Going For Two: Optimizing Between Extra Points And Two Point Conversions In The NFL

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Abstract

In 2015, to make extra point plays after touchdowns more uncertain, the NFL moved the extra point distance from the 2-yard line to the 15-yard line. Since the rule change, the expected points from an extra point attempt has fallen from 0.99 (averaging between the 2002 and 2014 NFL seasons) to 0.94 (averaging the 2015 and 2016 NFL seasons) while the expected points from the two point conversion remains 0.95 (averaging between 2002 and 2016 NFL seasons). While the total number of two point conversion attempts per season has almost doubled, most coaches still rarely attempt 2 point conversions when it would be point maxizing (and win maximizing under risk neutral or risk seeking preferences). Using dynamic programming, this paper argues that this result is evidence of a conservative bias and that teams could improve expected wins by attempting more two point conversions.

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JEL Classification Numbers: D03, C61, L10, D21, L83

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1 Introduction

In the 1994 NFL season, to make extra points scenarios following touchdowns more interesting, the NFL introduced 2 point conversions (where teams have an option of scoring two points after a touchdown through either running or passing the ball into the endzone from the 2-yard line).

Since then, teams have very sparingly used 2 point conversion attempts as a way to score 8 points in a touchdown drive (more than traditional 7 points following a successful extra point kick). Such scenarios often included deficit scenarios where teams are down by some factor of 8 points or a combination of 8 points and factor of 3 (points from a field goal) or 7 (points from a field goal with an extra point).

NFL coaches to this day use a popular 2-point conversion chart (Appendix A) created by former NFL and college football coach Dick Vermeil while coaching the UCLA football team the 1970s. 2-point conversions have been part of NCAA college football rules since 1958. 2 point conversions still remained rare. Between the 2002 and 2014 seasons (the 32 team era), only 1566 2-point conversions were attempted during 3328 regular season games, implying only 0.47 2-point conversions occurred per game. In many of these cases over this time period, they have been attempted out of desperation and had trivial impact on the game result whether converted or not. In addition, as kicking talent improved, one-point conversion extra point plays became automatic over the past few decades. Between 2002 and 2014, the extra point conversion rate was 99.2% (out of 7738 attempts).

As the average two point conversion rate remained 0.475, the expected points from a two-point conversion remains 0.95 below the automatic 0.992 points (Table 1) which implies teams remained point maximizers (except for during large point deficits when risk seeking is be optimal as a win maximizing strategy).

In 2015, at the annual NFL rules committee meeting, New England Patriots coach argued that the NFL should move the extra point kicking distance to the 25-yard line to make extra point plays less automatic and more interesting. The NFL ultimately moved the extra point

distance to the 15-yard line.

Over 2 seasons since the implementation of the new rules, the extra point conversion rate has fallen from 0.992 to 0.95. Moreover, the total number of 2 point conversion attempts per season has nearly doubled (Figure 2).

This paper explores optimization in the decision between attempting the 2-point conversion versus extra point conversion. We find that win maximizing teams should go for 2-points much more often than they currently do, particularly in earlier game scenarios when teams should optimally adopt risk neutral preferences. Some teams like the Pittsburgh Steelers have started attempting such a strategy. We argue that much of the hesitance to go for two is a result of coaching conservative bias and that team could improve expected wins by attempting more two point conversions.

The paper proceeds as follows. Section 2 presents some of the related literature on behavioral economics and coaching analytics. Section 3 describes the data and the empirical strategy. Section 4 investigates the results and Section 5 concludes.

2 Literature

Several academic research studies have examined optimal decision-making in professional sports and football.

Among the first papers in this literature is Gilovich, Vallone, and Tversky (1985) who analyzed the "hot hand", whether a momentum effect exists in basketball, finding there was a lack of evidence for the existence of such a "hot hand".

More recently, Bocskocsky, Ezekowitz, and Stein (2014) have revisited the old "hot hand" question in basketball finding a more nuanced answer about potential momentum effects. Johnson, Stimpson, and Clark (2012) similarly attempt to analyze momentum in the NFL.

Massey and Thaler (2006) analyze the ultimate surplus value from NFL draft picks by looking at their draft order versus the value of their first free agent contract, concluding

that teams overvalue first round draft picks and could optimally maximize surplus value by trading down top draft picks.

Palacios-Huerta (2003) analyzes penalty kicks in soccer and finds that players do engage in minimax randomization between kicking right and left.

Levitt and Kovash (2009) on the other hand, find that in MLB baseball and the NFL, teams do not optimally randomize either between types of pitches (in MLB) or passing versus running the ball. They find an optimal strategy would consist of throwing more fast balls (in MLB) or passing the ball more often (in NFL).

