BEATING THE ODDS: DEVISING A PROFITABLE BETTING SYSTEM USING PERCEIVED MOMENTUM IN THE NFL

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ABSTRACT

Many fans, players, and coaches hold a belief that during a sporting event, successful outcomes increase the likelihood of subsequent successes (Arkes, 2010; Gilovich, Vallone, & Tversky, 1985; Lehman & Hahn, 2013; Vergin, 2000). This concept is known as sports momentum and is thought to be present in a variety of sports both between and within games (Arkes, 2010; Fry & Shukairy, 2012; Gilovich, Vallone, & Tversky, 1985; Richardson, Adler, & Hankes, 1988**;** Vergin, 2000). Despite the incredibly common belief in momentum, there is very little evidence to support its existence (Fry & Shukairy, 2012; Gilovich, Vallone, & Tversky, 1985; Vergin, 2000). Since point spreads, which are a prediction of the margin of victory for each game utilized in sports betting, are influenced by gamblers' predictions of game outcomes and many gambles hold a false belief in sports momentum (Camerer, 1989; Gandar, Zuber, O'Brien, & Russo, 1988; Lock, 1997; Vergin & Scriabin, 1978), it is possible that this perception of momentum can be exploited to inform betting practices. The present study aimed to investigate this and revealed that when momentum calculation takes win probability into account, momentum is significantly correlated with a team's performance in relation to the point spread. This information can be utilized to make profitable bets, all of which are more profitable than a zero validity betting system resulting in winning 50% of bets. Overall, this study reveals that it may be possible to devise a system to inform bets using perceived momentum in the NFL.

INTRODUCTION

Among players, fans, and coaches, there is a widespread belief in sports momentum. Sports momentum is the idea that a player or team has a greater probability of success if they have just experienced a string of successful outcomes (Arkes, 2010; Gilovich, Vallone, & Tversky, 1985; Lehman & Hahn, 2013; Vergin, 2000). In basketball, this could mean that a player is more likely to make a basket after they have just made a shot than if they have just missed a shot (Gilovich, Vallone, & Tversky, 1985); the more free throw shots a player has made in a row, the more likely it is that this player will make his or her next shot (Arkes, 2010). Momentum can be within games, as with the 'hot hand' free throw example in basketball, or it can be between games with a team's performance in the last game being thought to influence their performance in the next. In football, this between game momentum is typically associated with a team's 'streak', or the amount of games they have won or lost in a row (Camerer, 1989**;** Iso-Ahola & Dotson, 2014; Vergin, 2000). Momentum is believed by many to be present in a wide range of sports, from football to baseball to tennis, and everything in between (Fry & Shukairy, 2012; Richardson, Adler, & Hankes, 1988**;** Vergin, 2000). Despite this incredibly common belief in sports momentum, there is an overwhelming lack of evidence in scientific literature to support it (Avugos, Koppen, Czienskowski, Raab, & Bar-Eli, 2013; Fry & Shukairy, 2012; Gilovich, Vallone, & Tversky, 1985; Vergin, 2000). Researchers have utilized a variety of methods to test whether this concept of momentum truly exists in the sense that current success leads to a higher probability of success in subsequent attempts, with many concluding that it does not.

One such way to test for momentum is to utilize actual game data. Gilovich, Vallone, and Tversky (1985) investigated momentum in basketball with shooting records from the Philadelphia 76ers and free throw records from the Boston Celtics. The authors concluded that momentum from previous successes did not influence subsequent outcomes. This conclusion came after observing no correlation between original and successive shot outcomes. More recently, a meta-analysis was conducted to assess the results and conclusions of Gilovich, Vallone, and Tversky (1985). Avugos, Koppen, Czienskowski, Raab, and Bar-Eli (2013) found similar evidence to suggest that momentum most likely does not exist in sports. Furthermore, Arkes (2010) also used game data to assess basketball momentum by analyzing free throw data from the entirety of the 2005 season. This study did find a small increase in successful free throws following a successful shot, but this effect decreased when individual differences between players were accounted for. A study which analyzed data from Major League Baseball (MLB) and the National Basketball Association (NBA) found no evidence of between game momentum for either basketball or baseball, concluding that the amount of winning and losing streaks observed was equal to what would be expected by chance (Vergin, 2000). As for momentum in the NFL, supporting evidence is also scarce. Fry and Shukairy (2012) utilized National Football League data to test for within game momentum in football following momentum changing plays. The authors concluded that even at times when players and fans believe momentum is strong, there is very limited, if any, momentum effect.

