How Much is a Point Worth?

Determining the effectiveness of field goal attempts in achieving victory in the NRL.

In the 67th minute of the Round 24 NRL match between the Cronulla Sharks and the Canberra Raiders, with the scores level at 12 all, Raiders' halfback Aiden Sezer kicked a field goal to put his team ahead by 1 point. Sezer presumably felt that the Raiders would be able to defend this lead for the 13 minutes remaining until full time.

Another three field goals were kicked in regular time, with the Sharks scoring two field goals to gain the lead before Sezer brought the scores level again in the 78th minute. The result of the match was not decided until Sezer kicked his third field goal of the game eight minutes into extra time.

By choosing to kick a goal with so much time remaining rather than attempt to score a try, did the Raiders allow the Sharks too much opportunity to regain the lead? Or should the first field goal be considered the difference between a 14-13 loss and ultimate victory? In general, under what circumstances does attempting a field goal maximise a team's chances of victory?

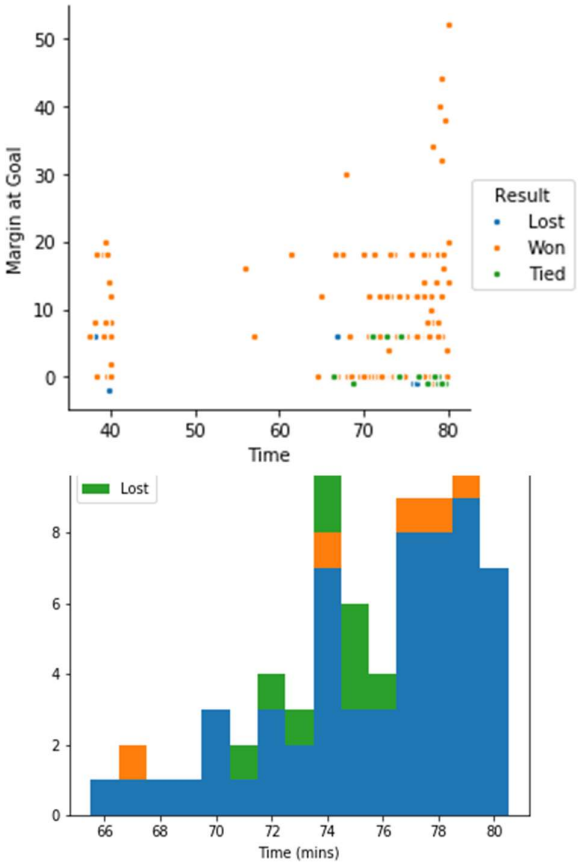
Data

The data used in this analysis comes from NRL.com, which has detailed statistics for every match from 2013 to the present. The relevant data includes the results for every regular season match from that period, and information on each scoring event and the time of the match at which that event occurred.

Preliminary Analysis

The first question we might ask is how often successful field goal attempts result in a win. Since 2013 there have been 207 successful field goals kicked in regular time, of which 168 were kicked by the time that went on to win the match, and 16 were kicked in matches where the scores were level after 80 minutes. However, in 105 of these cases the goal-kicking team was already in front when the goal was kicked, so it is difficult to assess whether the goal materially contributed to victory. There are also 320 missed field goal attempts, 166 from ultimately victorious teams, and on 76 occasions from games that ended regular time in a draw.

SUCCESSFUL FIELD GOAL ATTMPTS



If we narrow the focus to the 80 cases where scores were level when the goal was kicked, then we find 62 victories and 5 draws, with only 13 losses. Does this suggest teams ought to take any opportunity to kick a field goal when scores are level, no matter the time of the match?

In these cases, there is some evidence that the probability of victory increases the later in the match the field goal occurs, but it is hard to say anything definitive, especially since there are so few examples of goals kicked before the 74th minute.

