

# Using Random Forests to Estimate Win Probability Before Each Play of an NFL Football Game

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# Introduction

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- Idea
  - At any specific moment of an NFL game, find the probability a particular team will ultimately win the game.
    - For example, what's the probability a team receiving the ball on the 20 yard line down 3 with 2 minutes left will go on to win the game?
    - We combine pre-play variables to estimate win probability (WP) at any moment in an NFL game using a random forest methodology.



# Introduction

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- Idea
  - Demonstrate the use of WP estimates:
    - Fan interest
      - Plot the course of a game using win probability
      - Real time win probability estimation
    - Evaluate plays and play calling decisions
      - Example: Was Baltimore's decision to take an intentional safety late in the 4<sup>th</sup> quarter of Superbowl 47 a good one?



# Introduction

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- Motivation
  - Develop an alternative to Brian Burke’s win probability found at [www.advancednflstats.com](http://www.advancednflstats.com)
  - Why?
    1. Estimate WP empirically through objective “binning”.
    2. Include information measuring the quality of both teams competing.
    3. Develop a method that can be easily repeated on a new set of variables, especially in a different sport.



# Random Forest Method

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- Data

- Recently (since 2000) the NFL began releasing play-by-play data from all games, regular and post season.
  - We use the seasons 2001 – 2011 as training data and the 2012 season as test data.
  - Data was found at: [www.armchairanalysis.com](http://www.armchairanalysis.com)



# Random Forest Method

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- Data
  - Observational Unit: A pre-play situation observed with respect to the offensive team.
    - Example: 1<sup>st</sup> and 10 on the 20 yard line down by 3 with 2 minutes left
    - Score Difference = -3 implies the team with the ball is losing by 3.
    - Win probability is estimated for the offensive team.



# Random Forest Method

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- Data

- Variables:

- Binary Response,  $y_i = I(\textit{Offense Won}_i)$
    - Predictor variables: down, yards to go for a first down, field position, seconds remaining, score difference, adjusted score difference, total points scored, and the Las Vegas point spread

$$\text{adjusted score difference} = \frac{\text{score difference}}{\sqrt{\text{seconds remaining}}}$$



# Random Forest Method

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- Random Forest
  - A random forest is a combination of either classification or regression trees.
    - A tree is effectively a nearest neighbors method of binning observations on values of the predictor variables in order to maximize within-bin homogeneity of the training responses.
    - We chose to use a random forest of regression trees.
      - A regression tree takes the average of the response values in a resulting bin as a predicted response for future observations in that bin.





# Random Forest Method

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- Random Forest
  - Each tree of the random forest has two adjustments in order to grow a variety of trees:
    1. Each tree is grown on a bootstrapped version of the original sample.
    2. At each split of the training observations, only a subset of the variables are considered as candidates for deciding the splitting rule.



