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## The Passing Premium Puzzle

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# The Passing Premium Puzzle\*

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## Abstract

The passing premium puzzle is the existence of a balance between the number of passing and running plays, even though there is a greater expected return in passing plays. The puzzle is documented using both historical trends of aggregate numbers and play by play data from the 2005 NFL season.

**KEYWORDS:** NFL, football, passing, play selection, strategy

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In 1985 Mehra and Prescott published a paper that described an economics puzzle (Mehra and Prescott 1985). They noted that equities, on average, had a real return that was approximately six percentage points higher than the real return on “riskfree” bonds. They then argued that no economic model supports an “equity premium” that large and wondered why it should persist. Since publication, the article has been cited by over 600 other scholarly works, many of which have proposed solutions, but none of which have fully satisfied the community of financial economists. Football, at least in the National Football League (NFL), has a similar puzzle: the passing premium puzzle. Specifically, the passing premium puzzle is while the passing game has significantly better returns than the running game, teams choose to run as frequently as they choose to pass.

This paper lays out the empirical evidence to support the existence of the passing premium puzzle both over time using aggregated data and in 2005 using play-by-play data. The empirical evidence will demonstrate first that, while the passing game has become more efficient over time, teams have not changed their mix of passing and running to meet this change and second that there is a passing premium for the vast majority of teams and that they do nothing to capitalize on this premium. This does not suggest that teams should not run at all, but rather that they should simply run less.

While there are certainly some social and psychological explanations for the existence of this premium that are plausible, none of these would appear to outweigh the desire of a coach to improve his odds of winning and thus remain employed. Below are several comparisons between running and passing over time that illustrates the passing premium puzzle. The existence of this premium suggests that NFL teams will realize significant gains by throwing the ball more. The question remains regarding the puzzle: why are they not passing more?

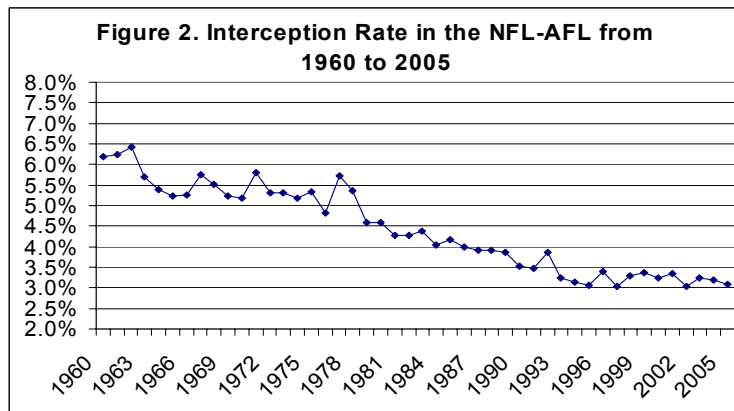
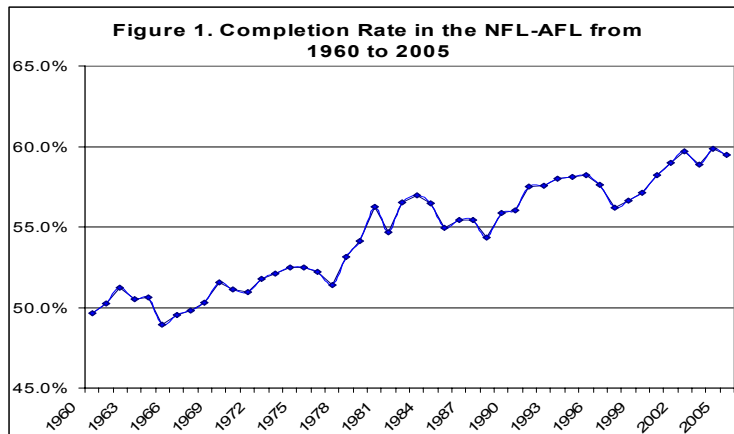
### **The Passing Premium Over Time**

Unlike the equity premium, the passing premium has not remained constant over time. As the NFL has evolved, so has the passing game. The passing game has become more efficient and less risky over time, yet these positive changes in the passing game have not been matched by an equal increase in the use of the passing game. While passing has become more frequent, the increase in passing frequency has not kept pace with the improvements to the passing game.

