

ESTIMATING SUCCESS PROBABILITY OF A RUGBY GOAL KICK AND DEVELOPING A MEASURE FOR RANKING RUGBY UNION GOAL KICKERS

Jurie NEL

Assupol Life, Pretoria, Republic of South Africa

ABSTRACT

The objective of this study was firstly to derive a formula to estimate the success probability of a particular rugby goal kick and, secondly to derive a goal kicker rating measure that could be used to rank rugby union goal kickers. Various factors that could influence the success of a particular goal kick were considered. A logistic regression analysis was performed to obtain the significant factors that were found to be the most important factors in the estimation of the success probability of a particular goal kick. The estimated success probability of the goal kick was then used to allocate a difficulty rating for the particular goal kick. The result of goal kicks attempted by the kicker along with the difficulty rating of these kicks was used to derive a measure for the ranking of rugby goal kickers. Goal kicker performances during the 2011 Rugby World Cup Tournament were used to illustrate the workings of the ranking system.

Key words: Goal kicker ranking; Rugby Union; Success probability; Difficulty rating.

INTRODUCTION

Goal kicking in rugby takes place after a try has been scored or a penalty has been awarded. The rugby ball is placed in an upright, static position and the goal kicker then attempts to kick the ball over the crossbar and between the two uprights of the goal posts (IRB, 2012). Berry and Berry (1985) used a data-analytic approach to estimate the probability that a field goal in American Football attempted from a certain distance will be successful for a particular kicker. They proposed measures by means of which to compare two kickers, such as the estimated probability of converting a 40-yard field goal for each of the two kickers.

The probability of a rugby goal kicker being successful with a particular goal kick depends on various factors. Bilder and Loughin (1997) did a study to determine the key factors affecting the success of a field goal in American Football. They found that the distance of the kick is most important, but also that field goal attempts, which could cause a change in lead, were more likely to be missed than others. Other factors that they considered and which were found to be of lesser significance in predicting whether a field goal would be successful include:

- Outside placekicks versus kicks inside a dome;
- Kicks at a kicker's home field versus kicks at the opponent's field;
- Kicks on turf versus kicks on artificial surfaces;

- Temperature at the time of the game;
- Time during the game when a kick was attempted;
- Wind speed when kick was attempted.

Table 1 includes the factors that were considered as explanatory variables to estimate the probability of a rugby goal kick being successful (some explanatory variables were transformed to binary variables for use in the analysis).

TABLE 1: EXPLANATORY VARIABLES CONSIDERED IN THE LOGISTIC REGRESSION ANALYSIS

Variable	Description
Altitude	Whether the kick was attempted at below or above 1000m above sea level (variable was transformed to a binary variable)
Angle	Angle of the kick in degrees
Distance	Distance of the kick in meters
Half	Whether the kick was attempted during the 1 st or 2 nd half of the game (variable was transformed to a binary variable)
Type	Whether the kick was a penalty kick or a conversion kick. A conversion kick is attempted after a try has been scored (variable was transformed to a binary variable).
Pressure	Whether the kick: if successful, will result in the team closing to within one score of the opponents; if successful, will result in the team remaining within one score of the opponents; if successful, will result in the scores being level; is taken while the team's lead is still within one score of the opponent's (a maximum of seven points can be scored at a time in Rugby Union (IRB, 2012)) (variable was transformed to a binary variable)

Data regarding weather conditions, including rain and wind, was not captured. Weather conditions may influence the probability of a kick being successful, but due to a lack of objective data it could not be included in the analysis.

METHOD

Sample

Rugby goal kick data was obtained from games played during the 2011 Rugby World Cup Tournament in New Zealand (2011 RWC Tournament), the 2012 Super-15 Tournament played in South Africa, New Zealand and Australia (S15 Tournament) and the 2012, 6-Nations Tournament played in Europe (6N Tournament). Data for 1 249 goal kicks attempted in these tournaments were hand-captured using video footage and used for the purpose of the study.

Measurements

Data captured included:

- Approximate angle of kick in degrees;
- Approximate length of kick in meters;
- Date when the game was played;
- Field where the game was played;
- Final score;
- Foot used for goal kicks;
- Player (kicker);
- Score at time of kick;
- Team against;
- Team for;
- Type of goal kick – penalty or conversion;
- When the goal kick was attempted – 1st or 2nd half;
- Whether the kick was successful or unsuccessful;
- Winning team;
- Zone from which kick attempted.