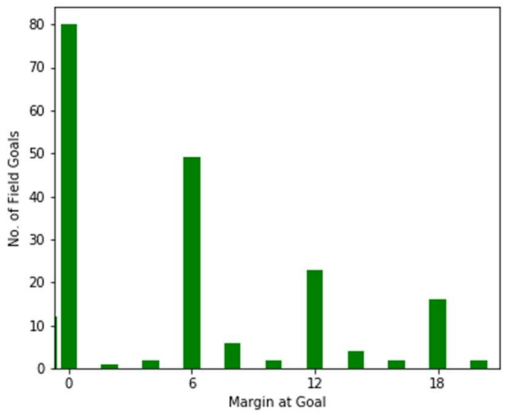
Clearly, if the choice is whether to add a single point to the score or not, the chances of victory will always be increased by adding to the score. However, attempting a field goal has costs to the attacking team as well as benefits:

1) There is a risk that the attempt will be unsuccessful, resulting in the opposition beginning a seven-tackle set on their own 20m line.
2) By attempting a drop goal, the attacking team forgoes the opportunity to score more points either through a try (4 or 6 points) or a penalty goal (2 points).

Since a team is potentially forgoing a higher scoring play, for an uncertain gain, it would be helpful to quantify just how much the chances of victory improve if a team kicks a field goal.

A simple model of Rugby League scoring

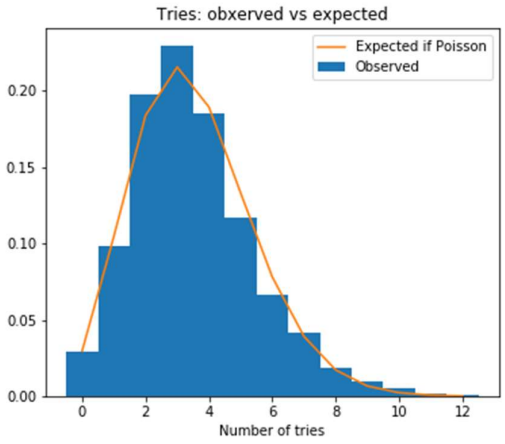
There are four means of scoring in rugby league, each worth a different number of points. These are converted tries (6 points), unconverted tries (4 points), penalty goals (2 points) and field goals (1 goals). Each of these scoring events occur at different rates and with different distributions, making the model of outcomes quite complex.



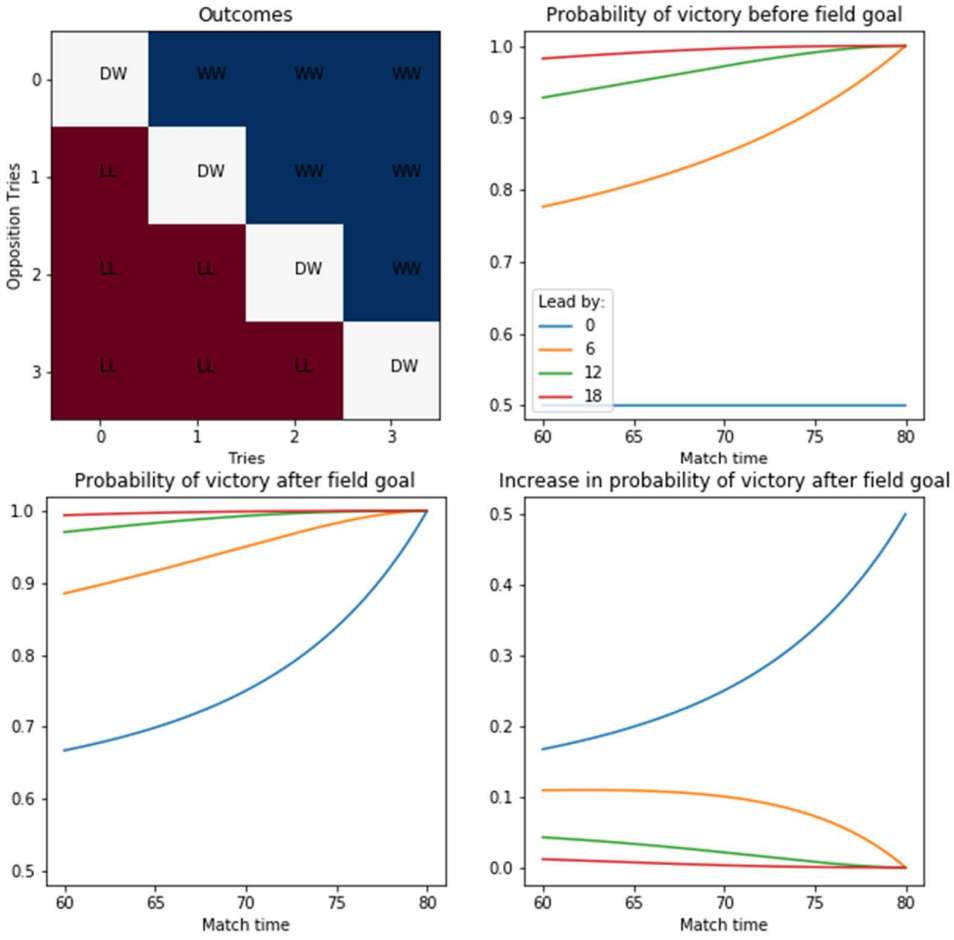
To simplify things, a reasonable assumption is that if a team scores a field goal, converted tries will be the only scoring event from that point forward. If a field goal is scored when the margin is equal to a multiple of six points, the effect is to increase by one the number of tries the opposing team needs to score in excess of the opposition. This assumption seems to be one that is shared by most NRL teams- almost all field goals are scored when the margin is 0, 6 ,12 or 18 points.