This paper is most similar in spirit to Romer (2006) which analyzes fourth down decision making using a dynamic programming framework. The paper finds that teams optimally should attempt fourth downs more often under risk-neutral (or risk-seeking) preferences which teams should optimally adopt in the first few quarters of the game. The paper argues that unilaterally doing so would on average win a team roughly one more game per season however coaches suffer from conservative biases that prevent them from doing so.

This paper takes a similar approach to analyzing win maximizing decision-making between 2-point conversion attempts and extra point attempts.

3 Data and Empirical Strategy

3.1 Extra Point and Two Point Conversion Attempt Data

In this paper, extra point and two point convserion attempt data is extracted from the NFL's play-by-play public use data. This paper uses regular season data from 2002-2016, which captures the entire NFL's 32 team era.

3.2 Defensive Two Point Conversions

The 2015 rule change also permitted a defensive two-point conversion where the receiving team gains possession of the ball (through an interception, fumble or blocked kick) during

the two point conversion play and scores on the same play.

While its a very rare event, in the first two years of the new rules, defensive two point conversions have occurred in the NFL. For instance, in December of the 2015 NFL regular season, Stephone Anthony of the New Orleans Saints became the first NFL player to score a defensive two-point conversion when he returned a blocked extra point kick from Carolina Panthers kicker Graham Gano.

In September of the 2016 NFL regular season, another blocked extra point attempt was returned by cornerback Tavon Young of the Baltimore Ravens against the Cleveland Browns.

In November of the 2016 season, the Broncos also blocked an extra point attempt, returning it for a defensive 2 point conversion.

In December of the 2016 NFL regular season, Eric Berry of the Kansas City Chiefs became the first NFL player to return an interception for a defensive two-point conversion after intercepting a pass from Atlanta Falcons quarterback Matt Ryan in what affectionately became known as a "pick 2" (rather than a pick 6 where an interception is returned for a touchdown).

In all, in two seasons of the new rules, only four defensive two point conversions have occurred. Such tail risk scenarios with negative point results for an offense are included in estimating expected points from a 2-point attempt in our two-sample t-tests.

3.3 Other Possible Costs To Two Point Conversions

Revealing information about goal-line plays and potential injuries from having regular offensive players involved in an additional play (rather than the special teams unit). This analysis does not account for such effects which are likely extremely small given the average number of touchdown scoring plays in a regular game is 2.454 (averaging across all NFL seasons from 2002 to 2016) while injuries also occur with low probabilities.

3.4 Two Sample T-test with unequal variances

We use a 2-sample t-test, a standard methodology used to determine if two population means statistically different.

In this instance, we are testing to see if the expected points from a 2-point conversion are statistically different from the expected points from an extra point attempt.

Since the expected points from the heavily uncertain 2-point conversion has an unequal variance from the extra point (Table 1 and Figure 1) we approach the two sample t-test by calculating a Behrens-Welch statistic as in Armitage and Berry (1994):

$$d = (x_{_1} - x_{_2})/SQRT(s_1^2/n_1 + s_2^2/n_2) \tag{1}$$

3.5 Dynamic Programming

Like Romer (2006) that uses dynamic programming to model optimal 4th down decision-making in an NFL football game, we similarly apply such a method to optimal decisionmaking between two point conversion attempts and extra point attempts:

$$\Sigma D_{g,t}^i V_i = E[P_{g,t} + \beta_t \Sigma D_{g,t}^i V_i] \tag{2}$$

where g is the index for games and t is the index for scenarios in a game, $P_{g,t}$ is the net points the team scores before the next scenario.

In our analysis of points after touchdowns, this can only take values of 0 (no points), 1 (from a point after the kick), or two (an offensive two point conversion), and rarely -2 (a defensive two point conversion). $D_{g,t}^i$ is a dummy variable that equals 1 if the t V_i is the value function in that scenario. Here, we substitute win probability V_i.

Win probability is defined as the historical probability of a team winning the game in the exact same scenario as defined by point differential and time left in the game.

4 Results

Since the 2015 rule change, moving the extra point distance from the 2-yard line to the 15-yard line, the expected points from an extra point attempt has fallen from 0.99 when averaging between the 2002 and 2014 NFL seasons to 0.94 when averaging the 2015 and 2016 NFL seasons while the expected points from the two point conversion remains 0.95 when averaging between 2002 and 2016 NFL seasons (Table 1, Figure 1).

Table 2 presents the results of a two sample t-test finding some evidence of statistical significance when using 2-point conversion rate data from 2012-2016. While the spread between expected points from 2-point conversions versus 1-point conversions remains positive over the 32-team era, statistical significance is largely due to smaller sample sizes from the limitedn number of 2 point converisions.

