they were in for calculation. We then put the average prices into the

Stand	North	South	West	East	Hospitality
100% capacity	29500	11500	14000	13500	1196
50% capacity	14750	5750	7000	6750	598
20% capacity	5700	2300	2800	2700	240
Prices (£)	44.09	38.2	38.4	38.4	450

objective function to maximize the matchday revenue based on the limits on stadium capacity due to Covid-19.

Analysis and Findings

Manchester United

The analysis of the clubs below is done in the order of size starting with Manchester United and ending with Arsenal and all problems were solved using solver on excel.

Manchester United FC was founded in 1878 under the name Newton Heath LYR Football club. It is currently situated in Greater Manchester, England and is one of the most successful clubs in English football as they have won 20 League Titles, 12 FA Cups, 5 League Cups and many more trophies. Their home stadium has been Old Trafford since 1910. Old Trafford was designed by Archibald Leitch and initially had a capacity of 100,000 spectators (Gifford C, 2021).

The last significant change in Old Trafford was made during 2006 where at that time a new premier league record with an attendance of 69070 was set. On 27 March 2021 the first ever Manchester United's women team's game was hosted at Old Trafford. Currently, Old Trafford can hold 74000 people and comprises four stands: the Sir Alex Ferguson Stand, Sir Bobby Charlton, West Stand, and the East stand.

Table 1:

Let:

X1=North/ Sir Alex Ferguson stand and half of north east and north west quadrant

X2= South/Sir Bobby Charlton stand

X3= West stand/ Stretford end and half of northwest quadrant

X4= East stand and half of northeast quadrant

X5= Hospitality seats

Maximizing function:

$$Z=44.09X_1+38.2X_2+38.4X_3+38.4X_4+450X_5$$

Subject to constraints:

$$X_1+X_2+X_3+X_4+X_5 \leq 18500$$

$$X_1 \leq 14750$$

$$X_1 \geq 5700$$

$$X_2 \leq 5750$$

$$X_2 \geq 2300$$

$$X_3 \leq 7000$$

$$X_3 \geq 2800$$

$$X_4 \leq 6750$$

$$X_4 \geq 2700$$

$$X_5 \leq 598$$

$$X_5 \geq 240$$

Answer: Z= £1013557.18

$$X_1=10102, X_2=2300, X_3=2800, X_4=2700 \text{ \& } X_5=598$$

The value for Z is equal to £1013557.18 which can be estimated as 1.01 million pounds earned by ticket sales in a matchday at 25% of stadium capacity. At the North stand there should be 10102 people, at the South stand there should be 2300 people, at the West stand there should be 2800 people, at the East stand there should be 2700 people and in the hospitality seats there should be 598 people.

Liverpool

Liverpool FC was founded in 1892 in Liverpool, England and since then it has been the one of the largest clubs globally and the most successful English team in European competitions. They have won 6 European cups/champions league trophies as well as being the Premier League champions 19

times and they won their first league title in the 1900/01 season. Their home stadium is known as Anfield which was constructed in 1884.

The last significant change in Anfield was made during the 1990s and during the 2000s there was talk of building a 60,000-seater stadium at Stanley Park, but the plan was foiled in 2012 due to a lack of finances (Gifford 2021). Currently, Anfield can hold 54074 people (25% capacity at 13518) and it comprises four stands: the Kop, Anfield road, Sir Kenny Dalglish, and the Main stand. They have the 4th highest average attendance in the premier league during the 19/20 season with 41955 people attending a game on average.

Liverpool’s match day revenue for the year ended 31 May 2020 was £70.9 million (2019: £84.2 million), which forms 19% of the total annual revenue for Liverpool FC.

Table 2:

Stand	Kop	Anfield Road	Sir Kenny Dalglish	Main Stand	Hospitality
100% capacity	12850	9074	8282	20676	3480
50% capacity	6425	4537	4141	10338	1740
20% capacity	2570	1814	1656	4135	696
Prices (£)	46.28	46.28	55	57	494.7

Let:

X1=Kop

X2=Anfield Road

X3= Sir Kenny Dalglish

X4= Main stand

X5=Hospitality

Maximizing function:

$$Z= 46.28X1+46.28X2+55X3+57X4+494.7X5$$

Subject to constraints:

$$X1+X2+X3+X4+X5 \leq 13518$$

$$X1 \leq 6425$$

$$X1 \geq 2570$$

$$X2 \leq 4537$$

$$X2 \geq 1814$$

$$X3 \leq 4141$$

$$X3 \geq 1656$$

$$X4 \leq 10338$$

$$X4 \geq 4135$$

$$X5 \leq 1740$$

$$X5 \geq 696$$

Answer: Z= £1481815.52

X1=2570, X2=1814, X3=1656, X4=5738 & X5=1740

The value for Z is equal to £1481815.52 which can be estimated as 1.48 million pounds earned by ticket sales in a matchday at 25% of stadium capacity. At Kop there should be 2570 people, at Anfield road stand there should be 1814 people, at Sir Kenny Dalglish stand there should be 1656 people, at the Main stand there should be 5738 people and in the hospitality seats there should be 1740 people.

Chelsea

Chelsea is an English team which plays in the topflight of English Football. They were founded in 1905. Their home stadium is the Stamford Bridge which can seat 41,631 people. All the stands in the stadium are roofed and adjacent to the pitch. The last significant change made to the stadium was 20 years ago when they began the construction of the East Stand (Chelsea FC, 2021). Chelsea earned a total of 62.1 million pounds in the year 2019-2020 from matchday revenue which accounted for 13.22% of their total revenue (Lange D, 2021).

