Decrease in Mean Value of NFL Extra Points

Sean Cooke

November 29, 2017

Abstract

Before the 2015 National Football League (NFL) season, Rule 11 Section 3 Article 1 of the was changed. This rule change moved the line of scrimmage for Conversion Kicks from the defensive team's 2-yard line to the the defensive team's 15-yard line and allowed the defense team to return any missed conversion for 2 points. We will explore how this rule change affected the mean value of NFL conversions.

1 Background

NFL Football is a ball game played by two teams. The team with the greater number of points wins the game. Regular season games may end in a tie. Postseason games cannot end in a tie. Teams attempt to score touchdowns by carrying the ball into their opponents end zone. After a team scores a touchdown for 6 points, they may attempt a conversion. It is a Safety if the spot of enforcement for a foul by the offense is behind its own goal line, or if the ball is dead in possession of a team on or behind its own goal line when the impetus comes from the team defending that goal line.²

The defensive team can earn points on a conversion. Since there are two teams in a game and the team with the greater score wins, the defensive team earning two points effectively takes two points away from the offensive team.

Before the 2015 change to Rule 11 Section 3 Article 12, 2 points can be earned by successfully completing a two-point conversion. 1 point can be earned by successfully completing a conversion kick. 0 points can be earned by unsuccessfully completing a two-point conversion or by unsuccessfully completing a conversion kick. -1 points can be earned by recording a safety against either team.

After the 2015 change to Rule 11 Section 3 Article 12, the line of scrimmage for conversion Kicks moved from the defensive team's 2-yard line to the defensive team's 15-yard line and -2 points can be earned by having the defensive team return any missed conversion to the offensive team's end zone.

2 Data

We will be using play by play data from NFLsavant.com.¹ Three years of data (2013, 2014, and 2015) will be used. 2013 and 2014 are the two years prior to the rule change and 2015 is the first year following the rule change.

Let a_0 be the number of successful two-point conversions in 2013 and 2014. Let b_0 be the number of two-point conversion attempts in 2013 and 2014. Let c_0 be the number of successful one-point conversions in 2013 and 2014. Let d_0 be the number of one-point conversions kicks in 2013 and 2014.

Let a_1 be the number of successful two-point conversions in 2015. Let b_1 be the number of two-point conversion attempts in 2015. Let c_1 be the number of successful one-point conversions in 2015. Let d_1 be the number of attempted one-point conversions in 2015. Let j_1 be the number of times the defense returned any missed Try for 2 points in 2015.

$$a_0 = 64
 b_0 = 133
 c_0 = 2337
 d_0 = 2352
 a_1 = 45
 b_1 = 96
 c_1 = 1148
 d_1 = 1219
 j_1 = 1$$
(1)

3 Probabilities

Since the line of scrimmage for conversion kicks, moved back 13 yards after the 2015 change to rule Rule 11 Section 3 Article 1, the probability of a successful conversion kick changed. Let p_{20} be the probability 2 points were awarded to the team attempting the conversion in 2013 and 2014. Let p_{10} be the probability 1 point is awarded to the team attempting the conversion in 2013 and 2014. Let p_{00} be the probability 0 points were awarded to the team attempting the conversion in 2013 and 2014. Let p_{-10} be the probability 1 point was awarded to the team defending the conversion in 2013 and 2014. Let p_{-20} be the probability 2 points were awarded to the team defending the conversion in 2013 and 2014. Let p_{-20} be the probability 2 points were awarded to the team defending the conversion in 2013 and 2014.

We have

$$p_{2_0} = \frac{a_0}{b_0 + d_0}$$

$$p_{1_0} = \frac{c_0}{b_0 + d_0}$$

$$p_{0_0} = 1 - \frac{a_0 + c_0}{b_0 + d_0}$$

$$p_{-1_0} = 0$$

$$p_{-2_0} = 0$$
(2)

Let p_{2_1} be the probability 2 points were awarded to the team attempting the conversion in 2015. Let p_{1_1} be the probability 1 point is awarded to the team attempting the conversion in 2015. Let p_{0_1} be the probability 0 points were awarded to the team attempting the conversion in 2015. Let p_{-1_1} be the probability 1 point was awarded to the team defending the conversion in 2015. Let p_{-2_1} be the probability 2 points were awarded to the team defending the conversion in 2015.

$$p_{2_{1}} = \frac{a_{1}}{b_{1} + d_{1}}$$

$$p_{1_{1}} = \frac{c_{1}}{b_{1} + d_{1}}$$

$$p_{0_{1}} = 1 - \frac{a_{1} + c_{1} + j_{1}}{b_{1} + d_{1}}$$

$$p_{-1_{1}} = 0$$

$$p_{-2_{1}} = \frac{j_{1}}{b_{1} + d_{1}}$$
(3)

4 Sample Mean Value

Since the probability of a successful Try Kick changed, the mean value of a Conversion changed. Suppose we have a random variable X with PMF

$$p_i = P(X = i), i = 0, 1, \dots, N$$

The mean value of X is

$$\mu_{X_0} = \mathbf{E}[X] = \sum_{i=0}^N ip_i$$

Let the random variable X_0 be the number of points added to the offensive team's score after attempting a conversion before the rule change. Let the random variable X_1 be the number of points added to the offensive team's score after attempting a conversion after the rule change.

