Can the Poisson Distribution be used to model outcomes in the Premier League?

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18th April 2020

1 Abstract

This paper will explore how accurately the Poisson distribution can help model and predict outcomes of football matches including *clean sheets*, the number of goals scored and the overall result. The set of English Premier League *fixtures* being predicted will be taking place on the weekend of the 1st and 2nd February 2020, using data from the start of the season up to the 24th game week. The probabilities will then be used to aid a low risk betting technique which will be tested by placing hypothetical £100 wagers on the various outcomes of matches that the Poisson model has indicated will happen. The factors taken into deliberation when investigating into this topic include home and away form while considering attacking and defensive strengths of each individual team.

2 Introduction

The *English Premier League* is often given the title of being the most unpredictable **(1)** and exciting football league in Europe. 'Surprising' results happen regularly where teams positioned near the bottom of the *league table* end up beating teams in the top half of the table, which rarely happens in other top leagues across the continent **(2)**. However, in the last four years the Premier League has seen Chelsea embark on a 13-game winning streak **(3)**, Manchester City go on an 18-match win streak **(4)** and Liverpool reach 20 consecutive home wins **(5)**. These lengthy winning streaks have made people question the unpredictability of the league. This paper will consolidate these growing views by seeing how outcomes of matches in the league can be determined using a Poisson distribution model by factoring in a team's attacking and defensive strength both home and away. Through analysis of the probabilities that the Poisson model provides, a smart and risk-free betting technique will be described and applied to a set of fixtures of match week 25 of the Premier League.

3 The Poisson Distribution

The Poisson distribution is a discrete probability distribution which gives the probability of events happening in a fixed time period, given the average number of times the event occurs over the said time period **(6)**. In the case of this paper, the average number of times an event occurs is given by the average amount of goals a team scores per game and the time period is given by the length of a football match i.e. 90 minutes.

Theoretically, the applicability of a Poisson distribution holds for football if one assumes that the probability of a goal being scored happens independently of the time since the last goal. This model will assume that the number of goals scored are independent random variables that are Poisson distributed. From this assumption, the model used to predict the result of matches will be a bivariate Poisson distribution.

The Poisson probability mass function of a discrete random variable is given by:

$$\boldsymbol{f(x,\mu) = P(X = x) = \frac{e^{-\mu}\mu^{x}}{x!}} \quad \textbf{(I)}$$

where $\boldsymbol{\mu}$ is the average number of events per time period. In this case it is the expected number of goals for each team per match.

$\boldsymbol{x}$ is the number of times an event occurs. This is the number of goals being scored by a team in a match i.e. $x = 0,1,2, \ldots$

$\boldsymbol{e}$ is Euler's number.

The bivariate Poisson probability mass function of two independent discrete random variables is given by:

$$\boldsymbol{P(X = x) \times P(Y = y) = \frac{e^{-\mu}\mu^{x}}{x!} \times \frac{e^{-\lambda}\lambda^{y}}{y!}} \quad \textbf{(II)}$$

$\boldsymbol{\mu}$ is the average of the number of events *H,* per time period. In this case it is the home team's expected goals.

$\boldsymbol{x}$ is the number of times event *H*, occurs. This is the number of goals being scored by the home team in a match i.e. $x = 0,1,2, \ldots$

$\boldsymbol{\lambda}$ is the average of the number of events *A*, per time period. In this case it is the away team's expected goals.

$\boldsymbol{y}$ is the number of times event *A,* occurs. This is the number of goals being scored by the away team in a match i.e. $y = 0,1,2, \ldots$

Simple Poisson Example

If Liverpool are expected to score 2 goals a game, calculate the probability that they will score 3 goals in a match.

Using **(I)**,

$$\boldsymbol{\mu = 2,\ x = 3}$$

$$\boldsymbol{f(3,2) = P(X = 3) = \frac{e^{-2} \cdot 2^{3}}{3!} = 0.1804} \textbf{ (to 4 decimal places)}$$

There is an 18.04% chance that Liverpool will score 3 goals.

This is a very basic example. This paper will delve into more complex calculations where the expected number of goals depend on a multitude of factors which will be further expanded on.

Simple Bivariate Poisson Example

To work out the probability of Bournemouth vs Aston Villa being 2-1, when given their respective expected goals, simply multiply Bournemouth's probability mass function by Aston Villa's probability mass function to form a bivariate Poisson mass function.

Using **(II)**,

$\boldsymbol{\mu}$ = Bournemouth's expected goals = 1.4648,

$$\boldsymbol{x = 2}$$

$\boldsymbol{\lambda}$ = Aston Villa's expected goals = 1.4469,

$$\boldsymbol{y = 1}$$

$$\boldsymbol{P(X = 2) \times P(Y = 1) = \frac{e^{-1.4648} \cdot 1.4648^{2}}{2!} \times \frac{e^{-1.4469} \cdot 1.4469^{2}}{1!} = 0.0844} \textbf{ (to 4 decimal places)}$$

The calculation shows that there is an 8.44% chance that the score will be 2-1.

The applicability of the Poisson model to the Premier League, and football leagues in general, can be tested by gathering historical results comparing the observed number of goals scored to the expected number of goals scored, both *home* and *away*. This is performed using data from twenty-two European leagues in the 2015/16 *season*. The expected number of goals scored is taken to be the average number of goals scored per match, worked out separately for both home and away. When putting the expected values into the Poisson formula **(I)** we gather the following statistics **(7)**:

Table 1

Home goals	Observed	Expected Poisson
0	1870	1806
1	2652	2645
2	1840	1936
3	933	945
4	349	346
5	107	101
6	45	25
7+	14	6