A team leading by 6 after *t* minutes have passed in the match will win unless the opposing team scores at least one more tries than the kicking team in the remaining 80-*t* minutes until full time. If a field goal is kicked by the leading team, the scoring team will win unless the opposing team scores at least 2 more tries than the kicking team in the remaining 80 time.

Since 2013, teams have scored around 3.5 tries per match on average. Looking at the number of tries scored in each match compared to the expected distributed if the number of tries were to have a Poisson distribution suggests that the scoring of tries can be modelled as a Poisson random variable with mean 3.5. In that case the number of tries that will be scored after time *t* is a Poisson random variable with mean $3.5(\frac{80-t}{80})$.



Assuming that the number of tries scored by each team after time *t* are independent, the difference between the two Poisson random variables will follow what is known as a Skellam distribution. This distribution can be used to calculate the probability of victory after kicking a field goal from a margin of 0,6,12, etc at various times throughout the match.



CLOCKWISE FROM TOP LEFT: A) OUTCOMES DEPENDING ON NUMBER OF TRIES SCORED AFTER TIME *T*. WW= ALWAYS WIN, LL=ALWAYS LOSE, DW=DRAW IF NO FIELD GOAL, WIN IF FIELD GOAL; B) PROBABILITY OF VICTORY AT TIME *T* FOR A TEAM LEADING BY 0,6 ETC POINTS; C) PROBABILITY OF VICTORY AT TIME *T* FOR A TEAM LEADING BY 0,6 ETC POINTS. IF THEY KICK A FIELD GOAL; D) CHANGE IN PROBABILITY OF VICTORY IF FIELD GOAL IS KICKED.

The plots above demonstrate that the marginal impact of kicking a field goal is greatest for teams that are tied and increases as the game approaches full time. For teams already leading the benefit diminishes over time since as full time approaches the probability that the currently leading team will win approaches 100%

A more complex model

The simple analysis above provides some insight, but is unsatisfactory for two reasons:

1) The model is too simple. Assuming the only scores are converted tries, and that the number of tries scored by each team are independent Poisson variables, will lead to incorrect conclusions. After any scoring event, a certain amount of time elapses before the restart of play, after which the team that scored the points receives the ball from a kick-off (usually near their own try-line). This contradicts the assumption of independence since consecutive scoring events cannot occur within a short time period. This is especially important towards the end of matches, when a significant portion of the remaining playing time is lost after each scoring event. On the other hand, the more time is left in the match, the less likely it is that the remaining scoring will consist only of converted tries.

2) The change in probability of victory after a field goal does not actually tell us if a field goal should be attempted, for two reasons:

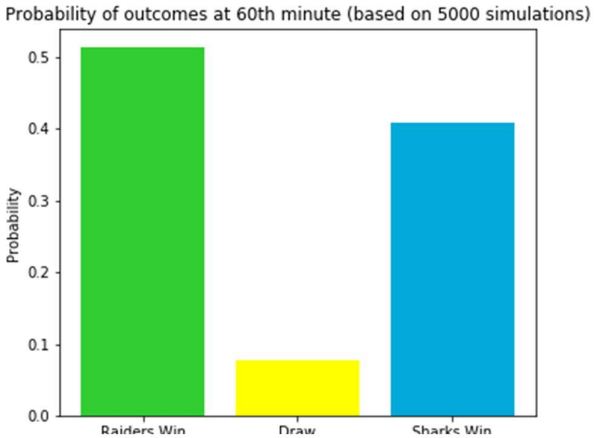
    i) *Not all field goal attempts are successful*: There have 207 successful field goals in regular time since 2013. In that same time there have been 320 missed attempts. A missed field hands possession to one's opponent on their own 20m line with a seven-tackle set- possibly giving them the opportunity to attempt their own field goal on the next possession

    ii) *By attempting a field goal, the attacking team forgoes an opportunity to score a try*. A position from which a team has a high probability of scoring a field goal may also be a position from which a team is likely to score a try and add 4 or even 6 points to their score instead of 1. The decision to kick a field goal will depend on the relative probabilities of successfully kicking the goal and the current possession ending with a try.

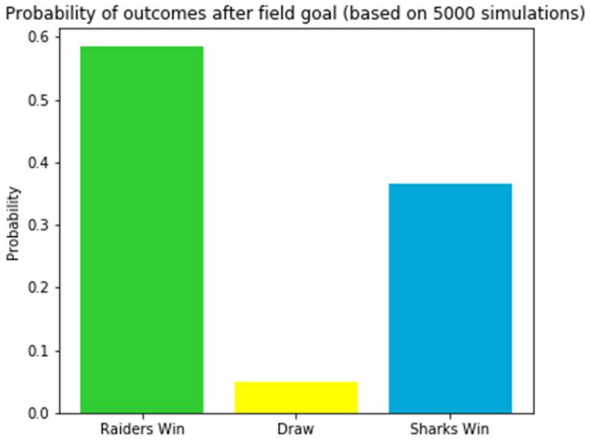
To account for the complexity of an actual rugby league match, we have built a model that takes into account the occurrence of different scoring events as well as the non-independence of those events.

Briefly, our model simulates a match by a succession of random samples which determine the next score, and the time that score occurs, until the match time elapsed reaches 80 mins. For each sample, tries and penalties are drawn from an exponential distribution that accounts for the relative strength of each team, while the distribution of field goals is estimated via nonparametric methods

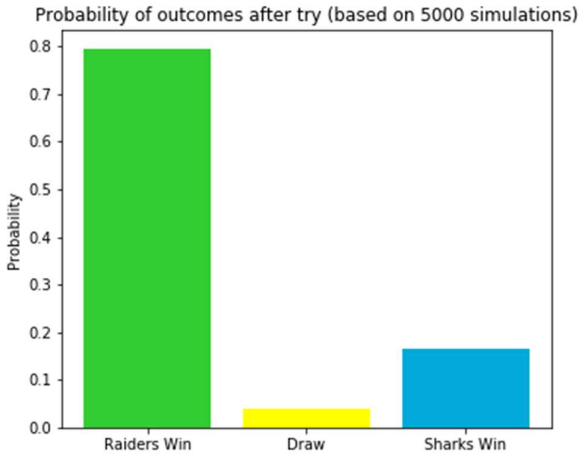
By running many simulations, the distribution of match outcomes can be estimated, and the probability of victory determined. To illustrate the method, consider the game discussed earlier. Scores were level at 12 all from the 60^{th} minute.



By running 5000 simulations of the game beginning at the 60th minute with the scores tied at 12-all, our model predicts that the Raiders have a slightly higher probability (around 51%) of winning the match since they are more highly rated team.



If the Raiders kicked a field goal at this time, the probability of victory would increase to 58%.