While the total number of two point conversion attempts per season has almost doubled (Figure 2), most coaches still rarely attempt 2 point conversions when it would be point maxizing (and win maximizing under risk neutral or risk seeking preferences).

Looking at the team level, Figure 3a, Figure 3b and Figure 3c present the 2-Point Conversion Success Rate vs. Total Number of 2-Point Conversion Attempts by team over three time periods, (2002-2014 seasons before the 2015 rule change, 2015-2016 seasons after the 2015 rule change, and the aggregate 2002-2016 32 team era).

While teams on average have slightly increased the frequency of 2-point attempts (), the Pittsburgh Steelers have been arguably the only team to dramatically step up 2-point attempts, trying 20 over the course of the 2015-2016 regular seasons. This likely was a result of identifying from the 2002-2014 time period that the Steelers had the highest 2-point conversion rate in the NFL above 75% when using data from 2002-2014. However, this practice was halted after the Pittsburgh Steelers loss to the Cowboys on November, 13, 2016 where 4 two-point conversions were missed in one game contributing to the Steelers 30-35 loss. If one were to argue that this was like four unsuccessful successive coin flips (given the long-run average 2-point conversion of 47.5%), one might argue this is a "Gamblers

fallacy" (irrational belief in persistence or belief in mean reversion). When including these failed attempts, over the 2015 and 2016 regular seasons, the Steelers still had a 2-point conversion rate of 55% and expected points of 1.1. If these parameter estimates were to be believed, the steelers should still attempt 2-point conversions over extra points in risk-neutral scenarios. Ironically, the Steelers missed an extra point attempt in the 2016 season's AFC Championship later that year.

Figure 4a and Figure 4b similarly present the 2-Point Conversion Success Rate vs. the 1-Point Conversion rate by team over three time periods, (2002-2014 seasons before the 2015 rule change, 2015-2016 seasons after the 2015 rule change). Assuming heterogeneity across extra point kickers and 2-point conversion ability and that the sampple estimates of 2-point and 1-point conversion ability are accurate (which can be susceptible to low sample size issues with respect to two point conversions), these graphs demonstrates what teams should do as if they are point maximizers (and win maximizers assuming risk-neutral preferences).

Looking at only data from the 2015 and 2016 seasons suggest that 17 teams should regularly be going for two points under a risk-neutral framework. A dynamic programming framework used to analyze win probability across various states of football games like in Romer (2006) suggests that such risk-neutral preferences should be adopted by teams in earlier quarters given that at team's objective is solely to win games. Similarly in deficit scenarios, an optimal strategy would be to adopt risk-seeking preferences. Nonetheless, given the evidence of presented across Figures 4a and Figure 4b, two-point attempts remain underutilized.

5 Conclusion

This paper suggests that there may be some irrational decision-making in teams not trying as many 2-point conversion attempts as they should if they were win-maximizing since the 2015 ruel change moving the extra point distance from the 2-yard line to the

15-yard line.

The expected points from an extra point attempt has fallen from 0.99 (averaging between the 2002 and 2014 NFL seasons) to 0.94 (averaging the 2015 and 2016 NFL seasons) while the expected points from the two point conversion remains 0.95 (averaging between 2002 and 2016 NFL seasons).

While teams have nearly doubled the overall number of 2-point attempts per season has doubled since the rule change, assuming homogeneity over two point conversion and extra point conversion ability, point maximizing teams should almost always be attempting 2-point conversions in earlier parts of the game when it is optimal to adopt-risk neutral (point maximizing preferences). Teams in large deficits that optimally should adopt risk-seeking preferences similarly should try more 2-point conversions across the game.

However, assuming teams have different two point conversion and extra point conversion ability, historical data from the 2015-2016 suggests 17 teams have greater expected points from two point conversion compared to one point extra point attempts.

Only one team (the Pittsburgh Steelers) has attempted to adopt such an optimal strategy of frequent two point conversions.

Philadelphia Eagles Head Coach Doug Pederson attempted a 2-point conversion against the Ravens in Week 15 of the 2016 NFL season and it arguably played a big role in their defeat against the Baltimore Ravens. Simlarly, Mike Tomlin's 4 unsuccessful 2-point conversions played a role in the Steelers defeat against the Cowboys in the 2016 regular season.

While two-point conversions indeed carry more risk, they also bring about greater expected points and in the long-run should bring about more points and more wins.

While coaching tenure has shorted significantly over recent years, whether teams will adopt such a strategy in the years to come will likely depend on coaching job security and other factors that can incentivize coaches to deviate from a win-maximizing strategy that consists of more 2-point attempts.