Momentum can also be tested through experiments. To test momentum in basketball, students at Cornell University were asked to make free throw shots and then predict the outcome of their next shot (Gilovich, Vallone, & Tversky, 1985). It was found that previous outcomes did significantly affect predictions such that participants were more likely to predict a successful outcome if they had just made their previous shot. These previous shots, however, did not influence subsequent shot outcomes, providing further evidence to suggest that momentum is a common belief with no effect on actual game outcomes.

In addition to testing for momentum, investigators have been looking for ways to succeed in the betting market. In the NFL, most betting is conducted using point spreads, which are used to equalize the chances of each team winning against the spread (Camerer, 1989; Gandar, Zuber, O'Brien, & Russo, 1988; Lock, 1997; Vergin & Scriabin, 1978). Take for example the first game of the 2000 season where the San Francisco 49ers played the Atlanta Falcons. The point spread for this game favored Atlanta by seven points, so, in order for Atlanta to 'beat the spread' they would need to win the game by eight or more points. If San Francisco either won the game or lost by less than seven points, then they would be regarded as winning against the spread. If Atlanta ties the spread and wins by exactly seven points, this would be known as a 'push' and would not result in any payout (Vergin & Scriabin, 1978). For this particular game Atlanta won by eight points and was declared the winner against the spread, meaning one would have won their bet had they bet for Atlanta. Point spreads are developed not with the goal of predicting the margin of victory for each game, but with the goal of producing equal bets for and against each team (Camerer, 1989; Lock, 1997; Vergin & Scriabin, 1978). When the amount of money wagered for and against each team is equal, the winners can simply be paid with the losers' money. The odds makers, who are setting the spread, will profit from a 10% fee collected from the losers. This means that a bet of one dollar would win one dollar, or lose one dollar and ten cents. Simple arithmetic demonstrates that under this system, one would need to win 52.4% of their bets in order to break even (Lock, 1997; Vergin & Scriabin, 1978).

Now, with an understanding of how the NFL betting market operates, the question still remains, can a system be devised to make profitable bets? Many investigators have tried to conceive of such a system and have produced mixed results (Arkes, 2011; Camerer, 1989; Vergin & Scriabin, 1978). Vergin and Scriabin (1978) developed a strategy that utilizes the size of the point spread in the NFL to determine bets. Since it was observed that small spreads, ranging from zero to five points, produced profitable bets when betting on the favored team. For larger spreads, betting on the underdog was more successful. The researchers hypothesize that this trend occurs due to the systematic errors in prediction made by those who are tasked with developing point spreads. According to the authors, this system could be utilized with a moderate degree of success given the systematic nature of these prediction errors.

Researchers have also attempted to employ momentum-based strategies when betting. Vergin and Scriabin (1978) discusses the mixed results obtained from these strategies. Some claim that a team who has been successful in their past game must "have it all together" and will likely succeed in subsequent games. Others claim that this is flawed as system since the general public puts too much emphasis on past success when predicting future outcomes. The authors found that betting with momentum would result in losing more often than winning, suggesting that this is not a worthwhile strategy (Vergin & Scriabin, 1978). As for point spread wagering in basketball, Camerer (1989) investigated how momentum affects the betting market in the NBA. This study, which utilized data from professional basketball games, found that teams on a winning streak tended to underperform relative to the point spread, suggesting that the perception of momentum significantly impacts point spreads. More recently, Arkes (2011) has investigated whether or not gamblers incorporate momentum when placing their bets. This study revealed that gamblers do tend to use momentum when predicting outcomes, specifically when momentum is characterized by previous successes against difficult teams. These studies suggest that this perception of momentum does tend to significantly impact betting markets in sports, which can be useful information when attempting to place profitable bets.

Perhaps the misperception of momentum in sports can provide opportunities for profitable betting in the NFL. Since, as research suggests, momentum does not impact performance but is present in the minds of many football fans, it is possible that this perception of momentum could affect point spreads even if it is nothing more than a cognitive illusion. If, for instance, a team is on a long winning streak and seems to have momentum in their favor, gamblers may be more inclined to bet on this team compared to when they are not on a streak. This will cause the point spread to favor this team more heavily than it may have had momentum not been involved. Since momentum does not actually improve the probability of success, the team in question may end up failing to cover the spread due to an abnormally high level of expectation imposed by the perception of momentum, as Camerer (1989) suggests occurs in the NBA. Research suggests that any such difference between real and perceived momentum can possibly be employed to inform betting (Camerer, 1989; Arkes, 2011). The aim of the present study is to look for any such opportunities to capitalize on the perception of momentum in the NFL in order to succeed in the betting market.

