Football Analytics Questionnaire

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1)

It's second-and-eight at midfield with the game tied early in the first quarter. How many yards must the offense gain for the play to be a good outcome for them? Why?

There are several ways one could approach this question.

A.

- Using publicly available NFL play-by-play data, build a machine learning model to predict the expected number of points scored at the end of the possession given current game state
- Compute expected points added (EPA) between the outcome of the next play and the current situation (second-and-eight at midfield with the game tied early in the first quarter).
- A good outcome is a positive EPA while a bad outcome is a negative EPA.

B.

- I could build a win probability model using similar data predicting the probability of winning the game given the current situation or state of game adjusting for team and player strengths.
- From the model, I can predict the estimated win probability in this situation (A second-and-eight at midfield with the game tied early in the first quarter) as well as the situation resulting from the next play.
- Compute the win probability added (win probability after next play minus win probability of current state).
- If the win probability added is positive, then it can be classified as a good outcome. Otherwise, it is a bad outcome.

C.

- Similar method as above but instead of win probability, I could build a model to predict the probability of converting a first down.
- This can specifically tell you how many yards does the offense need to gain on the next play to have a higher chance of converting the first down than before.

Overall, if the result of the next play puts you in a better position to win the game, then it is a good outcome.

2)

Measuring passing efficiency is hard. ESPN Total QBR is one attempt to improve on traditional QB passer rating. Explain concisely at least two others.

- Defense Adjusted Value over Average (DVOA)
  - Metric made by Football Outsiders that attempts to evaluate teams or players (including QBs) on each play outcome against the league average outcome as a baseline adjusted for game situation or context and opponent defensive strength.
  - An average play will have a DVOA of 0%. Any deviation above/below 0 represents the percentage above/below league average for that specific play.
  - Can aggregate by QB and compare/rank quarterbacks more accurately than total QBR.
- Win Probability Added (WPA)
  - Developed by NFL Advanced Stats, measures the impact of each play toward winning and losing
  - A model built to predict teams chances of winning based on game contextual info (time, score, down, distance, field position)
  - Every play is scored based on the difference of win probabilities of the current play to that from the previous play
  - Can aggregate win probability added by quarterback to rank which quarterbacks provided the most value to their teams.

3)

Many have argued that NFL teams should attempt to convert more fourth downs than they currently do. Briefly summarize this argument and provide at least two critiques of it.

The argument stems from traditionalists or risk-averse football minds believing that attempting fourth down conversions more frequently hurts a team's chance of winning. However, analytically-minded individuals have done the math (historical 4th down conversion rates and model building) that provides evidence the optimal decision to maximize chance of winning is to go for it on 4th down occurs more often than traditionalists believe. Yes, there are situations where going for it is the wrong decision (4th and 15+ at your own 20 yard line) but many situations such as 4th and short in the red zone down by 4 late is a definite go for it situation. Part of the issue is that sports tends to be an industry where we fear losing more than we want to win. Therefore, a team can convert 5 consecutive 4th down conversions but fail on the 6th and must deal with criticism from fans and media if the failed conversion leads to a loss. People need to understand it's not always about the outcome, but about the process.

4)

What yard line does a team have to reach to be in FG range? Why?

For simplicity, one can take each kicker's longest made field goal and call that the defined boundary of FG range. However, FG range per kicker varies depending on current game situation, playing field, and weather. Part of NFL's Next Gen Stats includes a model to predict the probability of making a field goal. Their field goal probability model estimates the likelihood of a made field goal, given the distance of the kick, weather and stadium type. Using this

model, we can define the field goal range as the longest distance that gives the kicker above some threshold probability (above 50%) of making the kick adjusting for weather and stadium. Also, all kickers are not the same so adjusting for each kicker's unique skill and ability must also be taken into account.

5)

Suppose there is a normal draft and that all teams are about equally good at drafting players. According to current prices, the No. 8 pick is generally worth about No. 15 and No. 50. Would you rather have No. 8, or would you rather have No. 15 and No. 50? Explain concisely.

The long-time NFL trade value chart created by Jimmy Johnson also shows that the No. 8 pick is similar in value to that of the No. 15 and No. 50 pick combined. Although a better approach would be to estimate average value per pick by fitting a curve to aggregated career approximate value metric or against surplus value (value of on-field performance minus cost of contract). Unless there is a projected franchise changing player (high-ranked QB) that falls in the draft to 8, I would prefer to have No. 15 and No 50 picks instead of the No. 8 pick. I believe in maximizing talent across an entire roster and the difference in value may be minimal between the No. 8 and No. 15 player that I would definitely trade back to obtain two picks and increase my number of options.

6)

What are some of the most valuable positions on a football roster and why? What are some of the lease valuable and why?

- Most Valuable
  - QB, OL, Edge Rushers (DE, OLB), C, SS
  - Logically and mathematically and unlike most team sports, everyone agrees there exists a position that is unanimously chosen as the most important position (QB). Teams that win do not have poor quarterback play.
  - Offensive lineman, especially left and right tackles that protect the QB's blind side and from pass rushing. We saw what happened to Mahomes and the Chiefs with an injured offensive line in the 2021 super bowl against the Bucs. Centers also contribute a lot in terms of protecting the pocket for the QB and opening up inside run routes for the RB.
  - On the other side, edge rushers pressure the quarterback and can neutralize a dual-threat QB and make them work much harder.
  - Safety's must cover a lot of ground and make many impact plays in the backfield and deep down-field (very athletic position).
- Least Valuable
  - RB, FB, P, K, Special Teams Returner, Long Snapper
  - Recent history shows RBs have lost leverage in contract extension negotiations. Strength in O-Line and blocking help the running game. Many RBs can be replaced with the "next man up" mentality.
  - In specific moments, kickers effect the game a lot in the scoring department (Just ask Adam Vinatieri). However, the amount of game time kickers, punters, long snappers, and special team returners are on the field is minimal compared to offensive and defensive players. And often times, those positions are easily replaceable, especially with punt/kick returners who often go to the fastest/quickest players on the team.