Figure 1

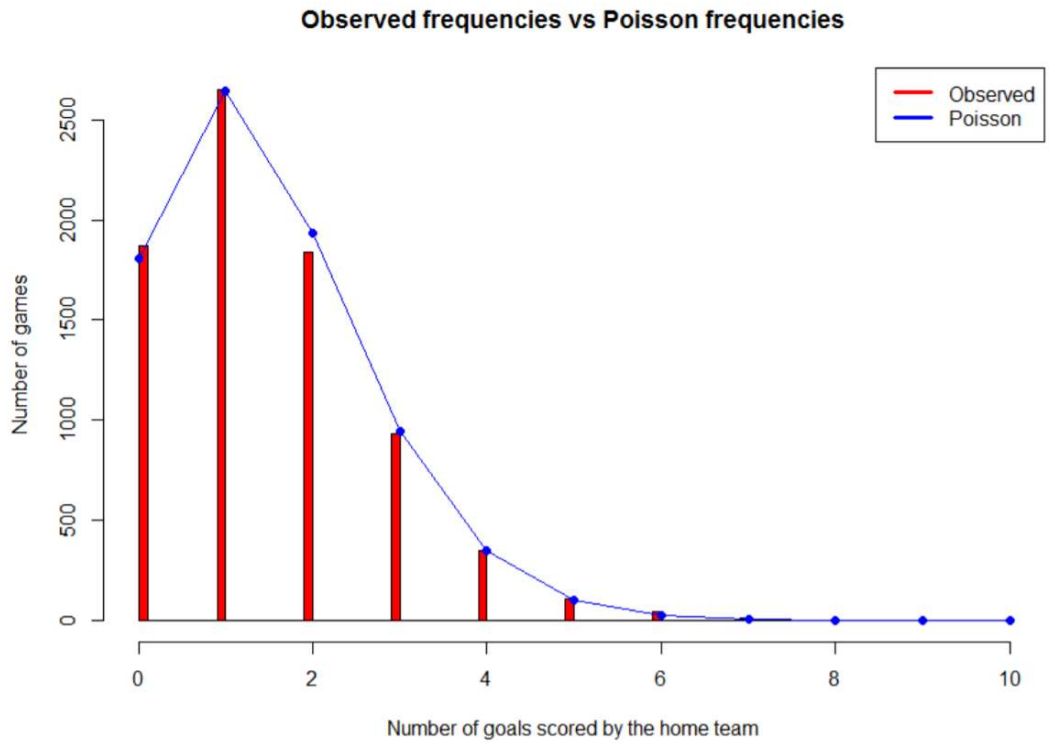
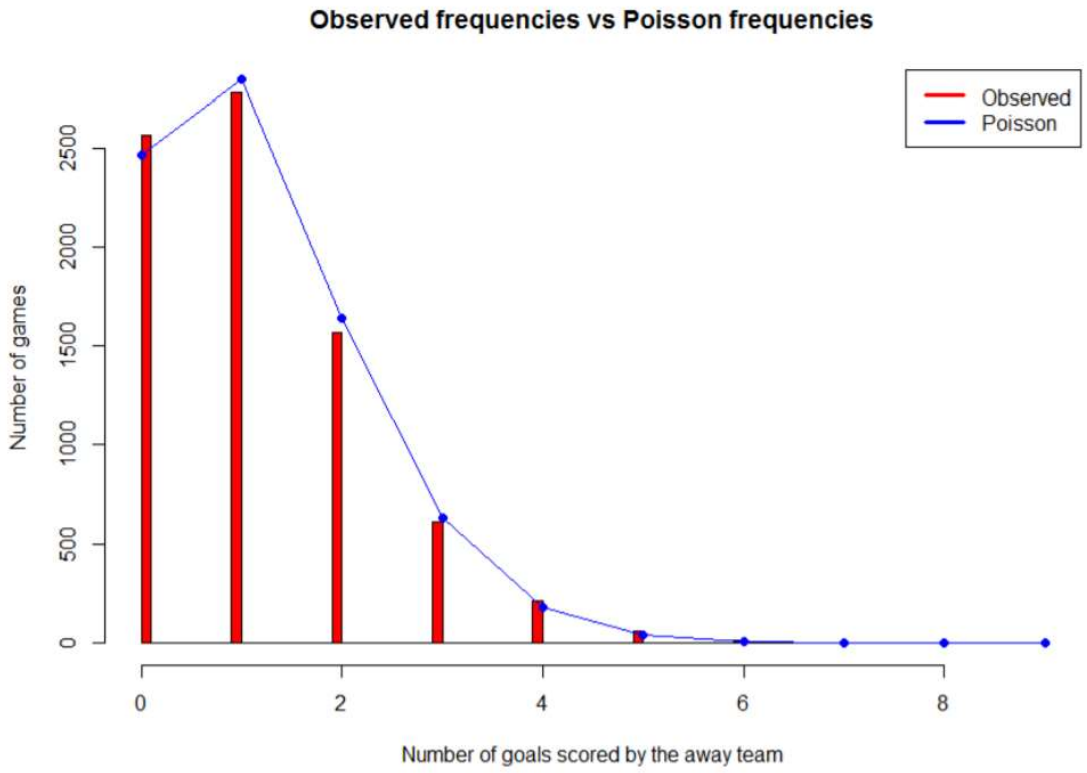


Table 2

Away goals	Observed	Expected Poisson
0	2563	2464
1	2778	2843
2	1569	1639
3	609	630
4	214	182
5	59	42
6+	18	10

Figure 2



Figures 1 and 2 show that the Poisson distribution fits the observed data to a good level of accuracy as the observed frequency of the number of goals being scored in matches was not far from the Poisson predictions. This is remarkable especially when you take into account the vast number of factors that effect football matches. After seeing this relationship between the observed and Poisson frequencies, it is reasonable to use the Poisson model to predict outcomes of the Premier League fixtures being explored in this paper.

4 Initial Data

The end goal is to be able to find the expected value of goals scored by each team in the Premier League over 90 minutes which will then be used in the calculation of probabilities of all possible score lines for a set of fixtures. The first step towards this is to compile two tables of data for the 2019/20 Premier League season, the first showing home statistics and the second showing away statistics. Splitting the data into two tables will allow for the accounting of both home and away bias as some team's performances may vary depending on where they play. An example of this is Southampton performing noticeably better when they are the away side in comparison to when they are at home, with 38.47% more goals scored on average when playing away compared to at home. On the other hand, the effect of home advantage can also be very large for some teams. This is shown by Manchester United having double the amount of goals at home on average compared to playing away. After looking into the cases of Southampton and Manchester United, it is advisable to take both home and away performances into consideration. This is further highlighted in Richard Pollard's 2008 paper, *'Home advantage in football'* where the effect of playing at home and away has been investigated **(8)**.

The statistics in the two tables below include the amount of games played, the total goals scored, the average number of goals scored per match, the total number of goals conceded, and the average number of goals conceded per match for each team in the English Premier League. The data is accurate up until the time just prior to the commencement of the 25th match week **(9)**. Table 3 shows the data for home matches while Table 4 shows the data for away matches.

Table 3

	HOME				
TEAMS	**Games Played**	**Goals Scored**	**Average Goals Scored**	**Goals Conceded**	**Average Goals Conceded**
Arsenal	12	18	1.5000	18	1.5000
Aston Villa	12	16	1.3333	21	1.7500
Bournemouth	12	13	1.0833	18	1.5000
Brighton & Hove Albion	12	16	1.3333	13	1.0833
Burnley	12	16	1.3333	18	1.5000
Chelsea	12	16	1.3333	12	1.0000
Crystal Palace	12	10	0.8333	12	1.0000
Everton	12	15	1.2500	13	1.0833
Leicester City	12	24	2.0000	12	1.0000
Liverpool	12	31	2.5833	9	0.7500
Manchester City	12	31	2.5833	12	1.0000
Manchester United	12	24	2.0000	12	1.0000
Newcastle United	12	12	1.0000	12	1.0000
Norwich City	12	18	1.5000	25	2.0833
Sheffield United	12	13	1.0833	11	0.9167
Southampton	12	13	1.0833	28	2.3333
Tottenham Hotspur	12	23	1.9167	12	1.0000
Watford	12	11	0.9167	14	1.1667
West Ham United	12	17	1.4167	22	1.8333
Wolverhampton Wanderers	12	18	1.5000	17	1.4167
Total	**240**	**355**	**29.5833**	**311**	**25.9167**
Average	**12**	**17.75**	**1.4792**	**15.55**	**1.2958**

Table 4

	AWAY				
TEAMS	Games Played	Goals Scored	Average Goals Scored	Goals Conceded	Average Goals Conceded
Arsenal	12	14	1.1667	16	1.3333
Aston Villa	12	15	1.2500	24	2.0000
Bournemouth	12	10	0.8333	19	1.5833
Brighton & Hove Albion	12	11	0.9167	21	1.7500
Burnley	12	12	1.0000	20	1.6667
Chelsea	12	25	2.0833	20	1.6667
Crystal Palace	12	12	1.0000	16	1.3333
Everton	12	13	1.0833	22	1.8333
Leicester City	12	28	2.3333	12	1.0000
Liverpool	12	25	2.0833	6	0.5000
Manchester City	12	34	2.8333	15	1.2500
Manchester United	12	12	1.0000	17	1.4167
Newcastle United	12	12	1.0000	24	2.0000
Norwich City	12	6	0.5000	22	1.8333
Sheffield United	12	12	1.0000	12	1.0000
Southampton	12	18	1.5000	14	1.1667
Tottenham Hotspur	12	15	1.2500	20	1.6667
Watford	12	10	0.8333	22	1.8333
West Ham United	12	10	0.8333	18	1.5000
Wolverhampton Wanderers	12	17	1.4167	15	1.2500
Total	240	311	25.9167	355	29.5833
Average	12	15.55	1.2958	17.75	1.4792