6 References

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Table 1. Expected Points For 2 Point Conversion Versus Extra Point Attempts (2002-2016 NFL Seasons)

	Conversion Rate	Expected Points	N
One Point Conversions			
2-yard Extra Point Attempt (Pre-2015 rules)	99.2%	0.992	7738
	(0.1%)	(0.001)	
15-yard Extra Point Attempt (Post-2015 rules)	93.9%	0.939	2412
	(0.5%)	(0.005)	
Two Point Conversions			
1-yard 2-Pt Attempt (after defensive penalties)	72.1%	1.442	43
	(6.8%)	(0.137)	
2-yard 2-Pt Attempt	47.3%	0.946	1489
	(1.6%)	(0.031)	
3-yard+ 2-Pt Attempt (after offensive penalties)	27.3%	0.546	33
	(7.8%)	(0.155)	

Notes: Standard errors are computed using the standard error formula for a binomial distribution: $\sqrt{\frac{p(1-p)}{n}}$

Table 2. Two Sample T-test Results

2-point conversion data period	2002-2016 (15 seasons)	2012-2016 (5 seasons)	2015-2016 (since rule change)
$\mu_{2pt-2-yd-attempt} - \mu_{1pt-15yd-attempt}$	+0.009	+0.030	+0.018
t-stat	0.548	1.143*	0.509

Notes: We use a 2-sample t-test, a standard methodology used to determine if two population means statistically different. In this instance, we are testing to see if the expected points from a 2-point conversion is statistically different from the expected points from an extra point attempt. Since the expected points from the heavily uncertain 2-point conversion has an unequal variance from the extra point, we approach the two sample t-test by calculating a Behrens-Welch statistic as in Armitage and Berry (1994):

$$t = \frac{\mu_{2pt-2-yd-attempt} - \mu_{1pt-15yd-attempt}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

$\mu_{2pt-2-yd-attempt}$ is the expected points from the 2-point conversion attempt at the 2-yard line.

$\mu_{1pt-15yd-attempt}$ is the expected points from the 1-point conversion attempt at the 15-yard line.

*indicates statistically significant at the 15% level.

Figure 1. Two Point Conversion Attempt vs. One Point Conversion Attempt Expected Points (2002-2016)

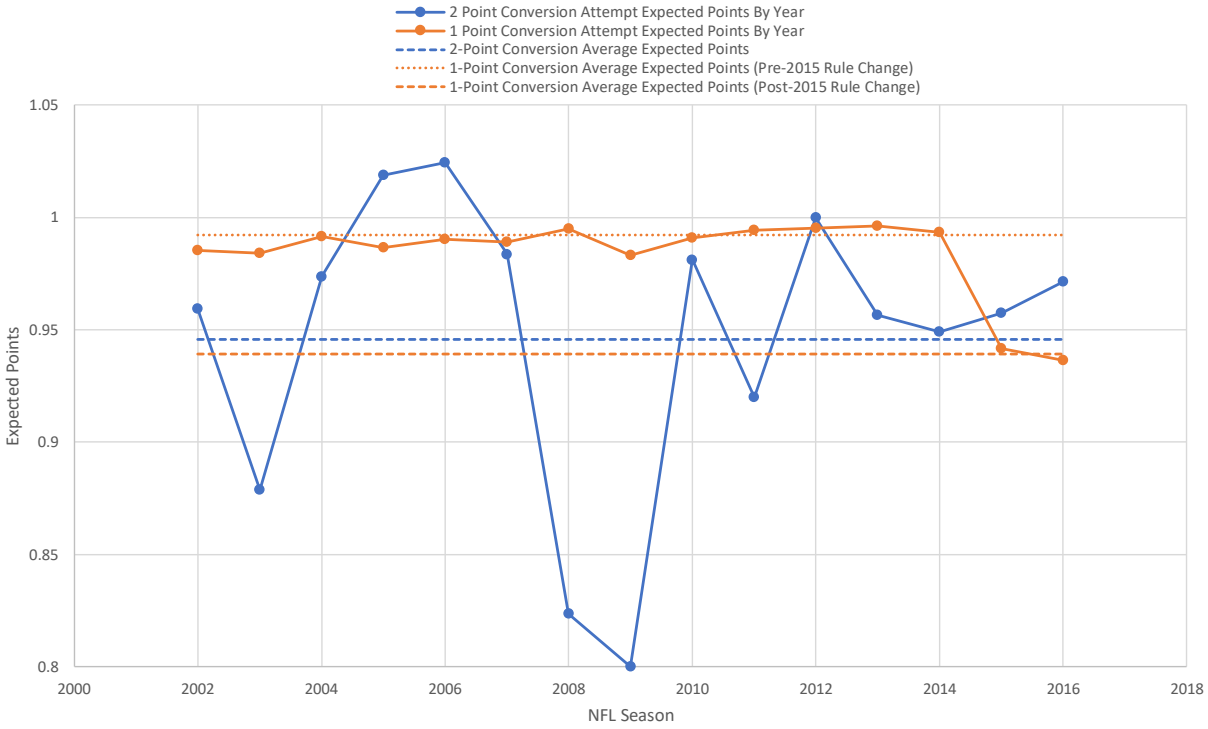


Figure 2. Total Number of Two Point Conversion Attempts By NFL Season (2002-2016):

