Predicting Football Outcomes by Using Poisson Model: Applied to Spanish Primera División

Abstract

During the past decades, sport, in general, has become one of the most powerful competitions and the most popular in the world. As well, everyone is waiting for the winner and who will be the champion in the end in different tournaments. Among these sports, football's popularity is higher than all other sports. Football match results prediction, as well as the champion in various competitions, has been seriously studied in recent years. Moreover, it has become an interesting field for many researchers. In this work, the Poisson model has been presented to predict the winner, draw, and loser of the football matches. The method is applied to the Spanish Primera División (First Division) in 2016–2017; the data has been downloaded from the football-data.co.uk website, which will be used to find the prediction accuracy.

Keywords: *IOT, Poisson model, Likelihood Estimation, Football Outcomes, La Liga, Goal Expectancy.*

I. Introduction

Football is one of the oldest sports practiced by most people around the world, which has become today one of the most popular sports [1]. In the beginning the people of England practiced this sport and after that they reached all over the world [2].The attempt to predict the gameplay outcome is now widespread among pepo [3]. Over the past years modeling football game has become very common challenges, as well as it has been suggesting different models to know and find a better way that predict the score of the game or predicting a team win or lose in the match [4] [5].

A. Poisson Model

The “events” that happen in sport are random. However, when looking in these events to check how and when they happened through a game period[6] . It can be observed that they can be illustrated as events timeline and interpreted as a 1-dimensional scatter diagram [7]. Consider a football game for instance, where teams score the goals during the match time which is 90 minutes, scoring the goals happen randomly over the ear of the match timeline [8]. The Poisson process can be defined as the most broadly utilized counting process, it is normally used in situations when counting the events of specific events that seems to occur at a specific rate, but completely at random . In general terms, the period ranges from 0 to T [9]. Within this time interval events may be happening at different points along the way that may have some impact on the eventual value of the process. A process can either be deterministic or stochastic [10].

Poisson distribution was developed by 19th-century French mathematician Siméon Denis Poisson [11]. The probabilities of various numbers of "successes"(just means that the outcome in question occurs) can be calculated by it and based on the mean number of successes, the various events must be independent [12]. It is a probability theory that uses historical sports data to predict the outcome of a sports event. It measures the likelihood of how many times an event will occur during a specific period [13]. Poisson regression is used to predict a dependent variable that consists of "count data" given one or more independent variables [14]. The variable we want to predict is called the dependent variable (or

sometimes the response, outcome, target or criterion variable) [15]. The variables we are using to predict the value of the dependent variable are called the independent variables (or sometimes the predictor, explanatory or regressor variables) [16, 17].

B. Maximum Likelihood Estimation

Maximum likelihood estimation is a technique used to define values for the parameters of a model [18]. The parameter values are found such that they maximize the likelihood that the process described by the model produced the data that were actually observed [19, 20].

The maximum likelihood approach is the widely utilized mechanism to approximate the parameter θ which identifies a probability function P(X = x|θ)of a discrete stochastic variable X (or a probability density function P(x|θ)of a continuous stochastic variable X) based on the observation X1, X2, ……, Xn which were independently sampled from the distribution. Note that for a continuous stochastic variable X, the probability density function P(x|θ)satisfies.

$$P(X < r|\theta) = \int_{-\infty}^{r} p(x|\theta)dx. \quad (1)$$

The maximum likelihood approximate is the value θ which maximize the likelihood function which is defined by

$$L(\theta) = \Pi_{i=1}^{n} P(X = x_i|\theta) = P(X = x_1|\theta)P(X = x_2|\theta)\cdots P(X = x_n|\theta), \quad (2)$$

When X is a discrete stochastic variable and

$$L(\theta) = \Pi_{i=1}^{n} p(x_i|\theta) = p(x_1|\theta)p(x_2|\theta)\cdots p(x_n|\theta), \quad (3)$$

When X is a continuous stochastic variable. That is the maximum likelihood approximation chooses the model parameter θ which is the most likely to generate the observed data. The maximum likelihood approximation is a core of mathematical statistics and several nice theorems demonstrate its optimality rigorously under certain regularity conditions. Hence, the sciences of the application to information are interested, the maximum likelihood approximation works and considered sufficient for most problems [21].

In this work the Poisson model that used to predict the football match score is:

P (k events in interval) = λk e –λ / k! where (k=0,1,2 ….)