The Premier League's average for goals scored per match and goals conceded per match are calculated using the following formulas:

$$\textbf{League Mean Goals Per Game} = \frac{\sum \textbf{Goals Scored}}{\sum \textbf{Games Played}} \qquad \textbf{(III)}$$

$$\textbf{League Mean Goals Conceded Per Game} = \frac{\sum \textbf{Goals Conceded}}{\sum \textbf{Games Played}} \qquad \textbf{(IV)}$$

Table 3 and 4 show the Premier League's mean goals scored per game is 1.4792 at home and 1.2958 away while the League's mean goals conceded per game is 1.2958 at home and 1.4792 away. These values will be useful in later calculations for the expected goals scored by a team.

The next step is to calculate each team's offensive and defensive strength using the following formulas:

$$\textbf{Offensive Strength} = \frac{\textbf{Team's average goals scored per game}}{\textbf{Overall league average goals scored per game}} \qquad \textbf{(V)}$$

$$\textbf{Defensive Strength} = \frac{\textbf{Team's average goals conceded per game}}{\textbf{Overall league average goals conceded per game}} \qquad \textbf{(VI)}$$

The offensive strength is an indication of a team's attacking strength compared to the average of the league. An example is Liverpool having an offensive strength of 1.7465 at home. This denotes that Liverpool scores 74.65% more goals than the average of the league at home. This logic can be applied to the defensive strength of a team, however, the smaller the value, the better the team is defensively. Liverpool have a home defensive strength of 0.5788. This tells us that Liverpool have a defence that is 42.12% better than the league's home average. These calculations are applied to all teams in the league, both home and away. The offensive and defensive strengths are outlined in the following tables:

Table 5

	HOME	
TEAMS	**Offensive Strength (Higher is better)**	**Defensive Strength (Lower is better)**
Arsenal	1.0141	1.1576
Aston Villa	0.9014	1.3505
Bournemouth	0.7324	1.1576
Brighton & Hove Albion	0.9014	0.8360
Burnley	0.9014	1.1576
Chelsea	0.9014	0.7717
Crystal Palace	0.5634	0.7717
Everton	0.8451	0.8360
Leicester City	1.3521	0.7717
Liverpool	1.7465	0.5788
Manchester City	1.7465	0.7717
Manchester United	1.3521	0.7717
Newcastle United	0.6761	0.7717
Norwich City	1.0141	1.6077
Sheffield United	0.7324	0.7074
Southampton	0.7324	1.8006
Tottenham Hotspur	1.2958	0.7717
Watford	0.6197	0.9003
West Ham United	0.9577	1.4148
Wolverhampton Wanderers	1.0141	1.0932

Table 6

	AWAY	
TEAMS	**Offensive Strength (Higher is better)**	**Defensive Strength (Lower is better)**
Arsenal	0.9003	0.9014
Aston Villa	0.9646	1.3521
Bournemouth	0.6431	1.0704
Brighton & Hove Albion	0.7074	1.1831
Burnley	0.7717	1.1268
Chelsea	1.6077	1.1268
Crystal Palace	0.7717	0.9014
Everton	0.8360	1.2394
Leicester City	1.8006	0.6761
Liverpool	1.6077	0.3380
Manchester City	2.1865	0.8451
Manchester United	0.7717	0.9577
Newcastle United	0.7717	1.3521
Norwich City	0.3859	1.2394
Sheffield United	0.7717	0.6761
Southampton	1.1576	0.7887
Tottenham Hotspur	0.9646	1.1268
Watford	0.6431	1.2394
West Ham United	0.6431	1.0141
Wolverhampton Wanderers	1.0932	0.8451

Using these tables, the expected value of goals scored by the home and away team can be calculated for the following fixtures taking place on the weekend of the 1st and 2nd February 2020 **(10)**:

Leicester City vs Chelsea

Bournemouth vs Aston Villa

Crystal Palace vs Sheffield United

Liverpool vs Southampton

Newcastle United vs Norwich City

Watford vs Everton

West Ham United vs Brighton

Manchester United vs Wolves

Burnley vs Arsenal

Tottenham Hotspur vs Manchester City

The expected value of goals scored by a team must reflect the attacking strength of that team's attack while also considering the defensive prowess of the opposition. For this reason, the following equations are used to calculate goal expectations:

$$\textbf{Home team expected goals} = \textbf{Home offensive strength} \times \textbf{Away defensive strength} \times \textbf{Average home goals} \quad \textbf{(VII)}$$

$$\textbf{Away team expected goals} = \textbf{Away offensive strength} \times \textbf{Home defensive strength} \times \textbf{Average away goals} \quad \textbf{(VIII)}$$

In the Leicester City vs Chelsea game, to work out the expected goals scored by the home team, Leicester City, their home offensive strength of 1.3521 is used, as well as Chelsea's defensive strength of 1.1268 and the league's average number of home goals per game which is 1.4792. By multiplying these variables together, Leicester's home expected goals is calculated to be 2.2535. When working out the expected goals scored by Chelsea, the away team, we obtain $1.6077 \times 0.7717 \times 1.2958 = 1.6077$ goals.

The full set of expected goals are shown in Table 7.

Table 7

Fixtures	Home Goal Expectancy	Away Goal Expectancy
Leicester City vs Chelsea	2.2535	1.6077
Bournemouth vs Aston Villa	1.4648	1.4469
Crystal Palace vs Sheffield United	0.5634	0.7717
Liverpool vs Southampton	2.0376	0.8682
Newcastle United vs Norwich City	1.2394	0.3859
Watford vs Everton	1.1362	0.9753
West Ham United vs Brighton & Hove Albion	1.6761	1.2969
Man United vs Wolverhampton Wanderers	1.6901	1.0932
Burnley vs Arsenal	1.2019	1.3505
Tottenham Hotpur vs Manchester City	1.6197	2.1865

The next step is where the Poisson distribution is utilized. The probabilities of all possible results can be calculated by multiplying the Poisson probability mass function for the home and away team together to form a bivariate Poisson model. The expected values, $\boldsymbol{\mu}$ and $\boldsymbol{\lambda}$, are to be used in the bivariate Poisson formula to work out a range of probabilities for different events occurring.

Example

To work out the probability of Leicester City vs Chelsea ending 2-2, use the bivariate Poisson formula (2).

Let:

$\boldsymbol{\mu}$ = Leicester City's expected goals = 2.2535,

$\boldsymbol{x} = \mathbf{2}$

$\boldsymbol{\lambda}$ = Chelsea's expected goals = 1.6077

$y = 2$

$$P(X = 2) \times P(Y = 2) = \frac{e^{-2.2535} \cdot 2.2535^2}{2!} \times \frac{e^{-1.6077} \cdot 1.6077^2}{2!} = 0.0691$$

Using bivariate Poisson, it is calculated that there is a 6.91% chance that the score will be 2-2. This formula can be applied to find the probability of any score line, however, in the Premier League the record for most goals scored in a game by one team is 9, so the probability of any score line involving more than 9 goals by one team was discarded. Furthermore, the probability of a team scoring more than 9 goals in a football match is so small that it is negligible. The full set of probabilities of all possible scores between 0 to 9 goals are shown below as percentages.