METHOD

Data Source

The database utilized in the present study was acquired through armchairanalysis.com and contains data from all games played between the 2000 and 2018 seasons. This database contains a total of 5057 games with data on a variety of variables including point spreads, final scores for both the home and the visiting team, and weeks within a season. All postseason games were eliminated from the sample due to their irregular nature in regards to momentum. Since only high achieving teams continue to play in the postseason and, in order to advance to the next week, teams need to have won at least the prior game, the idea of momentum becomes more complex. In order to better address the aims of the present study, all analyses have been conducted using only the 4848 regular seasons games within the original database.

Measures

The first measure utilized in this study was the point spread (PS) residual. This measure was calculated for each game as the visiting team's final score minus the home team's final score plus the visiting team's Vegas point spread. The PS residual illustrates how each team performed relative to the spread with positive values indicating the visiting team beat the spread and negative values indicating the home team beat the spread. A PS residual of zero indicates a push, or an exact tie of the spread. PS residual values were normally distributed with relatively equal variation across weeks, seasons, and point spread values.

The next measure that was employed was streaks. Conventionally, streaks are thought of as the number of games won or lost in a row (Iso-Ahola & Dotson, 2014; Vergin, 2000). For each game, streaks were calculated for the home team and the visiting team through simple addition, with each game won in a row earning a value of one and each game lost in a row earning a value of negative one. The summation of games for each team represented the streak value for each particular game. For the home

and visiting team, streak distribution was bimodal due to streaks of zero only occurring during the first week of the season.

In addition to conventional streaks, the present study also developed a measure known as weighted streaks. Weighted streaks go beyond just the number of games won or lost in a row, but give credit for how difficult each game was. The calculation of weighted streaks still utilized simple addition but instead of each game being worth a value of one, this value was related to win probability. If a team was on a winning streak, the value would be equal to one minus win probability. For a losing streak, the value would be equal to zero minus win probability. This creates a situation where a team gets more credit for winning a difficult game (one with a low win probability) compared to an easy game and loses less credit for losing a difficult game versus an easy game.

Win probability was calculated using a modified version of the Pro Football Reference win probability model (The P-F-R Win Probability Model, n.d). This model determines win probability by developing a normal curve with a center equal to that of the point spread and variation equal to the standard deviation of all PS residuals. The area under the curve between -0.5 and 0.5 represents the probability of a tie game. The area under the curve above 0.5 plus half of the tie probability is equal to the win probability. The present study modified this model by calculating the center using game location and difficulty of opponent. For game location, away games were valued at -1.5 whereas home games where valued at 1.5. These values were chosen as the average point differential between home and visiting teams is about three points favoring the home team. Difficulty of opponent was calculated as the opposing team's average point differential across the season. This modified model allowed for the calculation of win probability and subsequently the calculation of weighted streaks. The distributions of weighted streaks were bimodal for the home and visiting team and generally normal for the combination of weighted streaks, which was calculated as visiting team weighted streak minus home team weighted streak.

RESULTS

Streaks

PS residual variation across streak lengths was assessed in order to determine if being on a streak was related to beating the spread. There was generally even variation of PS residuals across streaks for both the home and the visiting teams. Streaks that were longer than six games were grouped together for this analysis due to the fact that there were very few instances of extreme streaks. Further analyses were conducted in order to determine the effect of both home and visiting team streaks together on PS residuals. In Figure 1, shades of gray were used to represent PS residual magnitude, with darker grays representing positive values and lighter grays representing negative values. As shown by Figure 1, there was no foreseeable trend among PS residuals. Had a momentum effect been present, a clear gradient would be present. In general, streak length was found to have an insignificant effect on PS residuals.