The rest of this work is organized as the following literature review in section two. In section three, building the model. Finally, in section four, the conclusion of this work is presented.

II. Literature Review

Some studies have been done on predicting the outcomes of football matches from different league in the past years. Saraiva et al. [1] suggested the Poisson Regression model for football game results. They utilize the suggested methodology to two national competitions. The 2012-2013 English Premier League and the 2015 Brazilian Football League. For each game simulation procedure, they determined the chance of win, draw and down. Within the chance of a team qualifying for continental games, being crowned champion or relegated to the second section is acquired.

Yawe et al. [10] they ultimately employ data of some football players in European primer League match to show if Poisson regression model can suit into the data and have with some predictions about selected players, in addition to make reasoning about the number of goals each player can score and the ability infer the game results in a match.

Bruinsma, R [22] suggested the Poisson regression sample to foretell the final outcomes of football games. The researcher foretells the rate goals marked by each team assuming that the number of marked goals by a team in a game followed a univariate Poisson division. Poisson regression sample was formulated from four covariates: the score rate in a game, the home-team usefulness, the team offensive power, and opposed team defensive power. The methodology was used to the 2017-2018 English Primer League. The outcomes acquired using this model had a very good accuracy.

Karlis and Ntzoufars [23] suggested the Skellam's distribution to model the non-alike of scores among home and opposite teams. The model is explained by the writers using 2006-2007 English Premier League.

Kuning et al. [24] conversed a simulation/probability model that explain and shows the most likely team to win a tournament. In addition to that the model can be utilized to answer some questions like 'which team had a lucky draw?' or 'what is the probability that two teams meet at moment in the tournament? ' entering to the simulation/probability sample are marking, that are marked as a weighted rate of marked goals. They applied their model to the World Cup and the European Cup Championships.

Boldrin B [25] tries to improve a model following a Poisson distribution in order to predict the outcomes with top betting selections from the 2016-2017 Premier League, which is the most productive football league and most watched in the word.

In this work, the match score has been focused using Poisson model, as these results will reflect the strength of the attack line and the defense line of the team, as well as impact of teams that are playing in their home field between their fans. The Poisson model applied to the Spanish Primera División (First Division) in 2016-2017.

III. 3. Building the Model

Before starting there are many steps should be taken in order to build the model, in the first one a dataset should be used and selected, then using a suitable Poisson model which will fit our demands, after that we should do some calculations for teams from the selected dataset. Finally testing the model for predicting accuracy of (win, draw and lose).

A. Dataset

In order to predict any team results, historical data should be depended therefore in this work Spanish League 2016-2017 (LA Liga) session dataset is selected. There are 20 teams competing with each other every session and in the end, there will be one league champion. Also, the first four teams go

directly to the Champions League and the last three teams go to the second division in every session.

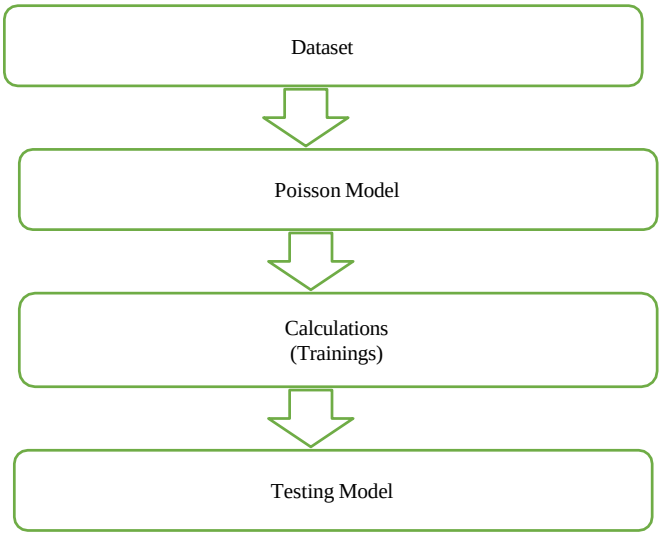

Fig 1: Model Building

The list of Spanish League teams (La Liga) in 2016-2017 session shown in below table:

TABLE I. LA LIGA TEAMS 2016-2017

ID	Team
1	Deportivo La Coruna
2	Malaga CF
3	FC Barcelona
4	Granada FC
5	Sevilla FC
6	Athletico Madrid
7	Real Sociedad
8	Sporting Gijon
9	Celta Vigo
10	Valencia CF
11	Real Betis
12	Espanyol
13	SD Eibar
14	CD Leganes
15	CA Osasuna
16	Real Madrid
17	CD Alaves
18	Athletic Bilbao
19	UD Las Palmas
20	Villarreal CF

The above list may change for the next session of La Liga, because as it mentioned before the last three teams in the end of each session go to the second division. There are many factors that influence the results and ranking of teams in the league every season, among the most important of these factors is the team budget, which controls its results greatly.