#### *Risk*

Risk in the passing game takes two forms. The first is whether a pass attempt will be completed or not, the second is whether a pass will be intercepted or not. The

completion rate in the NFL has increased from 49.6% in 1960 to 59.5% in 2005 (Figure 1).<sup>1</sup> This change represents a 20% increase in the completion rate in 45 years. The interception rate has decreased from 6.2% in 1960 to 3.1% in 2005 (Figure 2), a 50% decrease. This data demonstrates that both types of risk have dropped dramatically.

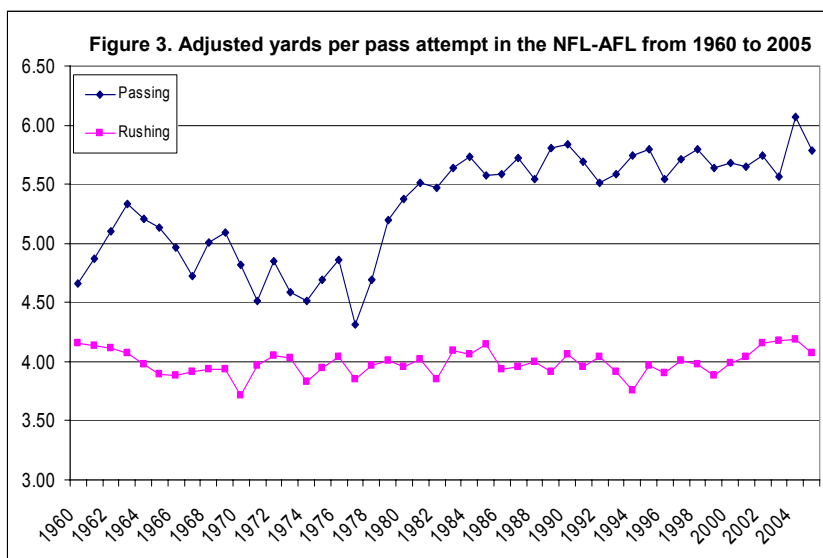


### Efficiency

The payoff for any football play is yardage. The most straightforward way of expressing the payoff of any type of football play is in yards per attempt. A straight yards per attempt calculation does not however, properly account for either interceptions or touchdowns. Interceptions create negative yards, yet they are not included when calculating total passing yards. Additionally, the length of

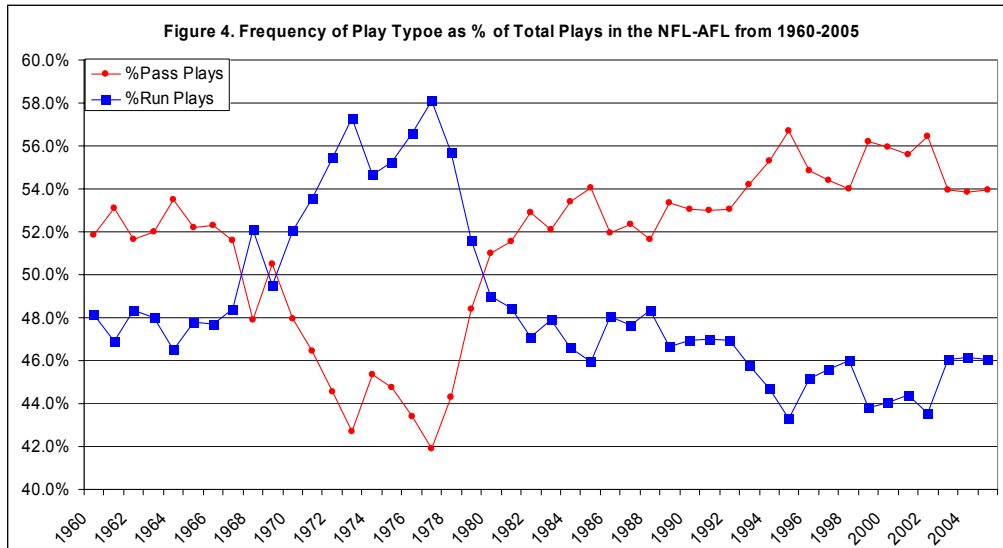
<sup>1</sup> The data represents league wide averages and includes data from the American Football League prior to its merger with the NFL. This data was provided by footballreference.com.