Table 8

		Chelsea (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Leicester City (Home)	0	2.104193	3.3829469	2.719410719	1.457347652	0.585750664	0.188344265	0.050467381	0.011591038	0.002329389	0.000416111
	1	4.741843	7.6235424	6.128249507	3.284163723	1.320001496	0.42443778	0.113729309	0.02612065	0.005249327	0.000937715
	2	5.342922	8.5899069	6.905069867	3.700466167	1.48732563	0.478239752	0.1281457	0.029431718	0.005914734	0.00105658
	3	4.013463	6.4525122	5.186906943	2.779692895	1.11723991	0.359241129	0.096259681	0.022108333	0.004442993	0.000793675
	4	2.261106	3.6352182	2.922201094	1.566024166	0.629430935	0.202389368	0.054230806	0.012455399	0.002503095	0.000447141
	5	1.01909	1.6384082	1.317048381	0.705813709	0.283687182	0.091217743	0.024442053	0.005613701	0.001128155	0.000201528
	6	0.382757	0.6153646	0.494666058	0.265094351	0.106549176	0.034260185	0.009180114	0.002108432	0.00042372	7.56914E-05
	7	0.123221	0.1981053	0.15924863	0.085342246	0.034301546	0.011029436	0.002955369	0.000678771	0.000136409	2.43674E-05
	8	0.03471	0.0558043	0.044858769	0.024040069	0.009662407	0.003106883	0.000832498	0.000191203	3.84251E-05	6.86407E-06
	9	0.008691	0.0139729	0.011232243	0.006019423	0.002419382	0.000777936	0.00020845	4.78756E-05	9.6213E-06	1.7187E-06

Table 9

		Aston Villa (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Bournemouth (Home)	0	5.438135	7.8686836	5.69277756	2.745712649	0.993224029	0.287428176	0.069315476	0.014327958	0.002591471	0.000416635
	1	7.965718	11.525959	8.338716425	4.021888951	1.454863367	0.421021553	0.101532529	0.020987431	0.003795958	0.000610283
	2	5.834047	8.4415475	6.107228931	2.945608809	1.065533733	0.308353813	0.074361852	0.015371076	0.002780138	0.000446968
	3	2.848549	4.1216946	2.981933375	1.438231531	0.520260602	0.150557731	0.036308134	0.007505127	0.001357438	0.000218238
	4	1.043131	1.5093529	1.091975602	0.526676335	0.190517967	0.055133817	0.013295937	0.002748356	0.00049709	7.9918E-05
	5	0.305593	0.4421766	0.319902712	0.154293912	0.055813714	0.016151879	0.003895148	0.000805152	0.000145626	2.34126E-05
	6	0.074605	0.1079492	0.078098315	0.037667997	0.013625883	0.003943182	0.000950928	0.000196563	3.5552E-05	5.71575E-06
	7	0.015611	0.022589	0.016342504	0.007882237	0.002851291	0.000825133	0.000198987	4.11319E-05	7.43945E-06	1.19605E-06
	8	0.002858	0.004136	0.00299229	0.001443226	0.000522067	0.000151081	3.64342E-05	7.53119E-06	1.36215E-06	2.18996E-07
	9	0.000465	0.0006732	0.000487008	0.000234891	8.49687E-05	2.4589E-05	5.92983E-06	1.22573E-06	2.21696E-07	3.56425E-08

Table 10

		Sheffield United (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Crystal Palace (Home)	0	26.31359	20.306311	7.835232626	2.015493923	0.388841271	0.060014087	0.007718854	0.000850953	8.20855E-05	7.03841E-06
	1	14.82456	11.440175	4.414215564	1.135489534	0.219065505	0.033810753	0.00434865	0.00047941	4.62454E-05	3.9653E-06
	2	4.175933	3.2225846	1.243441004	0.319856207	0.061708593	0.009524156	0.001224972	0.000135045	1.30269E-05	1.11699E-06
	3	0.784213	0.6051802	0.233510048	0.060066893	0.011588468	0.001788574	0.000230042	2.53606E-05	2.44636E-06	2.09763E-07
	4	0.110452	0.0852366	0.032888739	0.008460126	0.001632179	0.000251912	3.24002E-05	3.57191E-06	3.44558E-07	2.95441E-08
	5	0.012445	0.0096041	0.003705773	0.000953254	0.000183907	2.83844E-05	3.65073E-06	4.02469E-07	3.88234E-08	3.32891E-09
	6	0.001169	0.0009018	0.00034796	8.95074E-05	1.72683E-05	2.6652E-06	3.42792E-07	3.77905E-08	3.64539E-09	3.12574E-10
	7	9.41E-05	7.258E-05	2.80048E-05	7.20381E-06	1.3898E-06	2.14503E-07	2.75889E-08	3.04149E-09	2.93391E-10	2.51568E-11
	8	6.62E-06	5.111E-06	1.97217E-06	5.07311E-07	9.78735E-08	1.51059E-08	1.94288E-09	2.1419E-10	2.06614E-11	1.77161E-12
	9	4.15E-07	3.2E-07	1.23454E-07	3.17565E-08	6.12666E-09	9.45595E-10	1.2162E-10	1.34078E-11	1.29336E-12	1.10899E-13

Table 11

		Southampton (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Liverpool (Home)	0	5.470906	4.7496615	2.061750153	0.596647954	0.129497546	0.022485105	0.003253472	0.000403508	4.37891E-05	4.22403E-06
	1	11.14729	9.677714	4.200936932	1.215705221	0.26385885	0.04581472	0.00662914	0.000822172	8.92228E-05	8.6067E-06
	2	11.35663	9.8594551	4.279827766	1.238535366	0.268813946	0.04667509	0.00675363	0.000837611	9.08984E-05	8.76833E-06
	3	7.713268	6.6964061	2.906800079	0.841196164	0.18257473	0.031701079	0.004586973	0.000568894	6.17369E-05	5.95533E-06
	4	3.929059	3.4110801	1.480693937	0.428496638	0.093001682	0.016148202	0.002336557	0.000289789	3.14481E-05	3.03358E-06
	5	1.601138	1.3900552	0.603400158	0.174617409	0.037899277	0.006580582	0.000952174	0.000118092	1.28155E-05	1.23622E-06
	6	0.543735	0.4720532	0.204910539	0.05929887	0.012870333	0.00223472	0.000323352	4.01033E-05	4.35205E-06	4.19812E-07
	7	0.15827	0.1374051	0.059645321	0.017260704	0.003746294	0.000650482	9.41212E-05	1.16733E-05	1.26679E-06	1.22199E-07
	8	0.040311	0.0349964	0.015191355	0.004396212	0.000954162	0.000165674	2.39722E-05	2.97312E-06	3.22646E-07	3.11234E-08
	9	0.009126	0.007923	0.003439253	0.000995282	0.000216018	3.75079E-05	5.42719E-06	6.73101E-07	7.30456E-08	7.0462E-09