We have

$$\begin{split} \mu_{X_0} &= \mathbf{E}[X_0] \\ &= \sum_{i=-2}^2 i * p_{i_0} \\ &= -2 * p_{-2_0} + -1 * p_{-1_0} + 0 * p_{0_0} + 1 * p_{1_0} + 2 * p_{2_0} \\ &= -2 * p_{-2_0} - 1 * p_{-1_0} + 0 * p_{0_0} + 1 * p_{1_0} + 2 * p_{2_0} \\ &= -2 * p_{-2_0} - p_{-1_0} + 0 + p_{1_0} + 2 * p_{2_0} \\ &= -2 * p_{-2_0} - p_{-1_0} + p_{1_0} + 2 * p_{2_0} \\ &= -2 * 0 - 0 + \frac{c_0}{b_0 + d_0} + 2 * \frac{a_0}{b_0 + d_0} \\ &= 0 - 0 + \frac{c_0}{b_0 + d_0} + 2 * \frac{a_0}{b_0 + d_0} \\ &= \frac{c_0}{b_0 + d_0} + 2 * \frac{a_0}{b_0 + d_0} \\ &= \frac{c_0 + 2 * a_0}{b_0 + d_0} \\ &= \frac{2337 + 2 * 64}{133 + 2352} \\ &\approx 0.99195 \end{split}$$

and

$$\mu_{X1} = \mathbf{E}[X_1]$$

$$= \sum_{i=-2}^{2} i * p_{i_1}$$

$$= -2 * p_{-2_1} + -1 * p_{-1_1} + 0 * p_{0_1} + 1 * p_{1_1} + 2 * p_{2_1}$$

$$= -2 * p_{-2_1} - 1 * p_{-1_1} + 0 * p_{0_1} + 1 * p_{1_1} + 2 * p_{2_1}$$

$$= -2 * p_{-2_1} - p_{-1_1} + 0 + p_{1_1} + 2 * p_{2_1}$$

$$= -2 * \frac{j_1}{b_1 + d_1} - 0 + \frac{c_1}{d_1 + d_1} + 2 * \frac{a_1}{b_1 + d_1}$$

$$= -2 * \frac{j_1}{b_1 + d_1} + \frac{c_1}{b_1 + d_1} + 2 * \frac{a_1}{b_1 + d_1}$$

$$= \frac{-2 * j_1 + c_1 + 2 * a_1}{b_1 + d_1}$$

$$= \frac{-2 * 1 + 1148 + 2 * 45}{96 + 1219}$$

$$\approx 0.93992$$
(5)

5 Sample Variance

Two conduct a two-sided t-test for difference in population means, the sample variances are needed. Let S_0^2 be the sample variance for Conversion value in 2013 and 2014 and let S_1^2 be the sample variance for Conversion value in 2015.

$$S_0^2 \approx 0.05951652$$

$$S_1^2 \approx 0.1258549$$
(6)

6 Two-Sided t-Test for Difference in Population Means

Our samples are independent, the population variances are unknown and we cannot assume that they are equal. Assume the Let $\alpha = 0.05$. $h_0: \mu_{X_1} = \mu_{X_2}$. $h_a: \mu_{X_1} \neq \mu_{X_2}$.

$$\nu = b_0 + d_0 + b_1 + d_1 - 2$$

= 133 + 2352 + 96 + 1219 - 2
= 3798 (7)

The test statistic is then

$$T_{obs} = \frac{\mu_{X_1} - \mu_{X_0}}{\sqrt{\frac{S_0^2}{b_0 + d_0} + \frac{S_1^2}{b_1 + d_1}}} \approx \frac{0.99195 - 0.93992}{\sqrt{\frac{0.05951652}{133 + 2352} + \frac{0.1258549}{96 + 1219}}} \approx -4.75646$$

$$_{obs} = 2 * P(T_{\nu,\alpha} \le T_{obs})$$
(8)

$$\alpha_{obs} = 2 * P(T_{\nu,\alpha} \le T_{obs}) = 2 * P(T_{3798,0.05} \le -4.75646)$$
(9)
$$\approx 2.043366 * 10^{-}6$$

7 Conclusion

Since $\alpha_{obs} < \alpha$ we reject h_0 and conclude $\mu_{X_1} \neq \mu_{X_2}$. Therefore, the mean value of NFL conversions has changed since the 2015 change to Rule 11 Section 3 Article 1.

References

- [1] NFLSavant.com http://nflsavant.com/about.php 2016.
- [2] National Football League 2015 OFFICIAL PLAYING RULES OF THE NATIONAL FOOT-BALL LEAGUE 2016.
- [3] Anthony Almudevar Introduction to Statistics Lecture Notes for CSC/DSC 262/462.