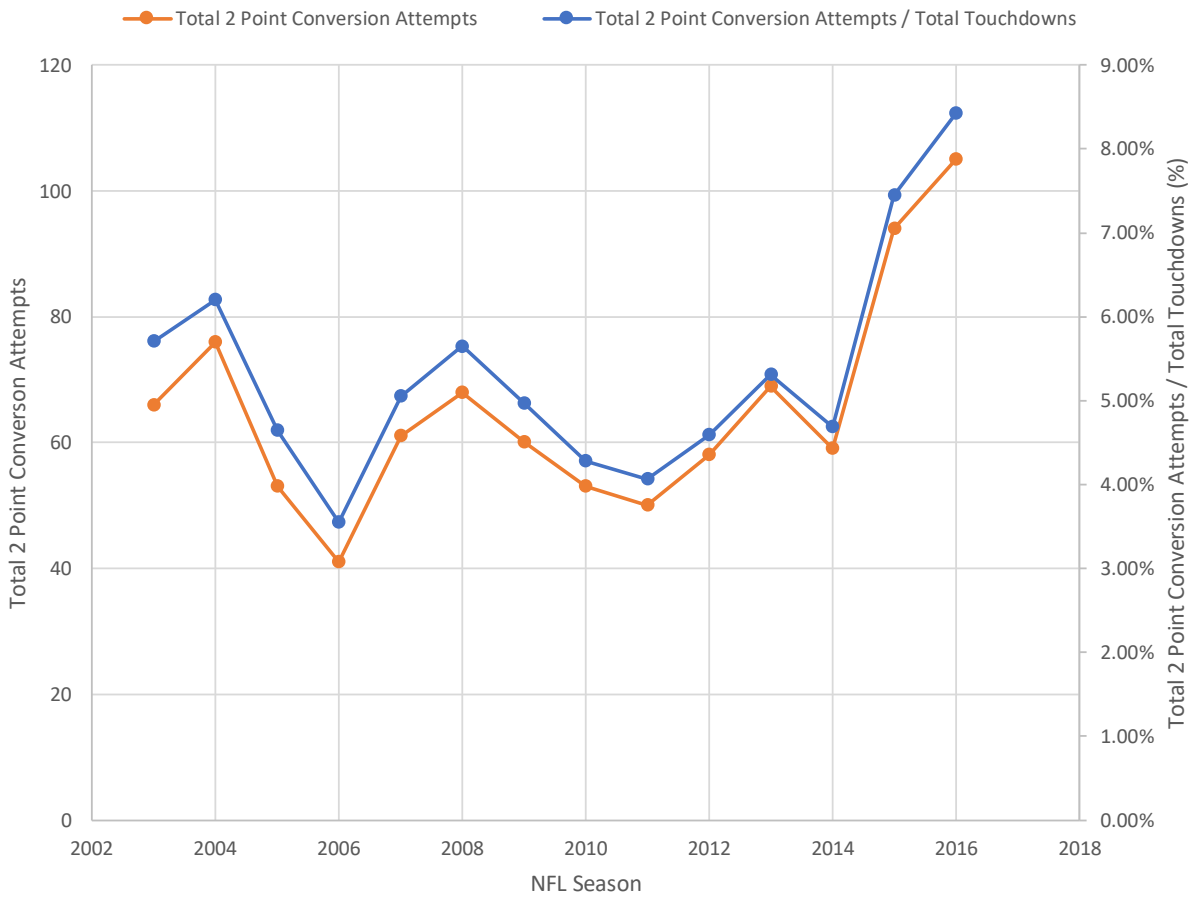


Figure 3a. Team 2-Point Conversion Success Rate vs. Total Number of 2-Point Conversion Attempts (2002-2014 Before Rule Change)