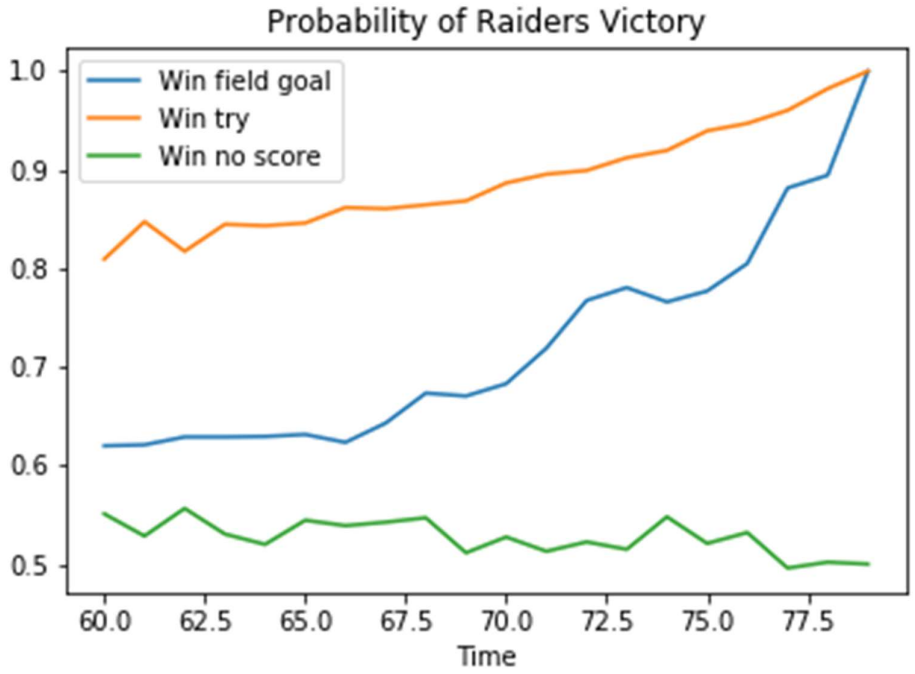


Finally, the effect of scoring a try would be to increase the probability of victory to around 80%.

Clearly the effect of a try is greater than that of a field goal.

To see how these probabilities change over time, the probability of winning after a field goal, a try, and under the status quo, are determined by running simulations at every minute from the 60th to the end of regular time.

Note: If the scores are level at the end of regular time, the game enters a 10 minute golden point period where the first team to score wins. We assume that both teams have a 50% chance of winning if scores are level after 80 mins and ignore the case of a 90 minute draw.



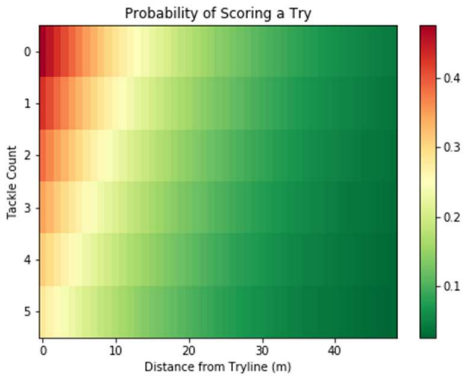
Estimating probability of scoring form current possession

At this point we have a method of estimating the probability of victory given the outcome of the current possession (i.e. field goal, try or no score). Gaining useful insights from this information depends on knowing how likely each outcome is. Unfortunately, the publicly available data does not allow for these probabilities to be estimated. For the purposes of illustration, we will use theoretical probability functions

The probability that a given possession will result in a try likely depends on many factors (relative skill of attacking and defending teams, fatigue, weather conditions etc.) but to simplify we say that it can be expressed as a function of field position and current tackle count (i.e. the closer you are to your opponent's try line, and the more tackles are remaining in your current set of 6, the more likely you will be to score).

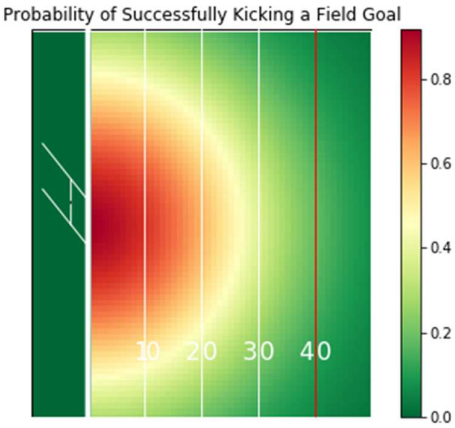
$$P(try|d_t, n) = f(d_t, n)$$

Where d_t is the vertical distance to the try line and *n* is the current tackle count.



