Quantifying the causal effects of conservative fourth down decision making in the National Football League

Derrick R. Yam, derrick_yam@brown.edu

Michael J. Lopez, Ph.D, mlopez1@skidmore.edu

Objective: To estimate the potential number of games lost for each NFL team due to conservative fourth down behavior, while controlling for confounding variables.

Motivation

"There's so much more involved with the game than just sitting there, looking at the numbers and saying, 'OK, these are my percentages, then I'm going to do it this way,' because that one time it doesn't work could *cost your team a football game*, and that's the thing a head coach has to live with, not the professor."
– Bill Cowher

Treatment: 4th down behavior

- Teams historically behave less aggressive than they should.
- Of roughly 13,000 plays in the New York Times 4th down bot "go for it" range, teams actually went for it ~ 35% of time.

What would outcomes look like if teams went for it when they should have?
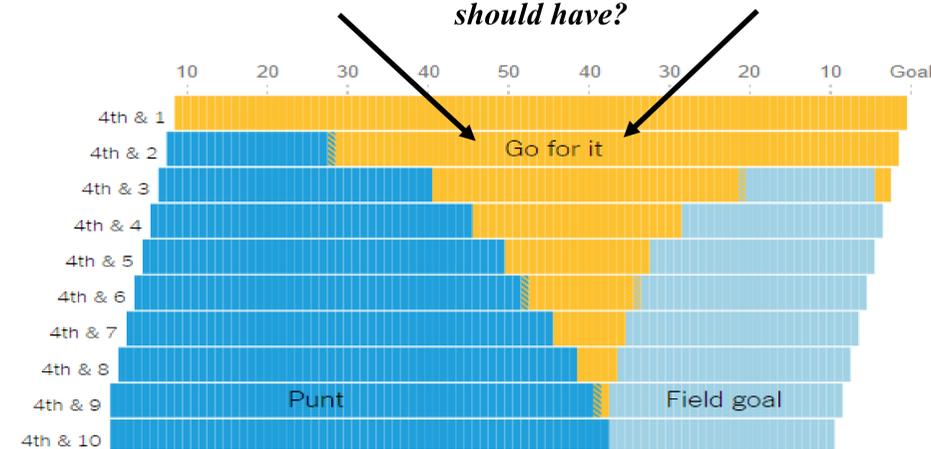
4th down outcomes are a missing data problem

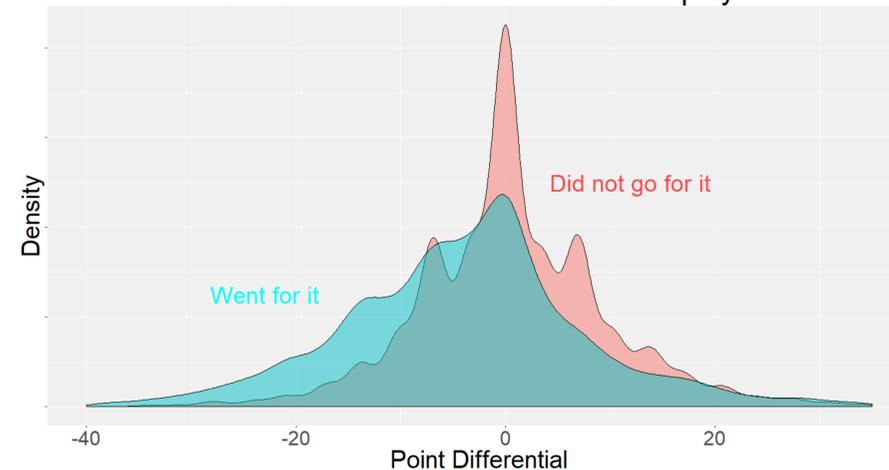| i	Covariates X_i	Treatment W_i	Outcome $Y_i(W_i=0)$	Outcome $Y_i(W_i=1)$
$i = 1$	X_1	$W_1 = 0$	$Y_1(0)$	?
$i = 2$	X_2	$W_2 = 0$	$Y_2(0)$	?
$i = 3$	X_3	$W_3 = 1$	?	$Y_3(1)$
$i = 4$	X_4	$W_4 = 1$	?	$Y_4(1)$
...	...	...	...	...

Causal estimand of interest: wins added

$$ATC_f = \sum_{i:W_i=0} (Y_f^{mis}(1) - Y_f^{obs}(0)).$$

for each NFL franchise, f, where $f = 1, 2, ...32$

Before Matching:

- Teams that went for it differ inherently from those that did not.

Point differential before fourth down plays

How matching works:

- Teams that did not go for it matched to those that did based on: win probability, game time, yards to go, and propensity score (defined as the probability of going for it).

Falcons Vs. Packers
4th & 2 on the opposing 35 yard line
5 minutes into the game. The game is tied.
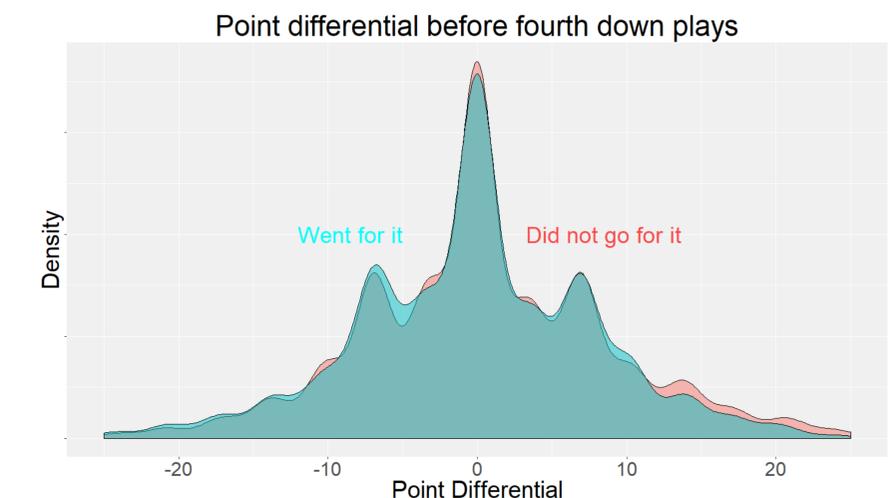Play Call: ATL punts
Outcome: ΔWP = -2.41%