B. The Model

The following Poisson formula has been used in this work to find out the probability and predict of any possible result.

P (k events in an interval) = (λk e –λ) / k!

- P is the probability
- k is the number of occurrences in the interval (number of predicted goals)
- k! is the factorial of k
- e is Euler's number (e = 2.71828…)
- λ (Lambda) is the expected number of goals (goal expectancy)

C. The Model

The downloaded dataset is simplified and only these fields are used which fulfill this work demands. The full season consists of 380 games between 20 teams, as each team plays 38 games, 19 of them at home and 19 in the opponent's playground (away). The following tables represent the total goals for all teams that scored in the session 2016-2017. The first table display the overall goals and points scored by each team in the session, the second table represent the goals when they played in home and the third table in Opponent's playground (away) respectively. Also, this data will be depended in the next steps.

TABLE II. OVERALL GOALS AND POINTS FOR EACH TEAM IN LA LIGA (2016-2017)

ID	Team	Games Played	Goals	Goals Against	pts
1	Deportivo La Coruna	38	43	61	36
2	Malaga CF	38	49	55	46
3	FC Barcelona	38	116	37	90
4	Granada FC	38	30	82	20
5	Sevilla FC	38	69	49	72
6	Athletico Madrid	38	70	27	78
7	Real Sociedad	38	59	53	64
8	Sporting Gijon	38	42	72	31
9	Celta Vigo	38	53	69	45
10	Valencia CF	38	56	65	46
11	Real Betis	38	41	64	39
12	Espanol	38	49	50	56
13	SD Eibar	38	56	51	54
14	CD Leganes	38	36	55	35

15	CA Osasuna	38	40	94	22
16	Real Madrid	38	106	41	93
17	CD Alaves	38	41	43	55
18	Athletic Bilbao	38	53	43	63
19	UD Las Palmas	38	53	74	39
20	Villarreal CF	38	56	33	67
	Total	760	1118	1118	
	League Average	38	1.47	1.47	

TABLE III. HOME SCORE FOR EACH TEAM IN LA LIGA (2016-2017)

		HOME				
ID	**Team**	**Games Played**	**Goals**	**Average Goals**	**Goals Against**	**Average Goals Against**
1	Deportivo La Coruna	19	27	1.42	23	1.21
2	Malaga CF	19	32	1.68	25	1.32
3	FC Barcelona	19	64	3.37	17	0.89
4	Granada FC	19	17	0.89	32	1.68
5	Sevilla FC	19	39	2.05	16	0.84
6	Athletico Madrid	19	40	2.11	14	0.74
7	Real Sociedad	19	30	1.58	24	1.26
8	Sporting Gijon	19	26	1.37	38	2.00
9	Celta Vigo	19	30	1.58	32	1.68
10	Valencia CF	19	32	1.68	32	1.68
11	Real Betis	19	22	1.16	24	1.26
12	Espanol	19	28	1.47	24	1.26
13	SD Eibar	19	29	1.53	21	1.11
14	CD Leganes	19	22	1.16	23	1.21
15	CA Osasuna	19	23	1.21	39	2.05
16	Real Madrid	19	48	2.53	20	1.05
17	CD Alaves	19	19	1.00	21	1.11
18	Athletic Bilbao	19	36	1.89	18	0.95
19	UD Las Palmas	19	33	1.74	25	1.32
20	Villarreal CF	19	35	1.84	18	0.95
	Total	380	632	33.26	486	25.58
	League Average	19	31.6	1.66	24.3	1.28

TABLE IV. AWAY (OPPONENT) SCORE FOR EACH TEAM IN LA LIGA (2016-2017)