Rugby field dimensions and zones analysed

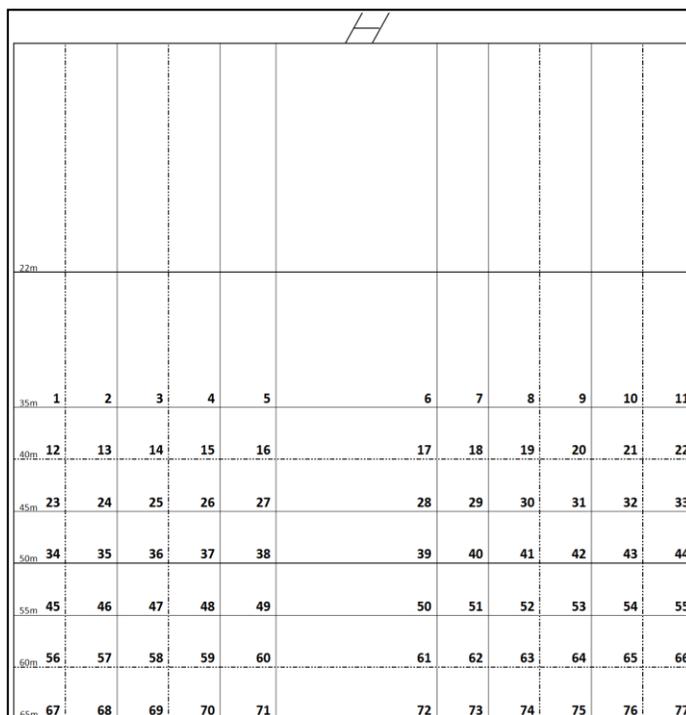


FIGURE 1: RUGBY FIELD DIVIDED INTO 77 ZONES

The length of a rugby field may not exceed 100m, excluding the in-goal areas behind the goal posts, and it may not be wider than 70m (IRB, 2012). The kick data was captured in 77 zones on the rugby field (Figure 1). The zones were constructed so that the 77 zones covered the entire rugby field and that all kicks from a particular zone were of the same approximate difficulty. The 77 zones were constructed using some of the lines already on the rugby field to assist with the data capturing. The zones were 5m long by 5m wide, except for zones 1 to 11 (these zones were closest to the goal posts and could not only be 5m in length) and the zones in front of the goal posts.

Probability of a successful goal kick

Following Hosmer and Lemeshow (2000), a logistic regression analysis that included possible explanatory variables that could explain the dependent variable (probability of a successful goal kick) was performed. Results of the logistic regression analysis are summarised in Table 2.

TABLE 2: RESULTS OF LOGISTIC REGRESSION ANALYSIS

Variable	Coefficient	Standard Error	Wald Chi-Square	Pr> Chi ²
Intercept	4.663	0.339	189.106	<0.0001
Altitude	0.580	0.250	5.374	0.0200
Angle	-0.016	0.004	13.191	0.0000
Distance	-0.097	0.008	161.206	<0.0001
Half	-0.036	0.140	0.066	0.7970
Type	-0.100	0.178	0.312	0.5760
Pressure	0.128	0.164	0.609	0.4350

From Table 2, it can be seen that altitude, angle and distance were the significant explanatory variables at a 2.5% significance level.

Final model

After the initial variable screening process, the model that best estimates the probability of a successful goal kick was developed (Hosmer & Lemeshow, 2000).

$$\hat{y}_i = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 \times \text{altitude}_i + \beta_2 \times \text{angle}_i + \beta_3 \times \text{distance}_i)})}$$

where

- \hat{y}_i = probability of a kick *i* being successful
- altitude_i = 1 if kick *i* attempted at ≥ 1000 m above sea level, else 0
- angle_i = angle of kick *i* in degrees
- distance_i = distance of kick *i* in meters

$$\beta_0 = 4.666 \quad \beta_1 = 0.572 \quad \beta_2 = -0.015 \quad \beta_3 = -0.098$$

This equation can therefore be used to calculate the probability of success of a goal kick based on the altitude above sea level at which the goal kick is attempted, the angle of the goal kick and the distance of the goal kick.

Difficulty rating of goal kicks

The success probability of a particular goal kick indicates the difficulty of the goal kick (the lower the success probability, the higher the difficulty of the kick). The success probability of a particular goal kick can be used to derive a difficulty rating for the particular goal kick.