a touchdown pass is truncated due to the boundaries of the field, so touchdowns do not, on average, count for as many yards as they could. Adjustments to the yards per pass attempt formula have been developed that account for these deficiencies in the straight calculation (Carroll, et al. 1988). In the adjusted yards per attempt calculation, each interception is counted as -45 yards and each touchdown is counted as 10 yards. With these adjustments, the yards per pass attempt has increased from 4.66 in 1960 to 5.8 in 2005, a 24% increase (Figure 3). During the same time frame, yards per rush attempt were essentially flat.



### Usage

From 1960 to 2005 the risks in the passing game have dropped dramatically, and the reward has increased, thereby substantially improving the payoff of the passing game. In this same time frame, however, usage has changed very little. In 1960, 52% of all plays were pass attempts (Figure 4) and in 2005 54% of all plays were pass attempts. So while passing frequency dropped in the 1970s below 50%, since 1960, when yards per pass attempt was 4.66, the frequency of passing has increased by 3.7% to 2005 when yards per pass attempt was 5.8, or 24% higher. The increase in the payoff of the passing game seems to have outpaced the growth in the use of the passing game.



### **The Passing Premium in 2005**

These historical aggregate numbers suggest that the passing game is underutilized in the NFL. It is conceivable however that this aggregation masks certain differences in situations and distorts the conclusion. A specific situation using play-by-play data examines the case for the existence of the passing premium. Specifically, the data described below is from all of the first and ten plays in 2005 on which the offense was between 60 and 80 yards from the end zone.<sup>2</sup> Analyzing the mix between runs and passes and the outcomes of the runs and passes on these downs allows for a fair comparison between the risks and rewards of both the running and passing games.

#### *Running on First and Ten*

In 2005, there were 4,738 plays on first and ten in which the offense was between 60 and 80 yards from the end zone. Of these plays 2,380 (or 50.2%) were running plays. As a gain of four yards or more is generally considered a successful first down play (Carroll, et al. 1988, Schatz 2004, Schatz, et al. 2005), the distribution of the yards gained on each running play in this sample shows that 1,383 or 58.11% of all running plays on first and ten would not be considered successful (Table 1). The median of the plays that were not successful was 1 yard. This indicates that running on first and ten, is, nearly 60% of the time, not successful.

<sup>2</sup> Play-by-play data for 2005 was provided by Stats Inc.

Table 1. Cumulative Distribution of the Outcome of Running Plays in 2005 on 1st and 10

Yards	Cumulative Plays	Cumulative Percent (%)
<0	307	12.9
0	490	20.59
1	733	30.8
2	1081	45.42
3	1383	58.11
4	1620	68.07
5	1800	75.63
6	1922	80.76
7	2016	84.71
8	2089	87.77
9	2166	91.01
10	2193	92.14
15	2298	96.55
20	2335	98.11
30	2361	99.2
57	2374	99.75
75	2379	99.96
80	2380	100
Total	2380	100

On the benefit side, fewer than 20% of all first and ten rushing plays go for between four and 8 yards and only 7.86% of all rushing attempts gain 10 yards or more.

*Passing on First and Ten*

The cumulative distribution of passing plays on first and ten in 2005 is very different from the rushing distribution. Again, using four yards as the marker of success, only 46.52% of all pass plays were not successful on first down in 2005. The median of the passing plays that were not successful was 0 yards.