		AWAY (Opponent playground)				
ID	**Team**	**Games Played**	**Goals**	**Average Goals**	**Goals Against**	**Average Goals Against**
1	Deportivo La Coruna	19	16	0.84	38	2.00
2	Malaga CF	19	17	0.89	30	1.58
3	FC Barcelona	19	52	2.74	20	1.05
4	Granada FC	19	13	0.68	50	2.63
5	Sevilla FC	19	30	1.58	33	1.74
6	Athletico Madrid	19	30	1.58	13	0.68
7	Real Sociedad	19	29	1.53	29	1.53
8	Sporting Gijon	19	16	0.84	34	1.79
9	Celta Vigo	19	23	1.21	37	1.95
10	Valencia CF	19	24	1.26	33	1.74
11	Real Betis	19	19	1.00	40	2.11
12	Espanol	19	21	1.11	26	1.37
13	SD Eibar	19	27	1.42	30	1.58
14	CD Leganes	19	14	0.74	32	1.68
15	CA Osasuna	19	17	0.89	55	2.89
16	Real Madrid	19	58	3.05	21	1.11
17	CD Alaves	19	22	1.16	22	1.16
18	Athletic Bilbao	19	17	0.89	25	1.32
19	UD Las Palmas	19	20	1.05	49	2.58
20	Villarreal CF	19	21	1.11	15	0.79
	Total	380	486	25.58	632	33.26
	League Average	19	24.3	1.28	31.6	1.66

Since we have the key statistics, so before using it in predicting games results, there are other points must be considered and should be calculated for example the defensive strength and attacking strength for each team, which can be calculated simply using the data of the above tables, by dividing Average Goals or Average Goals Against by the league average. For example, if we want to calculate the attacking strength for Sevilla FC (Se) team at Home the following formula will be used:

Home (Se)= Se Average Goals / League Average

Home (Se)= 2.05/1.66 = 1.23

In this case the Home attacking strength for Sevilla FC team result will be (1.23). Also, if we take another example lets calculate the Valencia CF (VA) Away defensive strength the following formula will be used:

Away (VA)= VA Average Goals Against / League Average

Away (VA)= 1.74 / 1.66 = 1.05

So, in this case the Away defensive strength for Valencia CF team result will be (1.05). Same calculations will be repeated to find out the attacking and defensive strength for all other teams, and the results is shown in the below table:

TABLE V. HOME & AWAY ATTACK AND DEFENSE STRENGTH FOR EACH TEAM

		HOME		AWAY	
ID	**Team**	**Attack Strength**	**Defensive Strength**	**Attack Strength**	**Defensive Strength**
1	Deportivo La Coruna	0.86	0.95	0.66	1.20
2	Malaga CF	1.01	1.03	0.70	0.95
3	FC Barcelona	2.03	0.70	2.14	0.63
4	Granada FC	0.54	1.32	0.53	1.59
5	Sevilla FC	1.24	0.66	1.23	1.05
6	Athletico Madrid	1.27	0.58	1.23	0.41
7	Real Sociedad	0.95	0.99	1.19	0.92
8	Sporting Gijon	0.82	1.56	0.66	1.08
9	Celta Vigo	0.95	1.32	0.95	1.17
10	Valencia CF	1.01	1.32	0.99	1.05
11	Real Betis	0.70	0.99	0.78	1.27
12	Espanol	0.89	0.99	0.86	0.82
13	SD Eibar	0.92	0.86	1.11	0.95
14	CD Leganes	0.70	0.95	0.58	1.01
15	CA Osasuna	0.73	1.60	0.70	1.74
16	Real Madrid	1.52	0.82	2.38	0.67
17	CD Alaves	0.60	0.86	0.90	0.70
18	Athletic Bilbao	1.14	0.74	0.70	0.79
19	UD Las Palmas	1.05	1.03	0.82	1.55
20	Villarreal CF	1.11	0.74	0.86	0.48

After calculating the Attack and Defense strength for each team in the league, now this result can be used to calculate the goals that the team expect to score in a specific match, which is called Goal Expectancy. Two formula are used for Goal Expectancy one for Home and the other for Away, which can be worked out for each match:

Home Goal Expectancy for team = Home team attacking strength X Away team defensive strength X Home average goals

Away Goal Expectancy for team = Away team attacking strength X Home team defensive strength X Away average goals

For example, let's continue taking same teams Sevilla (SE) vs Valencia (VL):

SE Home Goal Expectancy = 1.24 X 1.05 X 1.66 = 2.16

VL Away Goal Expectancy = 0.99 X 0.66 X 1.28 = 0.84

To find out Goal Expectancy for all other teams (Home and Away) in round 13 the same above formula is applied and the following table shows the results.