Let:

$$D_i = \frac{1}{y_i}$$

where

D_i = Difficulty rating of kick i

y_i = Probability of kick i being successful

Goal kicker performance rating

The performance rating of a goal kicker is an objective measure of the goal kicker's performance based on the success he had with the kicks he attempted and the difficulty of the kicks. The *success percentage* (the number of successful goal kicks made by a kicker divided by the total number of goal kicks attempted) is combined with the *difficulty rating* of the kicks attempted by the goal kicker to derive a measure for the *ranking* of rugby goal kickers.

During a particular rugby game, or over a number of rugby games, the following equation is proposed for kicker j :

$$\begin{aligned} \text{goal kicker performance rating}_j & \\ &= \text{success_percentage}_j \times \text{average difficulty rating of successful kicks}_j \end{aligned}$$

Where:

$$\text{success_percentage}_j = \frac{\sum_{k=1}^n \text{success}_{kj}}{n}$$

goal kicker performance rating $_j$ = Performance rating for goal kicker j for that particular game or over a number of games

success $_{kj}$ = 1 if kick k attempted by kicker j was successful, else 0

average difficulty rating of successful kicks $_j$ = Average difficulty rating of kicker j 's kicks for that particular game or over a number of games

n = number of kicks that goal kicker j attempted for that particular game or over a number of games

The average or expected goal kicker performance rating is 1. The *goal kicker performance rating* can be gauged as follows: >1 suggests better than average goal kicker performance; and <1 suggests poorer than average goal kicker performance.

RESULTS

The three tables to follow indicate the goal kicker performance statistics for the 2011 RWC Tournament.

TABLE 3: RANKING OF PLAYERS BY SUCCESS PERCENTAGE

Kicker	Country	No. Kicks Attempted	No Successful	Success %	Success % Ranking
1	South Africa	6	6	100%	1
2	Wales	15	13	87%	2
3	Ireland	22	19	86%	3
4	France	14	12	86%	3
5	Fiji	12	10	83%	5
6	Australia	5	4	80%	6
7	South Africa	27	21	78%	7
8	Australia	28	20	71%	8.5
9	England	14	10	71%	8.5
10	Samoa	10	7	70%	10
11	Wales	19	13	68%	12
12	France	22	15	68%	12
13	Tonga	25	17	68%	12
14	New Zealand	12	8	67%	16
15	USA	3	2	67%	16
16	Canada	12	8	67%	16
17	Romania	6	4	67%	16
18	Samoa	12	8	67%	16
19	New Zealand	23	15	65%	19
20	Japan	14	9	64%	20.5
21	Italy	11	7	64%	20.5
22	New Zealand	24	15	63%	23
23	USA	8	5	63%	23
24	Scotland	8	5	63%	23
25	Scotland	13	8	62%	25
26	Georgia	17	10	59%	26
27	Russia	7	4	57%	27.5
28	Italy	7	4	57%	27.5

TABLE 3: RANKING OF PLAYERS BY SUCCESS PERCENTAGE (cont.)

Kicker	Country	No. Kicks Attempted	No Successful	Success %	Success % Ranking
29	Wales	15	8	53%	29
30	Canada	8	4	50%	31
31	Argentina	16	8	50%	31
32	Australia	8	4	50%	31
33	England	21	10	48%	33
34	Argentina	17	8	47%	34
35	Ireland	14	6	43%	35
36	Namibia	10	4	40%	36
37	Romania	14	5	36%	37
38	Russia	6	2	33%	38
39	Italy	3	0	0%	39

TABLE 4: RANKING OF PLAYERS BY THE AVERAGE DIFFICULTY RATING OF GOAL KICKS

Kicker	Country	Ave. difficulty rating of goal kicks	Ave. difficulty rating of goal kicks ranking
36	Namibia	2.11	1
24	Scotland	1.77	2.5
12	France	1.77	2.5
5	Fiji	1.71	4
26	Georgia	1.61	5
6	Australia	1.57	6
37	Romania	1.55	7
18	Samoa	1.53	8
7	South Africa	1.50	9
13	Tonga	1.49	10
3	Ireland	1.48	11
9	England	1.47	12.5
14	New Zealand	1.47	12.5
32	Australia	1.45	14.5
33	England	1.45	14.5
25	Scotland	1.41	16
11	Wales	1.38	17

TABLE 4: RANKING OF PLAYERS BY THE AVERAGE DIFFICULTY RATING OF GOAL KICKS (cont.)