Table 12

		Norwich (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Newcastle United (Home)	0	19.68548	7.5956849	1.465405443	0.188476584	0.018181021	0.001403037	9.02275E-05	4.97349E-06	2.39879E-07	1.02842E-08
	1	24.39891	9.41437	1.816277168	0.233604781	0.022534223	0.001738975	0.000111831	6.16433E-06	2.97315E-07	1.27466E-08
	2	15.12045	5.8342575	1.125580217	0.14476916	0.013964871	0.001077675	6.93039E-05	3.82015E-06	1.84252E-07	7.89931E-09
	3	6.246947	2.4103974	0.465028446	0.059810733	0.005769524	0.000445237	2.86326E-05	1.57828E-06	7.61227E-08	3.26357E-09
	4	1.935674	0.7468837	0.144093321	0.018532903	0.00178774	0.000137961	8.87207E-06	4.89044E-07	2.35873E-08	1.01125E-09
	5	0.479829	0.185143	0.035718908	0.004594072	0.000443158	3.41987E-05	2.19927E-06	1.21228E-07	5.847E-09	2.50675E-10
	6	0.09912	0.0382455	0.007378554	0.00094901	9.15444E-05	7.06452E-06	4.5431E-07	2.50423E-08	1.20783E-09	5.17826E-11
	7	0.01755	0.0067718	0.001306464	0.000168034	1.62091E-05	1.25086E-06	8.04412E-08	4.43406E-09	2.13861E-10	9.16876E-12
	8	0.002719	0.0010492	0.00020241	2.60334E-05	2.51126E-06	1.93795E-07	1.24627E-08	6.86967E-10	3.31334E-11	1.42051E-12
	9	0.000374	0.0001445	2.78749E-05	3.5852E-06	3.45839E-07	2.66886E-08	1.71631E-09	9.46057E-11	4.56298E-12	1.95626E-13

Table 13

		Everton (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Watford (Home)	0	12.10564	11.807218	5.758075068	1.872042984	0.456473504	0.089044135	0.014474841	0.002016859	0.000245893	2.66479E-05
	1	13.75383	13.414773	6.54203834	2.126922076	0.518622478	0.101167515	0.016445595	0.002291455	0.000279371	3.0276E-05
	2	7.813207	7.6205988	3.716369198	1.208251508	0.294616525	0.057470748	0.009342333	0.001301718	0.000158704	1.7199E-05
	3	2.958992	2.8860484	1.407451246	0.457585078	0.111576211	0.021765134	0.003538098	0.000492983	6.01037E-05	6.51356E-06
	4	0.840465	0.8197461	0.399769016	0.129971348	0.031691835	0.006182116	0.001004953	0.000140026	1.70717E-05	1.8501E-06
	5	0.190979	0.186271	0.090839532	0.029533396	0.007201337	0.001404762	0.000228355	3.1818E-05	3.87921E-06	4.20397E-07
	6	0.036163	0.035272	0.017201226	0.005592396	0.001363633	0.000266004	4.3241E-05	6.02501E-06	7.3456E-07	7.96058E-08
	7	0.00587	0.0057249	0.002791882	0.000907686	0.000221327	4.31743E-05	7.01833E-06	9.77902E-07	1.19224E-07	1.29206E-08
	8	0.000834	0.000813	0.0003965	0.000128908	3.14327E-05	6.13156E-06	9.96734E-07	1.3888E-07	1.69321E-08	1.83497E-09
	9	0.000105	0.0001026	5.00537E-05	1.62733E-05	3.96803E-06	7.74041E-07	1.25827E-07	1.75321E-08	2.13749E-09	2.31644E-10

Table 14

		Brighton & Hove Albion (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
West Ham United (Home)	0	5.115229	6.6338978	4.30172367	1.859623309	0.60293253	0.156387645	0.033802974	0.006262685	0.001015253	0.000146297
	1	8.573411	11.118786	7.209931221	3.116833433	1.010548889	0.262114503	0.056655689	0.010496614	0.001701621	0.000245202
	2	7.18476	9.3178563	6.04212546	2.611994215	0.846868435	0.219659337	0.047479064	0.008796458	0.001426007	0.000205486
	3	4.014021	5.2057507	3.375647558	1.459283153	0.473133069	0.122720475	0.026525862	0.004914453	0.000796689	0.000114802
	4	1.681931	2.1812829	1.414443871	0.611460194	0.19824942	0.051421607	0.01111471	0.002059225	0.000333824	4.81037E-05
	5	0.563802	0.7311906	0.474137523	0.204968347	0.066455439	0.017237102	0.003725776	0.000690275	0.000111902	1.61249E-05
	6	0.157494	0.2042528	0.132446867	0.057256416	0.018563843	0.004815059	0.001040768	0.000192823	3.12589E-05	4.50438E-06
	7	0.03771	0.0489056	0.03171263	0.013709283	0.004444864	0.001152901	0.000249198	4.6169E-05	7.48452E-06	1.07851E-06
	8	0.0079	0.0102461	0.006644019	0.002872191	0.00093123	0.000241541	5.22087E-05	9.67273E-06	1.56806E-06	2.25956E-07
	9	0.001471	0.0019081	0.001237306	0.000534884	0.000173422	4.49818E-05	9.72276E-06	1.80134E-06	2.92017E-07	4.20794E-08

Table 15

		Wolverhampton Wanderers (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Manchester United (Home)	0	6.182865	6.7594022	3.694850091	1.346461984	0.368004079	0.080463914	0.014661163	0.002289755	0.000312909	3.80096E-05
	1	10.44991	11.424342	6.244817055	2.275710395	0.621978725	0.135995348	0.024779431	0.003870008	0.00052886	6.42416E-05
	2	8.830912	9.6543733	5.277310187	1.923135545	0.525615824	0.114925646	0.020940364	0.003270429	0.000446924	5.42887E-05
	3	4.975162	5.4390836	2.9731325	1.083456645	0.296121591	0.064746843	0.011797388	0.001842495	0.000251788	3.05852E-05
	4	2.102181	2.2982043	1.256253169	0.457798582	0.125121799	0.027357821	0.004984812	0.000778519	0.000106389	1.29233E-05
	5	0.710596	0.7768578	0.424648959	0.154748817	0.042294693	0.009247714	0.001685007	0.000263161	3.59626E-05	4.36844E-06
	6	0.200168	0.2188332	0.119619425	0.043591216	0.011913998	0.00260499	0.00047465	7.413E-05	1.01303E-05	1.23055E-06
	7	0.04833	0.052837	0.028881954	0.010525042	0.002876619	0.000628971	0.000114604	1.78986E-05	2.44595E-06	2.97114E-07
	8	0.010211	0.0111627	0.006101821	0.0022236	0.000607736	0.000132881	2.4212E-05	3.78139E-06	5.1675E-07	6.27706E-08
	9	0.001917	0.0020963	0.001145882	0.000417578	0.000114129	2.49542E-05	4.54686E-06	7.1012E-07	9.70422E-08	1.17879E-08

Table 16

		Arsenal (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Burnley (Home)	0	7.789759	10.519932	7.103491006	3.197712993	1.079613712	0.291599845	0.065633406	0.012662393	0.002137542	0.000320746
	1	9.36234	12.643674	8.537529097	3.843260687	1.297563897	0.350467419	0.078883342	0.015218651	0.002569065	0.000385497
	2	5.626195	7.5980764	5.130533917	2.309565107	0.779756708	0.210609529	0.047404074	0.009145481	0.001543851	0.00023166
	3	2.254	3.0439868	2.055425169	0.92527178	0.312390794	0.084375649	0.018991304	0.003663917	0.000618507	9.28092E-05
	4	0.677258	0.9146251	0.617592539	0.278015934	0.093863901	0.025352308	0.005706307	0.001100895	0.000185842	2.78863E-05
	5	0.162796	0.2198536	0.148454169	0.066828243	0.02256259	0.006094076	0.001371657	0.000264628	4.4672E-05	6.70319E-06
	6	0.03261	0.0440395	0.029737298	0.013386565	0.00451958	0.001220723	0.000274761	5.30085E-05	8.94838E-06	1.34274E-06
	7	0.005599	0.0075614	0.0051058	0.002298431	0.000775998	0.000209594	4.71755E-05	9.10139E-06	1.53641E-06	2.30544E-07
	8	0.000841	0.001136	0.000767069	0.000345304	0.000116582	3.14883E-05	7.08741E-06	1.36735E-06	2.30822E-07	3.46357E-08
	9	0.000112	0.0001517	0.000102436	4.61126E-05	1.55686E-05	4.20501E-06	9.46466E-07	1.82598E-07	3.08244E-08	4.62532E-09