TABLE VI. GOAL EXPECTANCY FOR EACH TEAM IN ROUND 13

ID	Home Team	Goal Expectancy	Away Team	Goal Expectancy
1	Eibar	1.94	Betis	0.85
2	Espanol	1.49	Leganes	0.73
3	Malaga	2.01	Deportivo La Coruna	0.87
4	Real Madrid	2.72	Sporting Gijon	0.69
5	Sevilla	2.16	Valencia	0.84
6	Celta	2.5	Granada	0.89
7	Osasuna	0.50	Athletico Madrid	2.52
8	Sociedad	0.99	Barcelona	2.71
9	Villarreal	1.29	Alaves	0.85
10	Las Palmas	1.38	Athletic Bilbao	0.92

D. Testing the Model (Poisson Formula)

Now the Poisson formula will be used to calculate the likelihood every possible score for any match, as we have the attack and defense strength it can be easily used with Poisson formula to find out the probability of any possible result. As mentioned before the model formula is:

P (k events in an interval) = $(\lambda^k e^{-\lambda}) / k!$

In this work we will predict up to **6** goals for each team in match **Sevilla (SE) vs Valencia (VL).** The following two tables

represent the probability for both team of scoring up to **6** goals in their match after applying Poisson formula:

Probability= $(\text{SevillaExpectancyGoals})^{\text{No.ofExpectedGoals}} * e^{-\text{SevillaExpectancyGoals}} / \text{No.of ExpectedGoals}$

Sevilla Goals probability:

TABLE VII. GOAL EXPECTANCY FOR EACH TEAM IN ROUND 13

Sevilla Goals	Probability
0	0.115
1	0.249
2	0.269
3	0.194
4	0.105
5	0.045
6	0.016

Fig 2: Model Building

Probability=$(\text{ValenciaExpectancyGoals})^{\text{No.ofExpectedGoals}} * e^{-\text{ValenciaExpectancyGoals}} / \text{No.of ExpectedGoals}$

Valencia Goals probability:

TABLE VIII. VALENCIA TEAM GOALS PROBABILITY

Valencia Goals	Probability
0	0.432
1	0.363
2	0.152
3	0.043
4	0.009
5	0.002
6	0.000

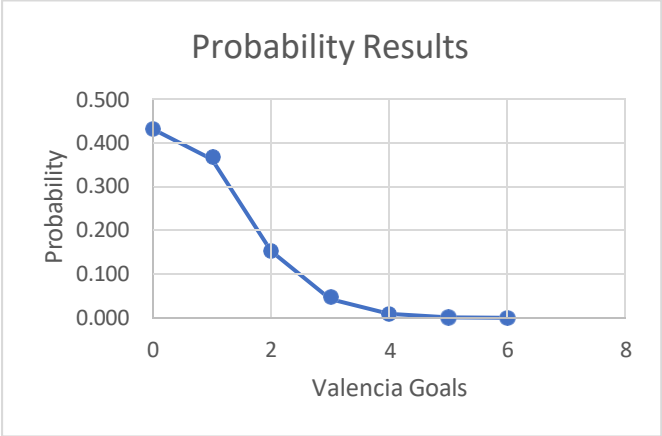

Fig 3: Model Building

Predicting the match results based on the previous probabilities. To get every possible score, multiply the probability of every possible score by each team by the probability of every score possible by the other team, the following table shows the distributions:

TABLE IX. PROBABILITY DISTRIBUTION FOR EACH TEAM UP TO 6 GOALS

No. of Goals	Valencia Goals	0	1	2	3	4	5	6
Sevilla Goals	Probability	0.432	0.363	0.152	0.043	0.009	0.002	0.000
0	0.115	0.050	0.042	0.018	0.005	0.001	0.000	0.000
1	0.249	0.108	0.090	0.038	0.011	0.002	0.000	0.000
2	0.269	0.116	0.098	0.041	0.011	0.002	0.000	0.000
3	0.194	0.084	0.070	0.030	0.008		0.000	0.000
4	0.105	0.045	0.038	0.016	0.004		0.000	0.000
5	0.045	0.020	0.016	0.007	0.002		0.000	0.000
6	0.016	0.007	0.006	0.002	0.001		0.000	0.000

Based on previous table it can be seen that the most likely score will be 2-0 for Sevilla followed by 1-0, 2-1, 1-1 and so on.

