



Football IV

Produced by Dr. Mario | UNC STOR 538



Football Decision Making



- ❖ **5 Key Decisions in Football**
 - ❖ Fourth and 4 on Opponent's 30 Yard Line. Field Goal or Punt?
 - ❖ Fourth and 4 on Own 30 Yard Line. Attempt or Punt?
 - ❖ Gained 7 Yards on First Down From Own 30 Yard Line and Defense Was Offsides. Accept the Penalty?
 - ❖ Opponent Gained 0 Yards on Run on First Down. They were Offside. Accept the Penalty?
 - ❖ Optimal Run/Pass Mixture on First Down? → Look at Later

- ❖ **Decision Based on States of Football**

- ❖ **Best Decision Maximizes the Expected Margin**

Expected Margin = $V(\text{Down}, \text{Yards For 1st Down}, \text{Yard Line})$





Football Decision Making



❖ Examples of Expected Margin Based on States

❖ $V(1,10,50) = 1.875$

❖ $V(3,3,80) = 3.851$

❖ $V(2,9,5) = -1.647$

❖ Works of Konstantinos Pelechrinis

❖ University of Pittsburgh in School of Computing and Information

❖ Excellent Sports Analytics Course

❖ Recent Research on American Football

❖ Analyzes Decision Making Based on Expected Points

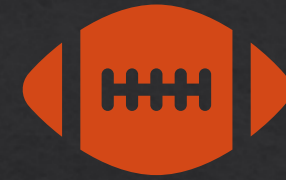
❖ Problem He Discusses: All Analysis is From View of Offense

❖ Builds Predictive Model for NFL Games





Football Decision Making



- ❖ Fourth and 4 on Opponent's 30 Yard Line
 - ❖ Evaluate Expected Margin if Team Attempts to Get 1st Down

$$\begin{aligned}
 E[\text{Margin}|\text{Go For It}] &= P(\text{Success})E[\text{Margin}|\text{Success}] + P(\text{Failure})E[\text{Margin}|\text{Failure}] \\
 &= P(\text{Success}) \times V(1,10,75) - P(\text{Failure}) \times V(1,10,28)
 \end{aligned}$$

What Assumptions are Being Made Here?

- ❖ Evaluate Expected Margin if Team Attempts Field Goal

$$\begin{aligned}
 E[\text{Margin}|\text{Field Goal}] &= P(\text{Success})E[\text{Margin}|\text{Success}] + P(\text{Failure})E[\text{Margin}|\text{Failure}] \\
 &= P(\text{Success}) \times (3 - V(1,10,27)) - P(\text{Failure}) \times V(1,10,37)
 \end{aligned}$$

What Assumptions are Being Made Here?





Football Decision Making



❖ Fourth and 4 on Opponent's 30 Yard Line

❖ Modeling Probability of Making Field Goal

- ❖ Let p Represent the Probability of Making a Field Goal
- ❖ Assumption: Distance Effects p
- ❖ Let d Represent the Distance of the Field Goal
- ❖ Consider the Linear Regression

$$p = \beta_0 + \beta_1 \times d + \epsilon \quad \leftarrow \text{What is the Problem Here?}$$

❖ Consider the Logistic Regression

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 \times d$$

❖ What Other Considerations Should Be Made?