Table 17

		Manchester City (Away)									
	GOALS	0	1	2	3	4	5	6	7	8	9
Tottenham Hotspur (Home	0	2.22322	4.8610603	5.314342463	3.873261388	2.117216836	0.92585688	0.337396934	0.10538811	0.028803824	0.006997714
	1	3.600991	7.8735484	8.607737792	6.273592389	3.429294875	1.499627341	0.546487991	0.170699051	0.046654081	0.011334325
	2	2.916295	6.3764652	6.971055254	5.08072623	2.777245849	1.214486931	0.442578303	0.138242189	0.037783235	0.009179207
	3	1.574526	3.4426925	3.763715278	2.743115101	1.499451984	0.655708906	0.238950727	0.074637802	0.020399399	0.00495591
	4	0.637572	1.394048	1.524039637	1.110768439	0.607172458	0.26551593	0.096758217	0.030223053	0.00826032	0.002006794
	5	0.206537	0.451593	0.493702981	0.359826396	0.19668967	0.086012203	0.031344211	0.009790567	0.002675878	0.000650088
	6	0.055755	0.1219089	0.133276626	0.097136234	0.053096977	0.023219257	0.008461465	0.002642993	0.000722362	0.000175493
	7	0.012901	0.0282083	0.030838656	0.022476191	0.012286021	0.005372665	0.001957884	0.000611558	0.000167146	4.06071E-05
	8	0.002612	0.0057112	0.006243742	0.004550637	0.002487487	0.001087775	0.000396403	0.000123819	3.38412E-05	8.22151E-06
	9	0.00047	0.0010278	0.001123678	0.000818972	0.00044767	0.000195766	7.13401E-05	2.22835E-05	6.09035E-06	1.47961E-06

5 Data Analysis

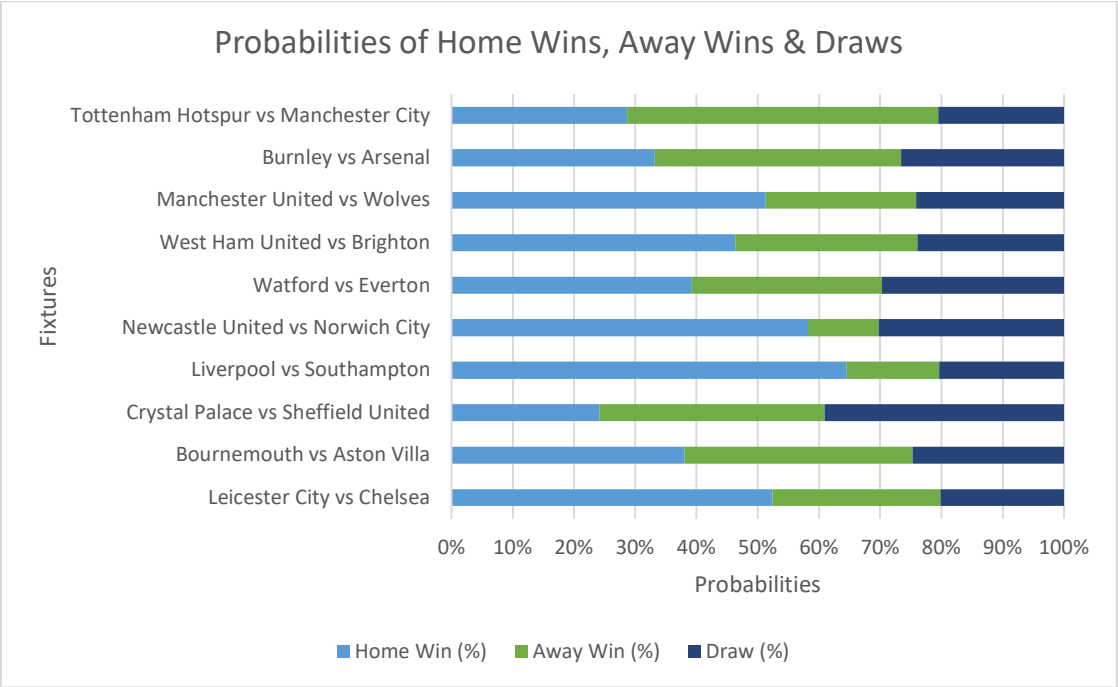
From the tables above, a wide range of statistics can be analysed. For example, to calculate the probability of the home team winning, one can just add up all the probabilities of winning results by the home team. The same method can be applied to calculate the chance of the away team winning or to calculate the likelihood of a draw. Calculating the probability of a specific total number of goals to be scored in a match can also be easily worked out by adding the probabilities of score lines that sum up to the specific goal totals that are being looked for. For example, to work out the probability of 2 goals being scored in a match, one would add up the probabilities of 2-0, 0-2 and 1-1. Another key probability to look for in these tables is the chance of a clean sheet which is worked out by adding the probabilities of scores in which there are no goals scored by either team. These are just a few of the many statistics that can be gathered from these tables.

The chances of a home win, away win, and draw are shown in the table and figure below:

Table 18

Fixtures	Home Win (%)	Away Win (%)	Draw (%)
Leicester City vs Chelsea	52.4056	27.4383	20.1430
Bournemouth vs Aston Villa	38.0387	37.2434	24.7172
Crystal Palace vs Sheffield United	24.1127	36.8284	39.0589
Liverpool vs Southampton	64.5263	15.0988	20.3696
Newcastle United vs Norwich City	58.2031	11.5098	30.2871
Watford vs Everton	39.2488	31.0236	29.7275
West Ham United vs Brighton	46.3481	29.6987	23.9520
Manchester United vs Wolves	51.3233	24.5727	24.1028
Burnley vs Arsenal	33.1988	40.2115	26.5895
Tottenham Hotspur vs Manchester City	28.6753	50.8011	20.5132

Figure 3



Out of the ten fixtures, the home team is the favourite on seven occasions, however for some matches the difference is very small, for example, in the Bournemouth vs Aston Villa match there is less than a 1% chance splitting a win for either team. The only match where a draw is the most likely outcome is in the match between Crystal Palace and Sheffield United.

In the next part of the paper the actual results of these fixtures will be compared to the gathered probabilities.

Match Day 25 Results (11)

Leicester City 2 - 2 Chelsea

Bournemouth 2 - 1 Aston Villa *

Crystal Palace 0 – 1 Sheffield United **

Liverpool 4 - 0 Southampton *

Newcastle United 0 - 0 Norwich City **

Watford 2 - 3 Everton **

West Ham United 3 - 3 Brighton

Manchester United 0 - 0 Wolves

Burnley 0 - 0 Arsenal

Tottenham Hotspur 2 - 0 Manchester City **

* means that the probability model correctly predicted the winner.