Estimating this probability would be a relatively simple matter, but would require the somewhat laborious collection of data for the position of the ball at every tackle, as well as the outcome of every possession. Here is a somewhat plausible looking model for purposes of illustration:

The probability of successfully kicking field goal is likely to be a little harder to estimate empirically, given the relative paucity of field goal attempts. However, it seems plausible that the probability mainly depends on the position from which the kick is taken, which mostly depends on where the previous tackle occurs. The greater the distance to the goalposts, the less likely that the attempt will be successful. The diagram on the right shows a hypothetical relationship between field position and the probability of success.



Putting it all together

The ultimate goal of this analysis is to describe a method for describing whether or not to attempt a field goal. The criterion for this decision is the expected increase in the probability of victory if a field goal is attempted:

$$\Delta P = P(Victory|Field\ Goal\ Attempt) - P(Victory|No\ Field\ Goal\ Attempt)$$

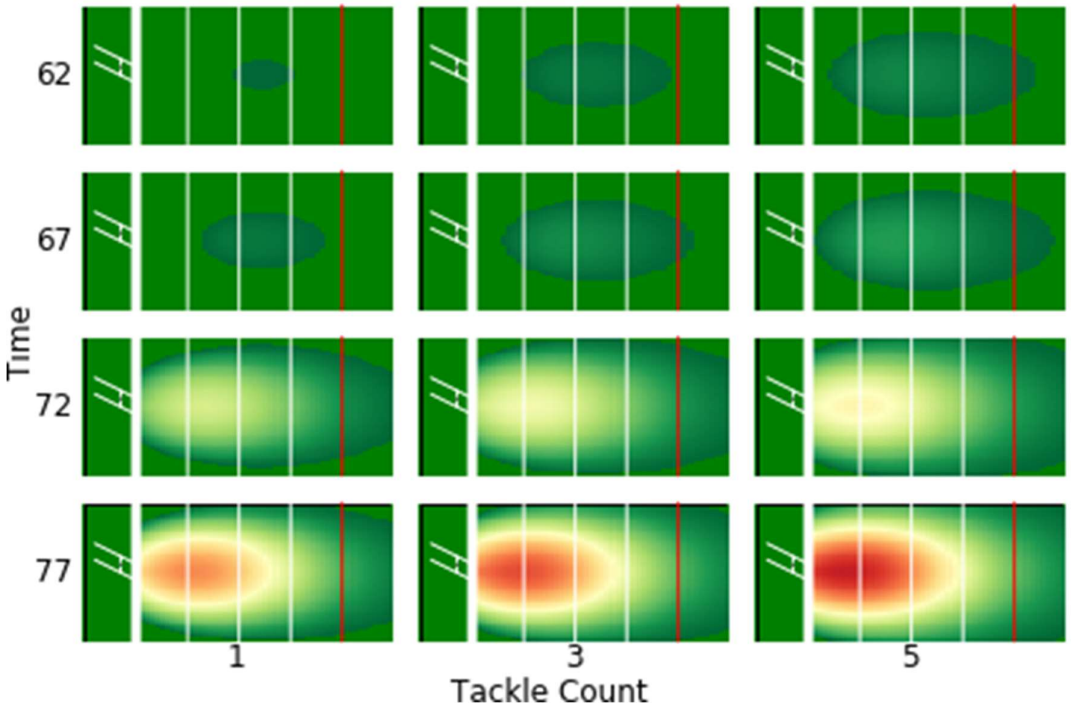
In our model, this quantity will depend on:

1) The relative strength of the two teams
2) The current score
3) The time elapsed in the match
4) The current field position
5) The current tackle count

Sezer's 67th minute field goal was taken after the fifth tackle which occurred 8m from the try-line and about 26m from the touchline. If we

for the moment or hypothetical try and field goal probabilities, then attempting a field goal changed the probability of victory from 60.4% to 62.2%, an increase of about 1.8%.

INCREASE IN PROBABILITY OF VICTORY IF FIELD GOAL IS ATTEMPTED IN THE SHARKS VS RAIDERS ATCH WITH THE SCORES AT 12-ALL. SOLID GREEN IN AREAS WHERE ATTEMPTING A FIELD GOAL DOES NOT INCREASE THE CHANCE OF WINNING



The plot above shows the conditions under which a field goal attempt increases the probability of victory in the case of the Sharks vs. Raiders match when the score is tied at various positions in the match. As expected, the efficacy of field goals increases as full-time approaches.