# Results

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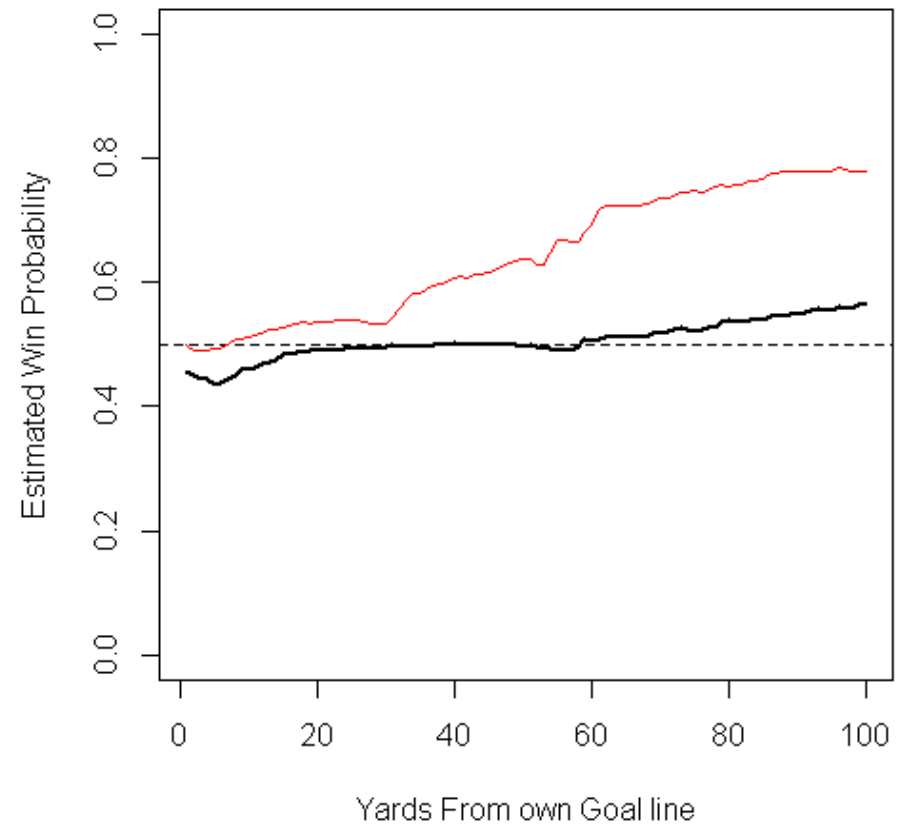
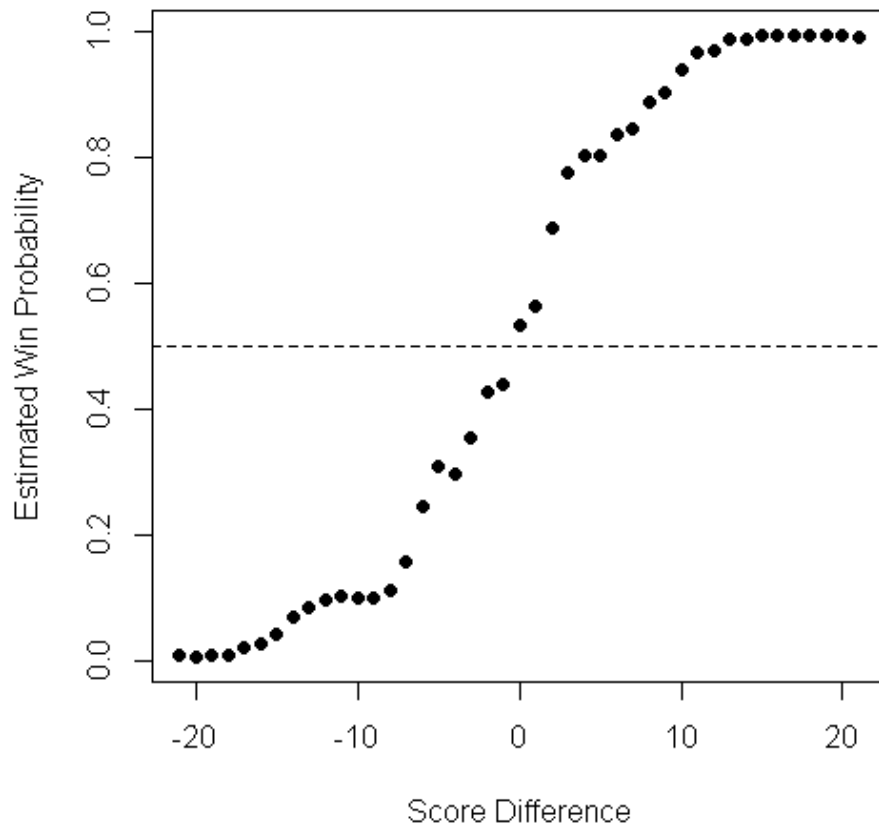
- Performance
  - Test set Mean Absolute Error by quarter:

Quarter:	1	2	3	4
Error:	<i>0.408</i>	<i>0.346</i>	<i>0.276</i>	<i>0.199</i>



# Results

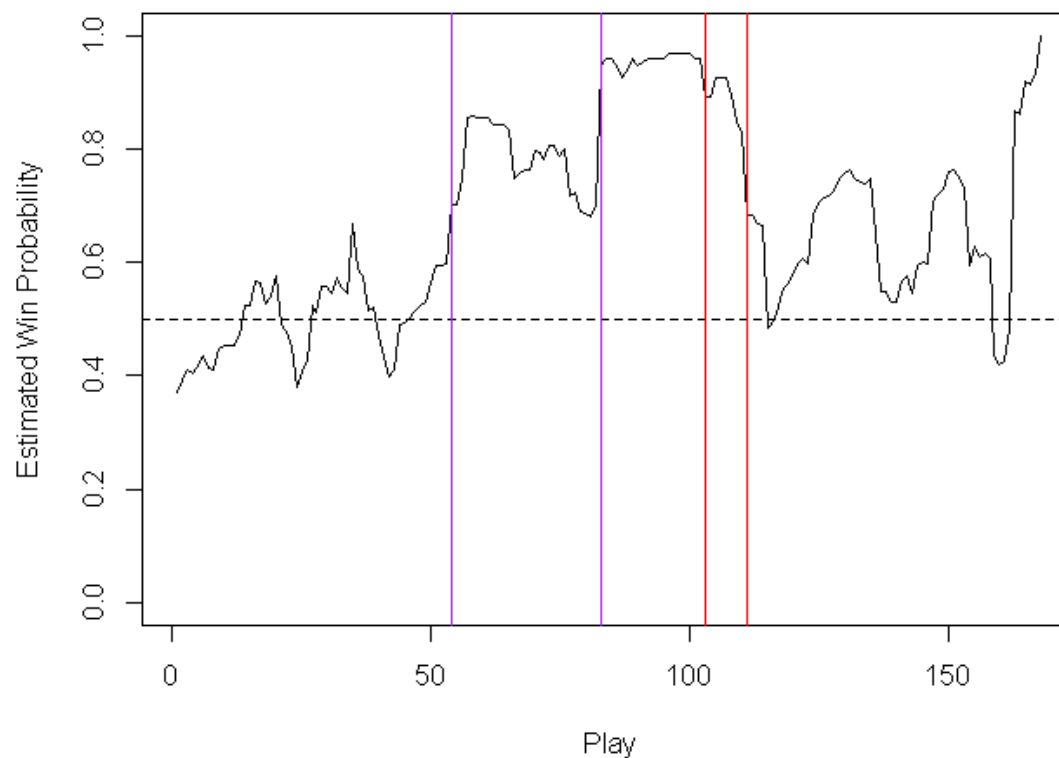
- Performance





# Results

- Superbowl 47 (BAL 33 – 30 SF)





# Results

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- Play Calling
  - By taking an intentional safety Baltimore increased their WP from 91.4% to 94.2%.
  - Changes in Win Probability ( $\Delta WP$ ) such as this can be used to evaluate play calling decisions.
  - For instance by kicking a surprise onside kick (successfully) in Superbowl 44, the Saints increased their win probability by 7%.