** means that the second most likely outcome occurred.

Only two results of matches were correctly predicted, although another four outcomes occurred which were said to be the second most likely result. From this, it may be look like the model being used does not fit the Premier League but if one looks at the data a lot closer, it will be noticeable that the probabilities of all possible results, shown in Tables 8 to 17, similarly match the final outcomes of the fixtures. This will be explained when each match is analysed individually.

From the probabilities of all possible results, a simple betting technique can be applied where one looks at the top five most likely results. Then by looking at outcomes that occur in at least four of the five results, bets should be placed accordingly.

Outcomes that can be bet on are as follows:

- The winning team
- Over/Under a specified number of goals in a match
- Clean sheets

If, for example, four of the top five highest probability outcomes all had 2 or more goals involved in the match, it would be advisable to place a bet on there being more than 1.5 goals scored. If there are two or more outcomes that appear in at least four out of the top five most likely probabilities, the outcome that yields the most money should be bet on to maximise profits.

The betting odds will be fractional odds taken from an average of twenty-one UK bookmakers (12) therefore winnings from bets will be average winnings from these twenty-one bookmakers. Fractional odds are commonly written with a slash, for example, 7/1. A fractional listing of 7/1 odds mean that you win £7 for every £1 you wager in addition to receiving back the amount you wagered. If you stake £100 at 7/1, you get a total return of £800 (£700 profit + £100 stake).

The winnings made will be based on bets of £100.

Each match will be analysed individually below, and the five highest probability events will be tabled below with the actual result being highlighted where applicable.

Leicester City vs Chelsea

Table 19

Leicester City vs Chelsea	
Top 5 Probabilties (%)	Top 5 Results
8.59	2:1
7.62	1:1
6.91	2:2
6.45	3:1
6.13	1:2

The result of this match was 2-2. According to Table 18 a draw was the least likely outcome at 20.14% however when looking at Table 19 this exact result had a 6.91% chance which turned out to be the third most likely result out of all possible score-lines. The probability of both teams scoring was calculated to be 71.56%. Both teams scoring occurred in all top five most likely results so it would be advisable to bet on this outcome. The betting odds for this were given to be 3/5 so a £100 bet would yield a profit of £60. When looking at the top five most likely results in Table 19, one can see that they all involve at least 2 goals so a bet could be placed on there being over 1.5 goals scored in the match. The odds were 1/4 for this event which would have generated £24 in profit. Due to the bet on 'both teams scoring' giving a larger profit, this is the advised bet rather than on 'over 1.5 goals being scored'. Aside from the advised bet, the probability of 4 goals being scored in this match was 19.49% which is relatively likely when you see that the third and fourth most likely results involved four goals. A risky bet on over

3.5 goals being scored in the match would have given a profit of £191 at the given average odds of 191/100. The fact that the probabilities calculated were able to be used successfully for betting provides reasonable evidence to believe that the Premier League can be modelled by the Poisson distribution.

Bournemouth vs Aston Villa

Table 20

Bournemouth vs Aston Villa	
Top 5 Probabilties (%)	Top 5 Results
11.53	1:1
8.44	2:1
8.34	1:2
7.97	1:0
7.87	0:1

The home side was the favourite to win over Aston Villa despite the probabilities being very close. This showed in the match with Bournemouth winning 2-1. Betting on a Bournemouth win would have produced £117 profit at odds of 5/2. As stated in Table 20, the 2-1 result had an 8.44% chance of happening which was the second most probable result. The probability of both teams scoring was 58.80% which again highlights how accurate this model is as this event took place. The top five likely results, as seen in Table 20, all show that there will be 3 or less goals. They also show that there will be at least 1 goal. However, the most advisable bet would be to place it on there being less than 3.5 goals as it would yield a larger profit than betting on over 0.5 goals. At 3/1 odds, a £100 bet would have generated £30 as profit.

Crystal Palace vs Sheffield United

Table 21

Crystal Palace vs Sheffield United	
Top 5 Probabilties (%)	Top 5 Results
26.31	0:0
20.31	0:1
14.82	1:0
11.44	1:1
7.84	0:2

Table 18 shows that a draw was the most likely outcome, having a likelihood of 39.06%. Moreover, the most likely result was a goalless draw with a chance of 26.31%. The game finished 1-0 to the away team which happened to be the second most likely result with Table 21 telling us that there was a 20.31% chance of this taking place. Not only this but the probability of there being 1 goal or less in the match was 61.44%. This indicates that once again it is sensible to use the Poisson model to predict Premier League matches. By looking at the top five probabilities, one can predict that the number of goals scored in the match will be low. All bar one of the results in the top five involved 1 or more goals but less than 3 goals. Hence the advised bet should be on there being less than 2.5 goals being scored. With odds of 4/9, a profit of £45 would be yielded which is greater than if the bet was on more than 0.5 goals being scored. The top three likely outcomes involve 1 goal or less so a bet on there being less than 1.5 goals at odds of 10/3 would have given a huge gain of £143.

Liverpool vs Southampton

Table 22

Liverpool vs Southampton	
Top 5 Probabilties (%)	Top 5 Results
11.36	2:0
11.15	1:0
9.86	2:1
9.68	1:1
7.71	3:0

Liverpool were strong favourites for this matchup with Table 18 displaying a huge 64.53% chance of victory. This probability proved to be highly accurate. The home side coasted to a 4-0 victory; despite the win, the chance of this exact result only had a probability of 3.93% as shown in Table 11. Liverpool scoring 4 goals may have been difficult to predict, however, the team not conceding a goal was much easier to predict with it being given a 41.97% likelihood of occurring according to Table 11 which was a very strong chance. Betting on a Liverpool clean sheet would provide £115 in profit given odds of 15/13. Despite the clean sheet being very likely, the most riskless betting option would have been on a Liverpool win as four of the five most likely events involved a win for the home side. Odds were given to be 3/10 which would have yielded profit of £30.

Newcastle United vs Norwich City

Table 23

Newcastle United vs Norwich City	
Top 5 Probabilties	Top 5 Results
24.40	1:0
19.69	0:0
15.12	2:0
9.41	1:1
7.60	0:1

This match was a scoreless draw which was a highly likely result having a probability of 19.69% shown in Table 12. This result was the second most likely outcome. Newcastle were heavily predicted not to concede a goal with a chance of them keeping a clean sheet at 67.99% which would have been a very safe bet. The chance of either side keeping a clean sheet was extremely large at 77.26% which again justifies this model being used as this event happened. From this statistic it would not be advisable to bet on there being more than 0.5 goals despite four of the five most likely results involving at least 1 goal. When looking at what bets to place on, one can see that all five most likely results involved 2 or less goals. So, a bet on less than 2.5 goals is advised which would have provided a profit of £75 with odds of 3/4. Odds of 20/9 on there being less than 1.5 goals would have given a profit of £222.

Watford vs Everton

Table 24

Watford vs Everton	
Top 5 Probabilties (%)	Top 5 Results
13.75	1:0
13.41	1:1
12.11	0:0
11.81	0:1
7.81	2:0

The result of this game was 3-2 to Everton which was not predicted by the model. There was only a 1.21% chance of this occurring, however the probability of either side scoring 2 or 3 goals was 52.33%, which is another strong indication that the model can be used to predict events other than the final score. Betting techniques used previously would not have produced winnings in this match as the bet that would have been advised would have been on under 2.5 goals being scored as all top five likely results involved less than 2 goals.