Kicker	Country	Ave. difficulty rating of goal kicks	Ave. difficulty rating of goal kicks ranking
19	New Zealand	1.36	18
34	Argentina	1.35	19.5
31	Argentina	1.35	19.5
4	France	1.34	21
16	Canada	1.32	22
35	Ireland	1.31	23.5
8	Australia	1.31	23.5
10	Samoa	1.30	25
27	Russia	1.29	26
29	Wales	1.28	27
38	Russia	1.25	28
2	Wales	1.24	30
30	Canada	1.24	30
22	New Zealand	1.24	30
21	Italy	1.22	32
20	Japan	1.19	33
23	USA	1.18	34
17	Romania	1.15	35
28	Italy	1.10	36.5
1	South Africa	1.10	36.5
15	USA	1.05	38
39	Italy	-	39

TABLE 5: RANKING PLAYERS BY OVERALL GOAL KICKER PERFORMANCE RATINGS AND RANKINGS

Kicker	Country	Goal Kicker Performance Rating	Goal Kicker Performance Ranking
5	Fiji	1.42	1
3	Ireland	1.28	2
6	Australia	1.26	3
12	France	1.21	4
7	South Africa	1.17	5
4	France	1.15	6

TABLE 5: RANKING PLAYERS BY OVERALL GOAL KICKER PERFORMANCE RATINGS AND RANKINGS (cont.)

24	Scotland	1.11	7
1	South Africa	1.10	8
2	Wales	1.07	9
9	England	1.05	10
18	Samoa	1.02	11
13	Tonga	1.01	12
14	New Zealand	0.98	13
26	Georgia	0.95	14
11	Wales	0.94	15.5
8	Australia	0.94	15.5
10	Samoa	0.91	17
19	New Zealand	0.89	18
16	Canada	0.88	19
25	Scotland	0.87	20
36	Namibia	0.84	21
21	Italy	0.77	23.5
22	New Zealand	0.77	23.5
17	Romania	0.77	23.5
20	Japan	0.77	23.5
27	Russia	0.74	26.5
23	USA	0.74	26.5
32	Australia	0.73	28
15	USA	0.70	29
33	England	0.69	30
29	Wales	0.68	31
31	Argentina	0.67	32
34	Argentina	0.64	33
28	Italy	0.63	34
30	Canada	0.62	35
35	Ireland	0.56	36
37	Romania	0.55	37
38	Russia	0.42	38
39	Italy	0.00	39

DISCUSSION

The results in Table 3 indicate that only one player was successful with all his attempts at goal (Player 1: 100% success). According to Table 4, player 1 was successful with all 6 goal kicks he attempted, but this table shows that the average difficulty rating of goal kicks for Player 1 was low (ranked 36.5 out of the 39 players). Player 36 had the highest average difficulty rating of goal kicks. This may be one of the reasons why he only ranked 36th by success percentage. On viewing the results of Table 5, Player 5 was the best goal kicker during the 2011 RWC Tournament based on the success percentage he achieved together with the average difficulty rating of goal kicks. Player 24 ranked 23rd by success percentage, but

much better (7th) by the overall goal kicker performance rating. This is due to the relatively high average difficulty rating of his goal kicks (ranked 2.5 out of the 39 players). Considering players ranked in the top 10 by their goal kicker performance rating, Player 5, Player 6 and Player 7 are the only players ranked in the top 10 by success percentage, as well as the average difficulty rating of goal kicks.

CONCLUSIONS

A formula was derived to estimate the success probability of a rugby goal kick. The most important variables determining the success probability of a particular goal kick were determined as the altitude above sea level at which the goal kick was attempted, the angle of the goal kick and the distance of the goal kick.

The success probability was then used to allocate a difficulty rating for the particular goal kick. The result of goal kicks attempted by the kicker along with the difficulty rating of these kicks is used to derive a performance rating for the goal kicker.

Goal kicker performance ratings provide an objective measure that could be used by rugby analysts and enthusiasts, as well as television broadcasters to better judge the goal kicking performance of goal kickers. By ordering goal kickers' goal kick performance ratings, a goal kicker ranking measure could be established to be used during tournaments or continuously to rank goal kickers objectively.

REFERENCES

- BERRY, D.A. & BERRY, T.D. (1985). The probability of a field goal: Rating kickers. *American Statistician*, 39: 152-155.
- BILDER, C.R. & LOUGHIN, T.M. (1997). It's good! An analysis of the probability of success for place kicks. Technical report, Department of Statistics, Kansas State University, Manhattan, KS.
- HOSMER, D.W. & LEMESHOW, S. (2000). *Applied logistic regression* (2nd ed.). New York, NY: John Wiley.
- IRB (2012). *Laws of the Game Rugby Union 2012*. Dublin (Ireland): International Rugby Board.