- First to calculate the change of Sevilla winning the game, all cell values under the middle or with yellow color background from the above table will be added which will gives: 0.669 or 67% of win.
- To calculate the change of Valencia winning the game, all cell values with white color background from the above table will be added which will gives: 0.13 or 13% of win.
- To calculate the draw chance, all cell values in the middle or with the blue color background will be added which will give the estimate of (0.19) or 19%.

In order to change the above chances in to odds, the following formula can be used:

Odds = 1 / probability

- Sevilla FC win: 1 / 0.669 = 1.49
- Valencia CF win: 1 / 0.13 = 7.69
- Draw: 1/ 0.19 = 5.26

The following table shows the real result for both team in season 2016 -2017:

TABLE X. THE ACTUAL RESULT FOR SEVILLA (HOME) VS VALENCIA (AWAY) TEAMS

Div	Date	Home Team	Away Team	Final Result
SP1	26/11/2016	Sevilla FC	Valencia CF	2 - 1

It can be seen that the prediction outcomes probability has a good accuracy as Sevilla team (Home) has more chance to win the game against Valencia team (Away), Then the second chance is draw and finally after many chances of Sevilla wins and draw, Valencia team will have a small chance to win and a big chance to lose the game against Sevilla.

The model is applied to an individual game between (Sevilla FC vs Valencia CF) in round 13, in order to predict for the whole round and then to the whole session teams games, the same above steps that done for both team in section (3.5) can be applied to all other teams' games to predict the outcome of each home and away match. The following table shows the predicted results and the real results in term of (Win, Draw or Loss) in round 13 after applying the above steps.

TABLE XI. THE PROBABILITY OF WIN, DRAW AND LOSS FOR EACH MATCH IN ROUND 13

ID	Home Team	Away Team	Probability			Match score	Correct Prediction
			Win	Loss	Draw		
1	Eibar	Betis	0.63	0.16	0.21	3-1	Yes
2	Espanol	Leganes	0.55	0.18	0.26	3-0	Yes
3	Malaga	Deportivo La Coruna	0.63	0.15	0.21	4-3	Yes
4	Real Madrid	Sporting Gijon	0.78	0.07	0.13	2-1	Yes
5	Sevilla	Valencia	0.67	0.13	0.19	2-1	Yes
6	Celta	Granada	0.71	0.11	0.16	3-1	Yes
7	Osasuna	Athletico Madrid	0.05	0.80	0.13	0-3	Yes
8	Sociedad	Barcelona	0.11	0.72	0.15	1-1	No
9	Villarreal	Alaves	0.47	0.25	0.29	0-2	No
10	Las Palmas	Athletic Bilbao	0.47	0.25	0.27	3-1	Yes

After applying the model to round 13 in Spanish Primera División (First Division) in 2016-2017, it can be seen that the probability of prediction outcomes has a good accuracy which show that from 10 matches 8 of them has a correct prediction according to the model.

As there are more fields in the dataset therefore, more parameters can be utilized to increase and improve the model accuracy. In addition, using more data led to more accuracy for example the number of goals in first half and second half and the strength of each player in the team and the team coach, all of this and others has an effect on the outcome prediction.

IV. CONCLUSION

In this work; the proposed Poisson model has been analyzed and tested to predict the outcomes of football matches (win, draw and lose). Also, to find out if the method is good for estimating each parameter for each football team. Including the match average goals which scored that reflect the attack team strength and the defensive strength of the away team and the home team influence.

To clarify the model, the method is applied using historical results of the Spanish League 2016-2017 session dataset. The home teams' attack strength and the defensive strength of each team in the specified session has been calculated. In addition to that the total and average goals of the La Liga session is calculated. Also, the goal expectancy for home and away team is calculated. To test those data for outcome prediction the Poisson model has been applied, which in result has a good accuracy.

Poisson model in sports can help to understand the betting system and how the odds are set by adding the likelihood of different possibilities. Also, we should not ignore the limitations of the model as it is a mathematical model. There are other factors that is related directly to the match outcome which is the human element including human errors, injuries during or before games as well as other factors that affect the final results of any sport events. Further investigation can be done for increasing the accuracy of the model by adding some mentioned parameters which is not considered can update the model and get better accuracy.

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