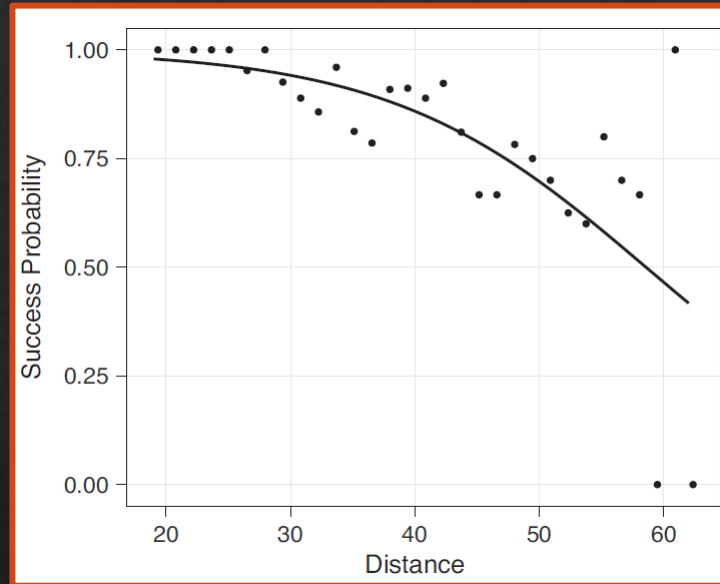




Football Decision Making



- ❖ Fourth and 4 on Opponent's 30 Yard Line
- ❖ Modeling Probability of Making Field Goal
- ❖ Data From 2017



Logistic Regression
Smooths This
Relationship?



- ❖ Estimated Model:

$$\log\left(\frac{\hat{p}}{1-\hat{p}}\right) = 5.697 - 0.097 * d$$



Football Decision Making



- ❖ Fourth and 4 on Opponent's 30 Yard Line
 - ❖ Modeling Probability of Making Field Goal
 - ❖ Expected Margin for States of Interest

$$V(1,10,75) = 3.884$$

$$V(1,10,28) = 0.336$$

$$V(1,10,27) = 0.266$$

$$V(1,10,37) = 0.979$$

- ❖ Calculate Probability of 47-yard FG

$$\hat{p} = \frac{e^{5.697 - 0.097 \cdot 47}}{1 + e^{5.697 - 0.097 \cdot 47}}$$

- ❖ Expected Margin Under Field Goal

$$0.76 \times (3 - 0.266) - 0.24 \times 0.978 = 1.84$$





Football Decision Making



- ❖ Fourth and 4 on Opponent's 30 Yard Line
- ❖ Modeling Probability of Making Field Goal
- ❖ When to Go for First Down

$$P(\text{Success}) \times 3.884 - (1 - P(\text{Success})) \times 0.336 \geq 1.84$$

$$P(\text{Success}) \times 3.884 - 0.336 + 0.336 \times P(\text{Success}) \geq 1.84$$

$$4.22 \times P(\text{Success}) \geq 2.176$$

$$P(\text{Success}) \geq 0.516$$

- ❖ According to Football Reference

Yards to Go	Probability 3 rd or 4 th Down Play Makes the First Down
1	.67
2	.55
3	.51
4	.48
5	.45





Football Decision Making



- ❖ Fourth and 4 on Our 30 Yard Line
- ❖ Evaluate Expected Margin If We Punt

$$E[\text{Margin}|\text{Punt}] = -V(1,10,25) = -0.46$$

$$E[\text{Margin}|\text{Punt}] = -P(5 \text{ YD}) \times V(1,10,65) - P(10 \text{ YD}) \times V(1,10,55) - \dots - P(65 \text{ YD}) \times V(1,10,5)$$



Consideration of All Possible Punt Scenarios
Assuming the Punt is Not Blocked

- ❖ Evaluate Expected Margin If We Go For It

$$\begin{aligned} E[\text{Margin}|\text{Go For It}] &= P(\text{Success}) \times V(1,10,35) - P(\text{Failure}) \times V(1,10,68) \\ &= P(\text{Success}) \times 0.839 - P(\text{Failure}) \times 3.265 \end{aligned}$$

- ❖ Need 67.8% Probability to Justify Going for First Down
- ❖ Romer: Should Go For It if Probability is At Least 45%





Football Decision Making



❖ Simpler Scenarios

❖ Gained 7 Yards on 1st Down from 30 Yard Line and Defense Offsides

$V(2,3,37) = 0.956$ → Don't Accept Penalty

$V(1,5,35) = 0.983$ → Accept Penalty

❖ Opponent Ran for 0 Yards on 1st Down on 30 Yard Line and Offense Offsides

$V(2,10,30) = 0.115$ → Don't Accept Penalty

$V(1,15,25) = -0.057$ → Accept Penalty

❖ Do You See Any Problems With Using This to Make Decisions?





Final Inspiration

**This is no democracy.
It is a dictatorship.
I am the law.**

- Coach Herman Boone