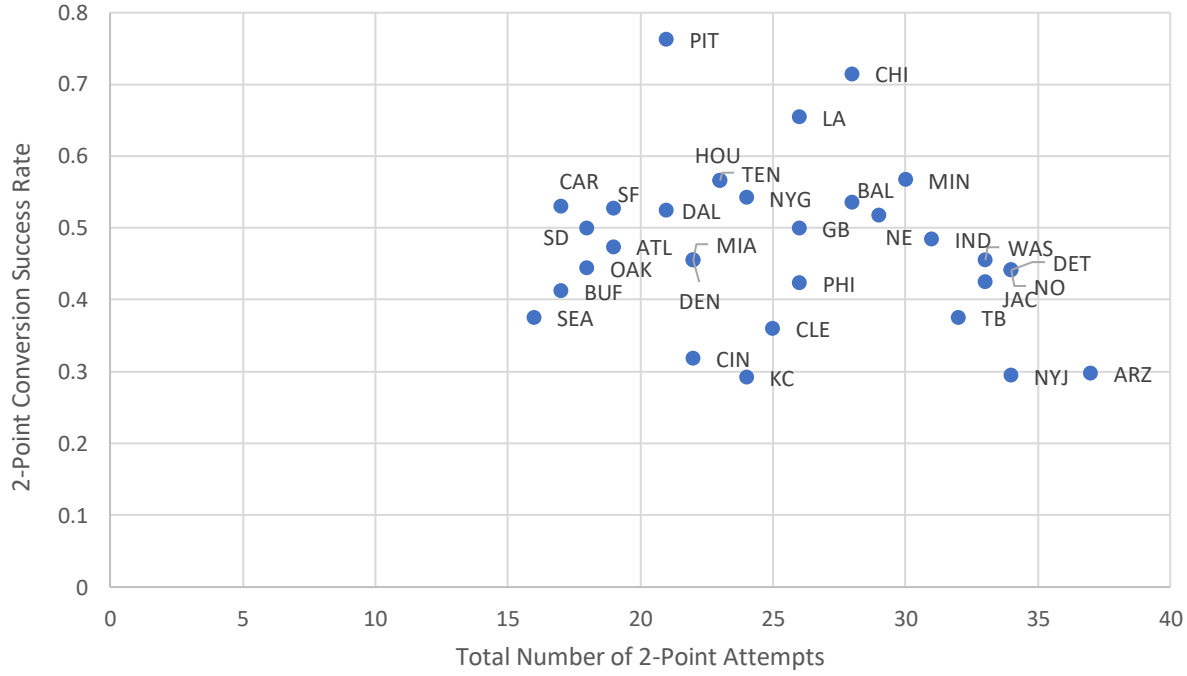


Figure 3b. Team 2-Point Conversion Success Rate vs. Total Number of 2-Point Conversion Attempts (2015-2016 seasons after 2015 rule change)

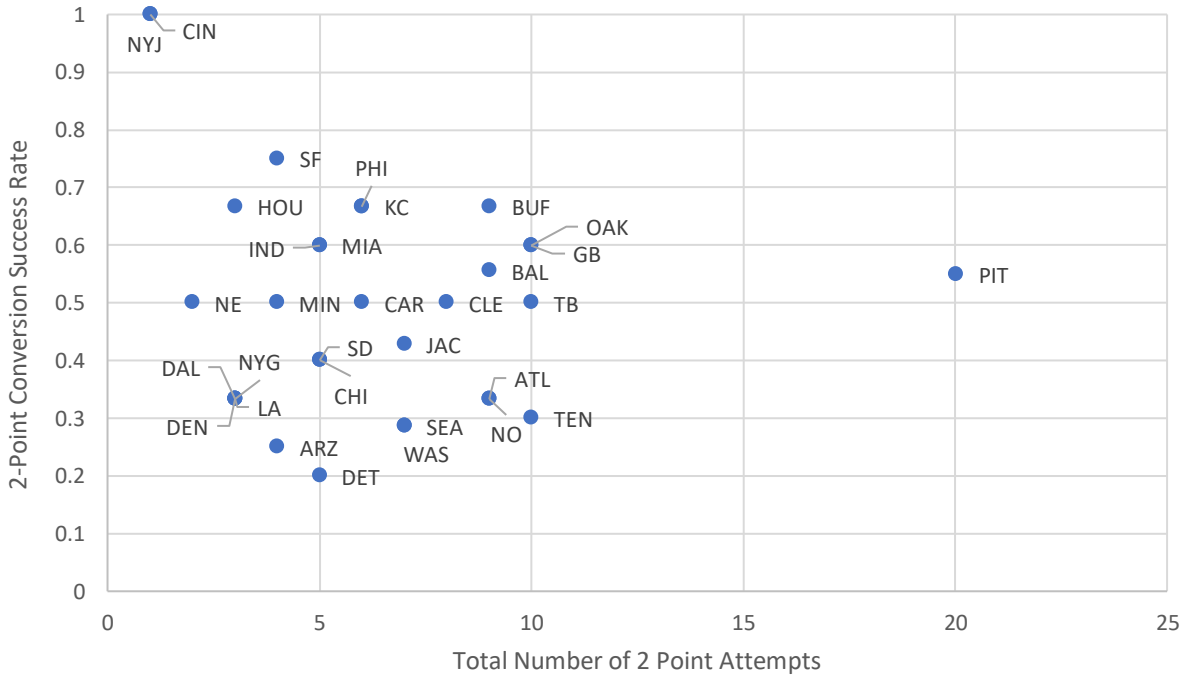


Figure 3c. Team 2-Point Conversion Success Rate vs. Total Number of 2-Point Conversion Attempts (2002-2016)