7)

How would you define a balanced offense? Why?

Balance can be defined as the ratio of pass plays to run plays per team's offense on every play such as the recommended 60%/40% split of pass/rush. However, this ratio has some bias in "garbage time" situations where teams may run heavy to run out the clock. Therefore, I would define a balanced offense not based on pass/rush splits, but based on how a team uses their skill players. An unbalanced offense may rely on 1-2 elite players on both ends. A balanced offense will distribute the workload more uniformly across all players in their respective position group. A balanced offense will also attack defenses with multiple versatile players at skilled positions that can play multiple roles (TEs that can catch and block or RBs that can run and pass catch).

8)

With three minutes left in the game, we score a touchdown to cut the deficit to eight points. We need to decide whether to kick the extra point or go for two. Which is the better choice? Why?

In this specific situation (down by 8 with 3 minutes left), it's a better choice to go for two instead of kicking the extra point in the long run. We can think about it logically.

If a team is against going for two, then they need to play perfect football in the last 3 minutes to essentially not lose the game or at least force overtime. That is convert the extra point, force a punt on the other end, and score another TD plus the extra point to tie the game. Only outcomes can be either to lose the game on a missed extra point or force overtime, but cannot win the game in regulation.

In contrast, if a team always goes for two, then only converting 1 of 2 2-point tries is needed to reach the above scenario given an unsuccessful first attempt at going for 2. If the first 2 point conversion is successful, then the second try only needs to be an extra point attempt to win the game. In today's rule where the extra point is at the 15 yard line instead of the 2, the probability of converting the extra point is no longer with 99% certainty. Regardless of the decision, you are still down in the game and still need to rely on the defense to get a stop quickly. The opportunity of going for 2 to be down only 6 outweighs the risk of being down 8 or 7 with an unsuccessful 2 point conversion or an extra point conversion.

9)

Suppose a good kicker makes 3/4 of his field goals from exactly 50 yards and a bad one makes 2/3 of his field goals from exactly 50 yards. We bring Martin, a college kicker, in for a tryout. Before he kicks, we think he's equally likely to be a good kicker as a bad one. We ask him to take two 50-yard kicks. He makes both.

A)

What is the probability Martin is a good kicker?

- Let's use Bayes Theorem to answer this question.
- Our prior belief on the probability of Martin being a good kicker or bad kicker is 50/50

- $\Pr(\text{Good}) = 0.5$ and $\Pr(\text{Bad}) = 0.5$

- We observe Martin make both of his 50 yard field goal attempts.
- Given Martin is a good kicker, the probability that he makes both of his two kicks is $\frac{3}{4} * \frac{3}{4} = \frac{9}{16}$
  - $\Pr(\text{Makes Both} \mid \text{Good}) = \frac{9}{16}$
- Given Martin is a bad kicker, the probability that he makes both of his two kicks is $\frac{2}{3} * \frac{2}{3} = \frac{4}{9}$
  - $\Pr(\text{Makes Both} \mid \text{Bad}) = \frac{4}{9}$
- Therefore, the posterior probability that Martin is a good kicker given he made both of his kicks is…
  - $\Pr(\text{Good} \mid \text{Makes Both}) = \frac{\Pr(\text{Makes Both} \mid \text{Good}) * \Pr(\text{Good})}{\Pr(\text{Makes Both} \mid \text{Good}) * \Pr(\text{Good}) + \Pr(\text{Makes Both} \mid \text{Bad}) * \Pr(\text{Bad})}$
  - $\Pr(\text{Good} \mid \text{Makes Both}) = \frac{\frac{9}{16} * \frac{1}{2}}{\frac{9}{16} * \frac{1}{2} + \frac{4}{9} * \frac{1}{2}}$
  - $\Pr(\text{Good} \mid \text{Makes Both}) = 0.5586$

B)

How many more 50-yard kicks would Martin have to make in a row for you to think there's at least a 90% chance Martin is a good kicker?

- Let random variable X represent the number of kicks Martin makes in a row.
- $0.9 = \Pr(\text{Good} \mid X = x) \leq \frac{\Pr(X = x \mid \text{Good}) * \Pr(\text{Good})}{\Pr(X = x \mid \text{Good}) * \Pr(\text{Good}) + \Pr(X = x \mid \text{Bad}) * \Pr(\text{Bad})}$
- $0.9 \leq \frac{\left(\frac{3}{4}\right)^x * \frac{1}{2}}{\left(\frac{3}{4}\right)^x * \frac{1}{2} + \left(\frac{2}{3}\right)^x * \frac{1}{2}}$
- $x \geq 18.655$ or $x \geq 19$
- Martin is currently 2 for 2 on 50 yard field goal attempts. Therefore, he must make an additional 17 kicks in a row for there to be at least a 90% chance of Martin being a good kicker.