Table 2. Cumulative Distribution of the Outcome of Passing Plays in 2005 on 1st and 10

Yards	Cumulative Plays	Cumulative Percent (%)
<0	161	6.83
0	962	40.83
1	1000	42.44
2	1042	44.23
3	1096	46.52
4	1180	50.08
5	1279	54.29
6	1385	58.79
7	1482	62.9
8	1572	66.72
9	1679	71.26
10	1713	72.71
15	2015	85.53
20	2164	91.85
30	2264	96.1
57	2329	98.85
73	2351	99.79
80	2356	100
Total	2356	100

On the benefit side, fewer than 17% of all first and ten passing plays go for between four and 8 yards and 27.29% of all passing attempts gain 10 yards or more. More than a quarter of all passing plays on first and ten earn a first down for the offense. Thus for a gain of 1 yard on the median of the unsuccessful plays, coaches give up a huge potential benefit on first down by running instead of passing.

Much like the historical data, these data (Table 2) indicate that the passing game is more frequently successful than the running game, gains more yards, has more upside when it is successful, and has a similar outcome when it is not successful. Yet even with all of the potential benefits on first and ten, passing is still used just as often as running. There appears to be a premium that teams could claim if they passed more, but they simply choose not to pass more frequently than they run.

### *Passing on Third and Long*

There is a situation in which teams pass more frequently than they run, and that is on third and long (defined as third down with seven or more yards to go for the first down). On third and long, teams passed the ball 88% of the time in 2005. Defenses were not surprised by the pass in these situations, as all teams exhibited this tendency, so defenses were designed to stop the pass before the run.

Some coaches claim that surprise in the passing game is effective which would imply that passing should be less effective when the defense is expecting it. A t-test on the means of the distributions of yards gained on pass plays on first and ten and on third and long indicates that surprise in the passing game may not increase success in the passing game. The t-test of the means failed to reject equality ( $p=0.2518$ ). An F-test on the equality of the variances of the two variables also failed to reject equality ( $p=0.537$ ). Additionally, the same tests on the yards gained from running on first and ten and third and long showed an increase in yards gained when running is less frequent.<sup>3</sup> In the case of running the t-test of the means rejected equality ( $p=0.0002$ ). The third and long running plays have a mean of 6.7 versus 4.1 for first and ten running plays. The F-test on the variances failed to reject equality with both variables having standard deviations of approximately 6.5.

These results indicate that the element of surprise helps the running game by increasing the mean result of the play, while predictability in the passing game does not tend to lower the mean result of passing plays. While the situations are clearly different, there is further evidence to suggest that teams do not pass enough. Not only would passing increase the total output of the offense, it may increase the efficiency of the running game as well.

### **Conclusion**

There are two possible conclusions that could be drawn from the calculations above. First, the calculations do not properly present the costs and benefits of running and passing. This is possible as the data is either aggregated (historical) or on a play-by-play basis (2005 data). It could be that there is some benefit to “establishing the run” that these calculations do not recognize, even if, while “establishing the run,” teams do not gain as many yards as efficiently as they could. A more thorough drive-by-drive analysis could potentially uncover this effect if in fact it does exist.

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<sup>3</sup> The differences in rushing yards are in part due to the defenses willingness yards as long as they do not give up a first down. The differences also reflect however, defenses that are primarily designed to stop the passing game and anticipating a pass play from the offense.

A second possible conclusion is that, for all of their planning and late nights NFL coaches do not act in a fully rational manner. This is not an original conclusion as Romer (Romer 2002) first showed and Surowiecki (Surowiecki 2004) has attempted to explain, NFL coaches opt to kick field goals or punt instead of attempting to get a first down much more frequently than the actual payoffs to these choices would indicate is rational.

The data on the passing premium indicate a clear advantage (that has grown over time) to the passing game with little change in the frequency in which teams use the pass. The existence of the passing premium indicates that teams should pass more frequently and coaches, as a group, are not acting rationally when they run as much as they pass.

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