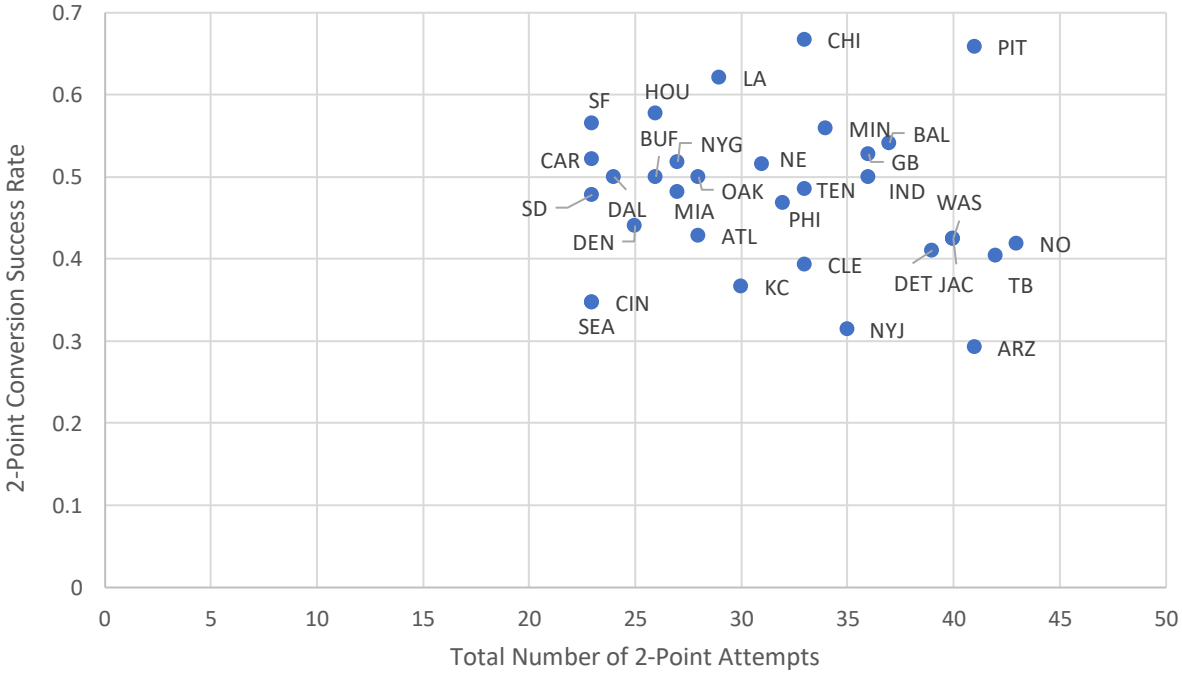


Figure 4a. Team Two Point Conversion Rate vs. Team One Point Conversion Rate (2002-2014 Before Rule Change)