Prices (£)	73.1	41.6	60	60
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Table 3:

Stand	West Stand	East Stand	Matthew Harding Stand	Shed End
100% Capacity	13500	10925	10884	6831
50% Capacity	6750	5642	5442	3416
20% Capacity	2700	2185	2177	1366

Let:

- X1=West Stand
- X2=East Stand
- X3= Matthew Harding Stand
- X4= Shed End

Maximizing Function:

$$Z = 73.1X1 + 41.6X2 + 60X3 + 60X4$$

Subject to Constraints:

$$X1 + X2 + X3 + X4 \leq 10408$$

$$X1 \leq 6750$$

$$X1 \geq 2700$$

$$X2 \leq 5642$$

$$X2 \geq 2185$$

$$X3 \leq 5442$$

$$X3 \geq 2177$$

$$X4 \leq 3416$$

$$X4 \geq 1366$$

Answer:

$$Z = \text{£}645,584$$

$$X1 = 4680$$

$$X2 = 2185$$

$$X3 = 2177$$

$$X4 = 1366$$

Using these constraints, we can calculate that the average maximum revenue earned from ticket sales for a matchday under Covid-19 restrictions for Chelsea is £645,584.

To attain this maximum profit, all stands have fulfilled their minimum capacity of 20% while the West Stand has exceeded the minimum number of

tickets and is absorbing all the seats left to fulfil 25% capacity after each stand has fulfilled its 20% limit.

The West Stand will seat 4680 people, the East Stand will seat 2185 people, the Matthew Harding Stand will seat 2177 people and the Shed End will seat 1366 people.

Thus, we can obtain the maximum revenue possible to be earned by Chelsea by optimizing the capacity of the stadium according to the constraints.

Arsenal

The Emirates Stadium is a football stadium in Holloway, England, and the home of Arsenal Football Club. After considering various options, the club bought an industrial and waste disposal estate in Ashburton Grove in 2000. Emirates was later announced as the main sponsor for the stadium. The entire stadium project was completed in 2006 at a cost of £390 million. The club's former stadium was redeveloped as Highbury Square, an apartment complex. With a capacity of 60,361 it is the fourth largest stadium in the English Premier League. Emirates Stadium has 4 stands: North Bank stand, East stand, West stand, and clock. Each stand has an upper tier, lower tier, executive box, and club level (Arsenal FC, 2021).

X_1 =Upper Tier

X_2 =Lower Tier

Maximizing Function:

$$Z=45.29X_1+31.64X_2$$

Subject to Constraints:

$$X_1+X_2\leq 15090$$

$$X_1\leq 25535$$

$$X_1\geq 5107$$

$$X_2\leq 25535$$

$$X_2\geq 5107$$

Answer:

$$Z = \text{£}613715.55$$

$$X_1=9983$$

$$X_2=5107$$

Due to a lack of data on Arsenal's capacity per stand, the capacity of upper and lower tier seats was taken for calculation. The matchday revenue value is £613715.55, the upper tier value for Arsenal was 9983 people and for the lower tier the value was 5107 people.

Limitations and Recommendations

Some of the limitations of this project were the availability of data for capacity and prices of each stand as they keep fluctuating each game, competitiveness of the match and after every season the club or any secondary site would not post data on it like in the case for Arsenal.

Our data was based on only four of the biggest clubs who have large stadiums and a well-established fan base and deals primarily with one league. This may not be applicable to smaller clubs in the Premier League or even teams for other leagues, as they may have different rules in place.

We also assumed that the stands would be full at 25% capacity which in reality is very rare, and this would be different from the actual matchday revenue value. Furthermore, the minimum constraints were being satisfied for the stands with

lower prices and for the stand with the highest price the maximum constraint was being met. This caused getting a value in between the constraints to be uncommon.

Moreover, the matchday revenues calculated only took into account the ticket sales and not any other purchases that happen like for food, beverages, pay per views and merchandise like banners and for future research. In future research one should try and incorporate the additional matchday purchases, other revenue streams and minimize costs to optimize overall finances, profit, and revenue for Premier League clubs.

When we started the research, we did not have in-depth knowledge on operations research and its techniques, so our applications of techniques were limited by this. We also had to meet deadlines, so our time spent researching and to apply more concepts was cut short by deadlines.

Conclusion

For all clubs, the matchday revenues with 25% capacity have been in 6 or 7 figures and the data is entirely based on ticket sales and the figures for revenue and optimal number of people for each stand were solved using simplex method. The problem in this was that there was no consideration of the money made on goods sold inside the stadium like food, beverages and products like banners and flags. Furthermore, in a single matchday the pay per views could also be added to get a more accurate answer for the revenue earned into a single matchday.

The data and findings helped us to solve the issues related to maximizing the revenue of all the teams.

The revenue generated using the covid -19 restrictions as guidelines are as follows:

The highest amount of revenue was generated by Liverpool which was 1481815.52 pounds. This was mainly due to its large stands and its huge stadium capacity, even with the restriction of 25% maximum applicable. Moreover, the ticket prices are steep for most of their stands which helps maximize their revenue earning capacity.

The second highest amount of revenue was generated by Manchester United which was around 1013557.18 pounds. Their stadium capacity being lower than Liverpool's was the main factor which led to a lower revenue.

The third highest amount of revenue generated was by Chelsea which was calculated under the given constraints and the excess sale of tickets which summed up the amount to be around 645,584 pounds.

Arsenal collected the least amount of revenue which was around 613,715.55 pounds and the main reason for less revenue is because of the lesser stand capacity and its particular seat allocation. The average ticket prices too were lower for each stand and thus their revenue was lower too.

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