# Results

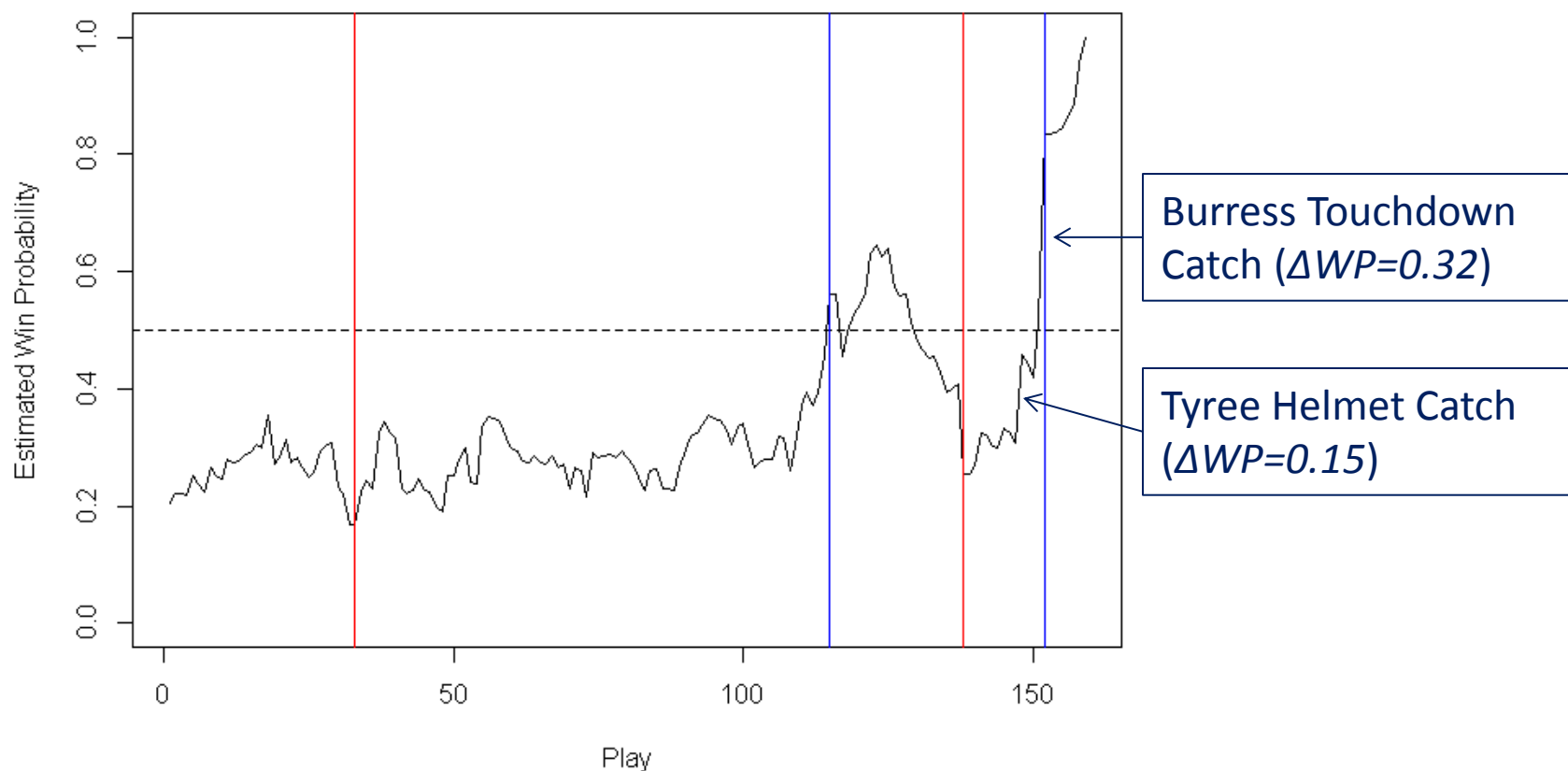
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- Play Calling
  - We can also use average  $\Delta WP$  to evaluate play calling decisions, examples:
    - The average  $\Delta WP$  for surprise onside kicks is +0.02.
    - With 4<sup>th</sup> down decisions average  $\Delta WP$  shows evidence that with 3 or fewer yards remaining it is better to attempt to pick up the first down.



# Results

- Superbowl 42 (NYG 17 – 14 NE)





# Results

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- Influential Plays

- We can judge the most influential plays from a set of plays (season, game, etc.) using  $\Delta WP$ .
  - The best Superbowl play of the last 12 years as judged by  $\Delta WP$  was James Harrison's 100 yard interception return before halftime in 2008 ( $\Delta WP=0.343$ ).
  - The best 2 plays of the 2012 season were both receptions by Cecil Shorts of the Jacksonville Jaguars:
    - 80 yard touchdown v. Colts down 3 with 1:45 left ( $\Delta WP=0.680$ )
    - 39 yard touchdown v. Vikings down 3 with 0:20 left ( $\Delta WP=0.694$ )





# Future Considerations

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- Independence Problem
  - Each game has approximately 150 observations all predicting 1 response value (Won or lost).
  - We have tried multiple solutions but none show advantages in prediction.



# Future Considerations

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- Variables
  - We are currently looking to include variables which measure how the game has developed
    - Examples include yards gained, yards allowed, number of possessions, etc.
  - This idea could be especially beneficial for estimating WP in other sports.
    - Basketball: Shooting percentages, turnovers, rebounding



# Takeaways

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- Two Takeaways
  - The Random Forest is a fairly simple and effective way of estimating win probability.
  - Estimated WP can have many uses.
    - *“In any sport win probability is basically the holy grail of analytics.”*

-Brian Burke



Thank You!

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