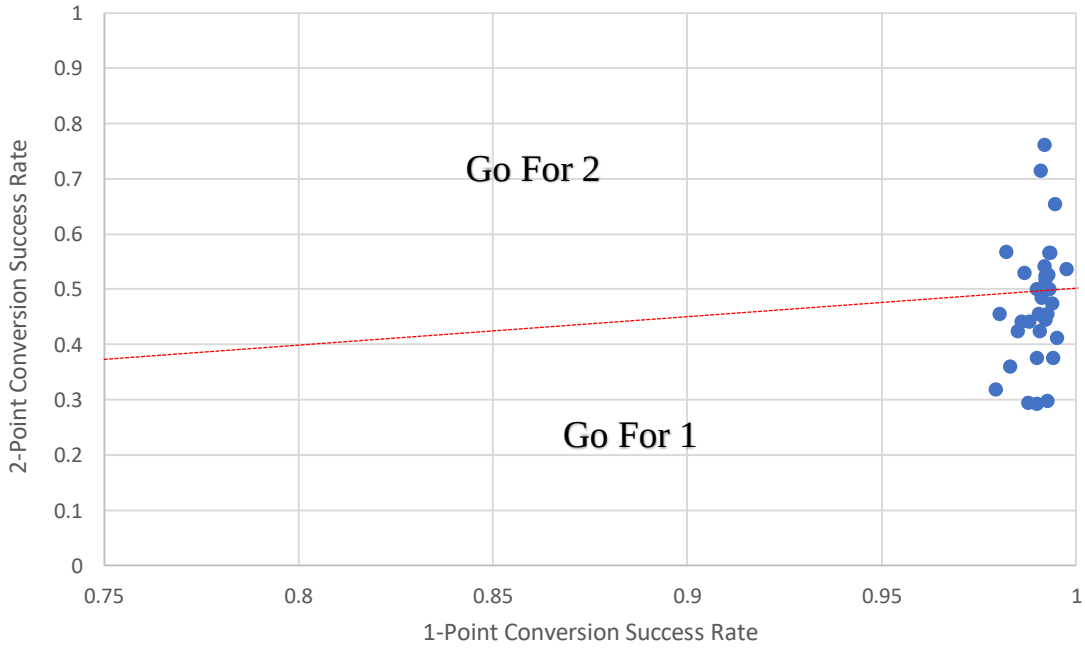
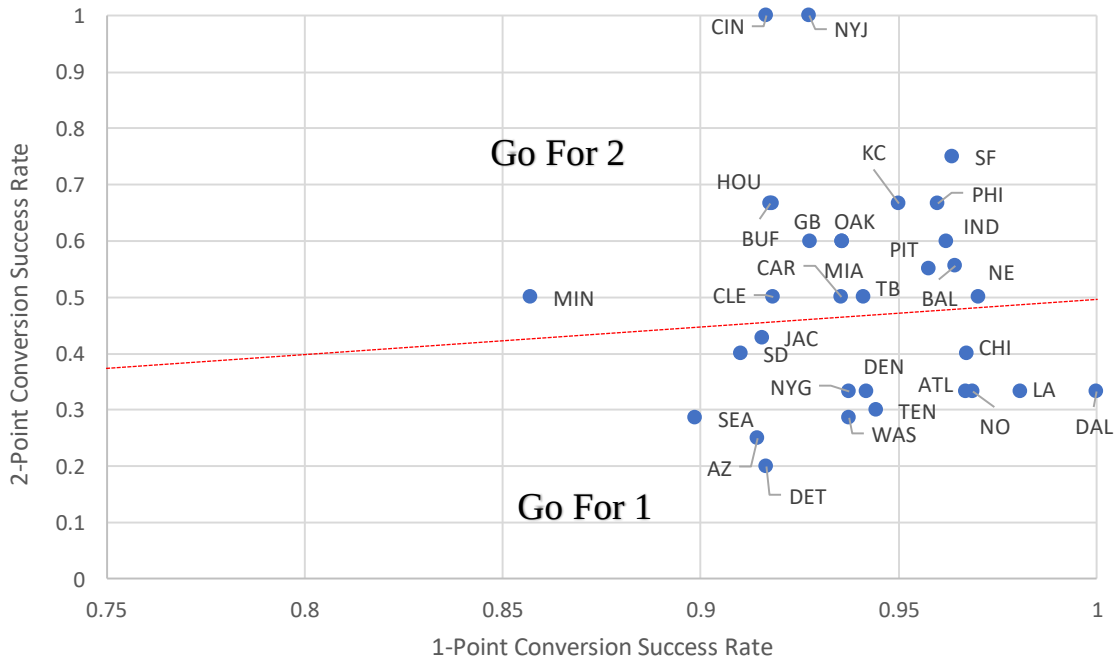


Figure 4b. Team Two Point Conversion Rate vs. Team One Point Conversion Rate (2015-2016 After Rule Change)



Appendix A: Dick Vermeil 2 Point Conversion Chart

EXTRA POINT SYSTEM

TEAM AHEAD RECOMMENDATIONS				TEAM BEHIND RECOMMENDATIONS				
POINTS	GO FOR 1	GO FOR 2	REMARKS	POINTS BEHIND	GO FOR 1	GO FOR 2	REMARKS	KEY TO REMARKS
0	X			0	X			
+1		X		-1	X			
+2	X			-2		X		
+3	X			-3	X			
+4		X		-4	X			
+5		X		-5		X		
+6	X			-6	X			
+7	X			-7	X			
+8	X			-8	X			
+9	X			-9	X			
+10	X			-10		X		
+11		X		-11	X			
+12		X		-12	X			
+13	X			-13	X			
+14	X			-14	X			
+15	X			-15	X			
+16	X			-16		X		
+17	X			-17		X		
+18	X			-18		X		
+19		X		-19	X			
+20	X			-20	X			
+21	X			-21		X		
+22		X		-22	X			
+23	X			-23	X			
+24	X			-24	X			
+25		X		-25		X		
+26	X			-26		X		
+27	X			-27	X			
+28	X			-28		X		