Patriots Vs. Saints
4th & 2 on the opposing 32 yard line
10 minutes into the game. The game is tied.
Play Call: NE goes for it
Outcome: ΔWP 8.45%

$i = 1$	$e(x) = 54\%, wp = 54\%$ time $= 5...$	$W_1 = 0$	$Y_1^{obs}(0) = -2.4\%$	$Y_1^{mis}(1) = 8.5\%$

After Matching:

- Increased similarity between teams that went for it & those that did not.

Point differential before fourth down plays

Outcome

- Change in win probability, calculated using average of two models:
  - **Lock & Nettleton's** Random Forest model.
  - **NFLscrapR's** Generalized Additive model.
- Distributions of wins added estimated using non-parametric bootstrap.
  - Number of wins is the aggregated pairwise difference in the change in win probability between "going for it" and "kicking".

Results: Estimated ATC_f's

Estimated Numbers of Wins Added from 2004 - 2016
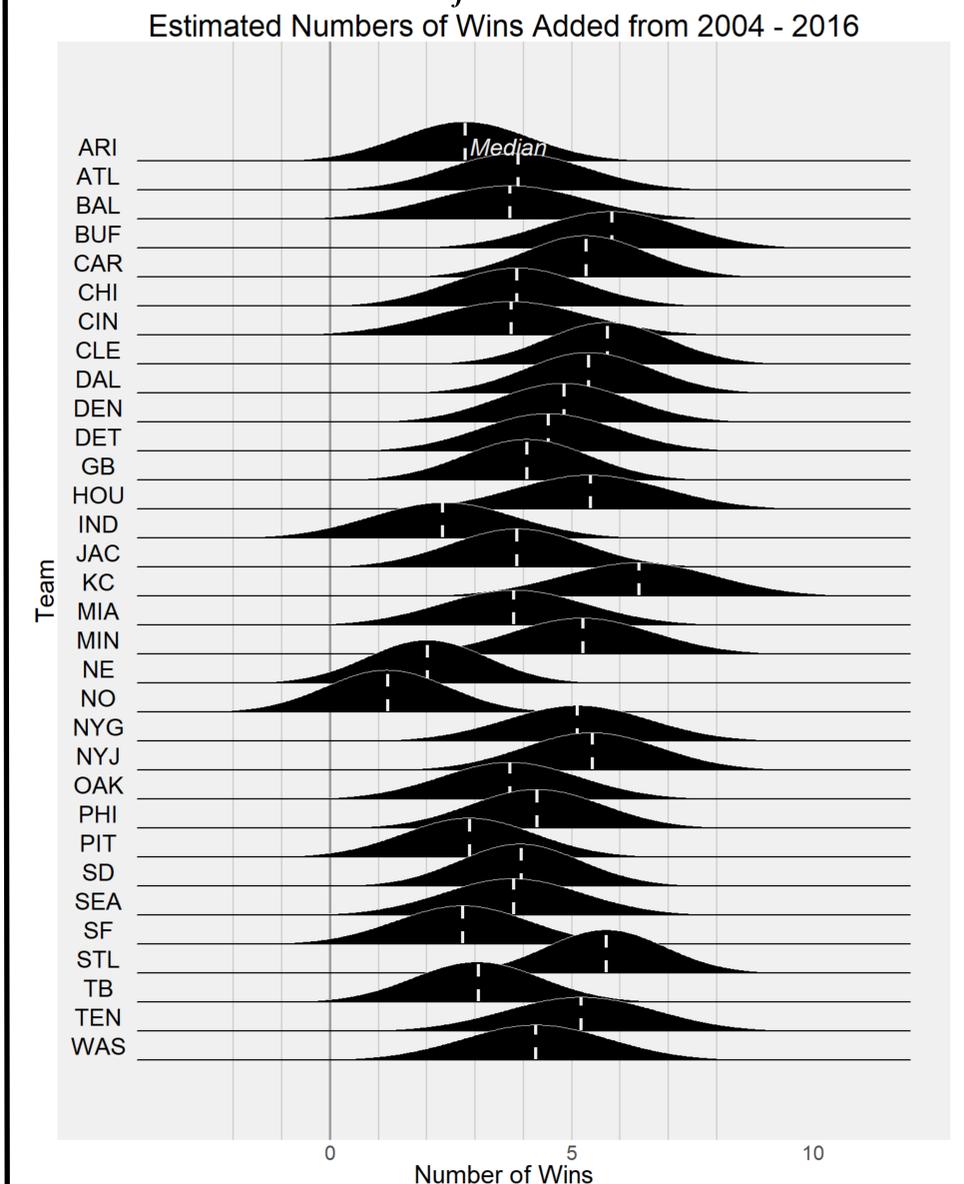
Summary

- Median number of wins added ~ 4.2.
- Significant evidence ~ 80% of teams would have won more games.
- Maximum number of additional wins is Kansas City (6.4).
- Minimum number of additional wins is New Orleans (1.8).