West Ham United vs Brighton

Table 25

West Ham United vs Brighton & Hove Albion	
Top 5 Probabilties (%)	Top 5 Results
11.12	1:1
9.32	2:1
8.57	1:0
7.21	1:2
7.18	2:0

This game ended 3-3. A draw was given a probability of 23.95% but the precise score line of the game ending 3-3 was not anticipated. The model could not predict this; therefore, it may be a 'fluke' result as the probability of this occurring was only 4.91%. Hence, betting on this match would not have led to a profit.

Manchester United vs Wolverhampton Wanderers

Table 26

Manchester United vs Wolverhampton Wanderers	
Top 5 Probabilties (%)	Top 5 Results
11.42	1:1
10.45	1:0
9.65	2:1
8.83	2:0
6.76	0:1

Manchester United and Wolverhampton played out to a scoreless draw which had 6.18% chance of happening. Looking at Table 15, this was the seventh most probable result, however there was only a difference of 0.58% from the fifth most likely result which is evidence for this probability model providing an insight on how the match turned out. Even though the top five highest likelihood score lines did not contain the final result of the game, the betting techniques used previously can still be applied. The top five likely results pointed to there being at least 1 goal but there being less than 3 goals. The bet that would have yielded the most profit out of 'less than 2.5 goals' or 'more than 0.5 goals' would be the former. At odds of 2/3, £60 would have been won.

Burnley vs Arsenal

Table 27

Burnley vs Arsenal	
Top 5 Probabilties (%)	Top 5 Results
12.64	1:1
10.52	0:1
9.36	1:0
8.54	1:2
7.79	0:0

This fixture finished at 0-0 which was the fifth most likely result, having a 7.79% chance of occurring. There was a 55.97% chance of at least one of the two sides keeping a clean sheet, so this result does not come as a shock. Surprisingly, despite the Poisson model showing a high chance that there would be a low amount of goals, more specifically under 3 goals, bookmakers gave odds of 1/1 on there being under 2.5 goals. This successful bet would have doubled the £100.

Tottenham Hotspur vs Manchester City

Table 28

Tottenham Hotspur vs Manchester City	
Top 5 Probabilties (%)	Top 5 Results
8.61	1:2
7.87	1:1
6.97	2:2
6.38	2:1
6.27	1:3

The game ended 2-0 to the home side. This was a result that the model did not predict as well as the others. This is partly due to the fact that Tottenham Hotspur changed their head coach midway through the season **(13)**. This new head coach has changed the way Tottenham play to a more defensive approach which would mean that their defensive strength would have increased, thus Manchester City's expected goals in this fixture would be lower **(14)**. These changes would have most likely increased the probability of the result being 2-0 to Tottenham Hotspur.

When adding up the money made and lost from the advised bets, the total amount is a profit of £100, showing that this betting technique is great way to make money at a low risk of losing.

6 Conclusion and Limitations

The model explained in this paper helps to provide predictions of Premier League matches using the bivariate Poisson distribution model to a great degree of accuracy. This was shown by calculating the chance of every possible score line on matchday 25 where it is seen that out of the ten matches that took place, four of those had a final result that was in the top three most likely predicted outcomes, while a fifth match had a score that was the fifth most likely result. This is strong evidence of a successful prediction model when considering the large number of possible final scores that could play out. Even where the result is not correctly predicted, the model is able to forecast other occurrences in matches on many occasions, for example, the probability of keeping clean sheets or the likelihood of scoring more/less than a specified number of goals. This was illustrated when the model hinted strongly at a clean sheet in the match between Newcastle United and Norwich City. These hints turned out to be precise with the game finishing 0-0. This is just one of the many instances of the Poisson based model's indications turning out to be correct.

Where results are unable to be predicted, as seen in the Tottenham Hotspur vs Manchester City and West Ham United vs Brighton & Hove Albion matches, there is a common theme being the changing of managers mid-way through the season. Tottenham Hotspur's appointment of a new head coach during the season has caused an alteration to their style of play. This in turn proved influential in the improvement of the team's defensive strength thus reducing the expected goals of their opponent. Therefore, the model was unable to predict the 2-0 win for the home side that ultimately transpired. West Ham United also had a change of coaching personnel **(15)**. The new coach had a win percentage of 25.4% in his previous three jobs which is rather poor **(16)**. Despite West Ham being the most likely victors according to the model, they ended up drawing. This may largely be in part to the new coach lacking quality. Having a coach with a significantly large loss ratio translates poorly to the organisation of the side, implying that defensively, the team would be weaker. Hence the true expected value of goals scored by the opposition would be greater than what was calculated. This partially explains why the 3-3 draw was not anticipated.

Another limitation of this model is that it does not reflect the effect of having key first team squad members being ruled out of matches due to being injured or suspended. Manchester City were without one of their key defenders resulting in a weaker defence **(17)**. This would boost Tottenham Hotspur's chances of scoring goals thus in reality the true expected value of their goals scored would have increased. Due to this the probability of Tottenham winning 2-0 would have been larger than what was previously determined.

The Premier League has a transfer window in January where players can be purchased and sold. An injection of quality via new signings can dramatically improve a team's performances. Teams may be struggling prior to January but once new players arrive during the window, they can see an upturn in results. A team's improvement in defensive or offensive strength would not be able to be accounted for with the model in its current format. When teams sell key players, a downturn in results can be expected however the model would not be able to consider this when computing probabilities.

The final limitation of this model is that it can only be used to forecast outcomes of football matches taking place between teams in the same league. If this model was to be used for predicting a match between two teams from separate leagues, the data for each team would come from two different samples which would not give accurate predictions due to the differences in skill levels between leagues. The model should not be used close to the start of the season as there are not enough matches played and thus not enough data to calculate probabilities to a reasonable degree of accuracy. Experts say that the Premier League table starts to take shape around the Christmas period **(18)**. From this point onwards it is advisable to use this model otherwise the probabilities will not be reliable to use for predictions.

Despite its limitations, the Poisson model helped to serve as a strong basis to aid betting. In seven of the ten matches a profit was made when placing £100 on various outcomes. If £100 was placed on all matches on outcomes chosen using the betting technique described in this paper, a total profit of £100 would have been made. This is strong enough evidence to show that through analysis of the bivariate Poisson distribution probabilities, a low risk betting strategy can be employed to yield winnings. Even when the final score of matches is not in the top five most likely results, the betting technique can still be implemented to produce a profit. This is what happened in the Manchester United vs Wolverhampton match. This is yet more evidence for the Poisson model being able to provide insights on football match outcomes.

After finding that the probabilities of different results closely fit in with the final scores of the football matches on the 25th game week of the Premier League, there is enough evidence to show that the Premier League can be modelled by a Poisson distribution to an accurate degree and from this, a low risk betting strategy can be applied. Football, like many things in the world, can be predicted and explained by mathematics. The skills used in this paper are easy to transfer to other events that are Poisson processes

although in some cases the methodology would have to change slightly. People can use the probabilities of events calculated using the Poisson distribution model and compare them to odds provided by bookmakers to help place smarter bets that are highly likely to make money.

7 Glossary

Clean sheets *– Prevention of the opposing side scoring.*

Fixtures *– A sporting event arranged to take place on a specified date.*

English Premier League – *The top level of the English football league system founded in 1992.*

League table *– A list of competitors in the league, showing their ranking according to performance in a particular season.*

Season *– A portion of the year in which regulated matches take place. The Premier League season consists of 38 games.*

Home *– The stadium where the host team plays its matches. The home team is the team that is hosting the fixture.*

Away - *The away team is the team that is visiting the host team's stadium for the fixture.*

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