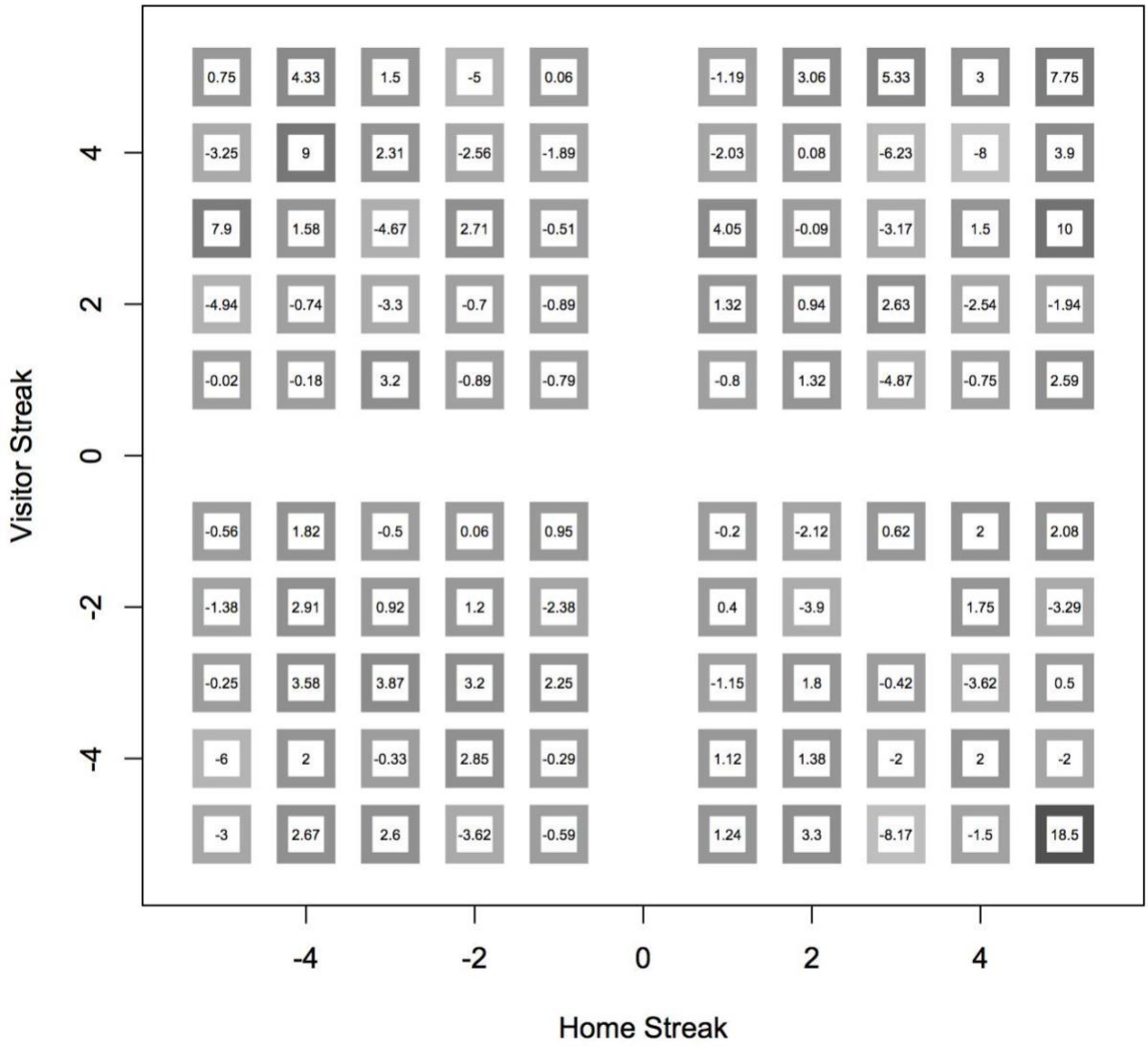


Figure 1. Point spread residuals (visitor score - home score + point spread) plotted by home streak and visitor streak. Darker gray represents positive point spread residual values and lighter gray represents negative values.

Weighted Streaks

After finding minimal effects of conventional streaks on game outcome related to the point spread, correlational analyses were conducted using weighted streaks. These analyses demonstrated that weighted streak length was significantly correlated with PS residual for the home team, $r(4846) = -.07$, $p < .001$, the visiting team, $r(4846) = .04$, $p = .004$, and the combined weighted streak condition, $r(4846) = .07$, $p < .001$, which was calculated as weighted visitor streak minus weighted home streak. For all conditions, being on a winning streak correlated significantly with beating the spread, and vise versa for a losing streak. A multiple regression analysis was also conducted to further explore the relationship between weighted streaks and PS residuals, which yielded the following equation: PS residual = -.599(weighted home streak) + .230(weighted visitor streak) - .151. It was determined that weighted home streak and weighted visitor streak together significantly predict PS residuals, $r = .07$, $r_2 = .005$, $SEest = 13.36$, $p < .001$. The results of the weighted streak analyses are displayed in Figure 2.

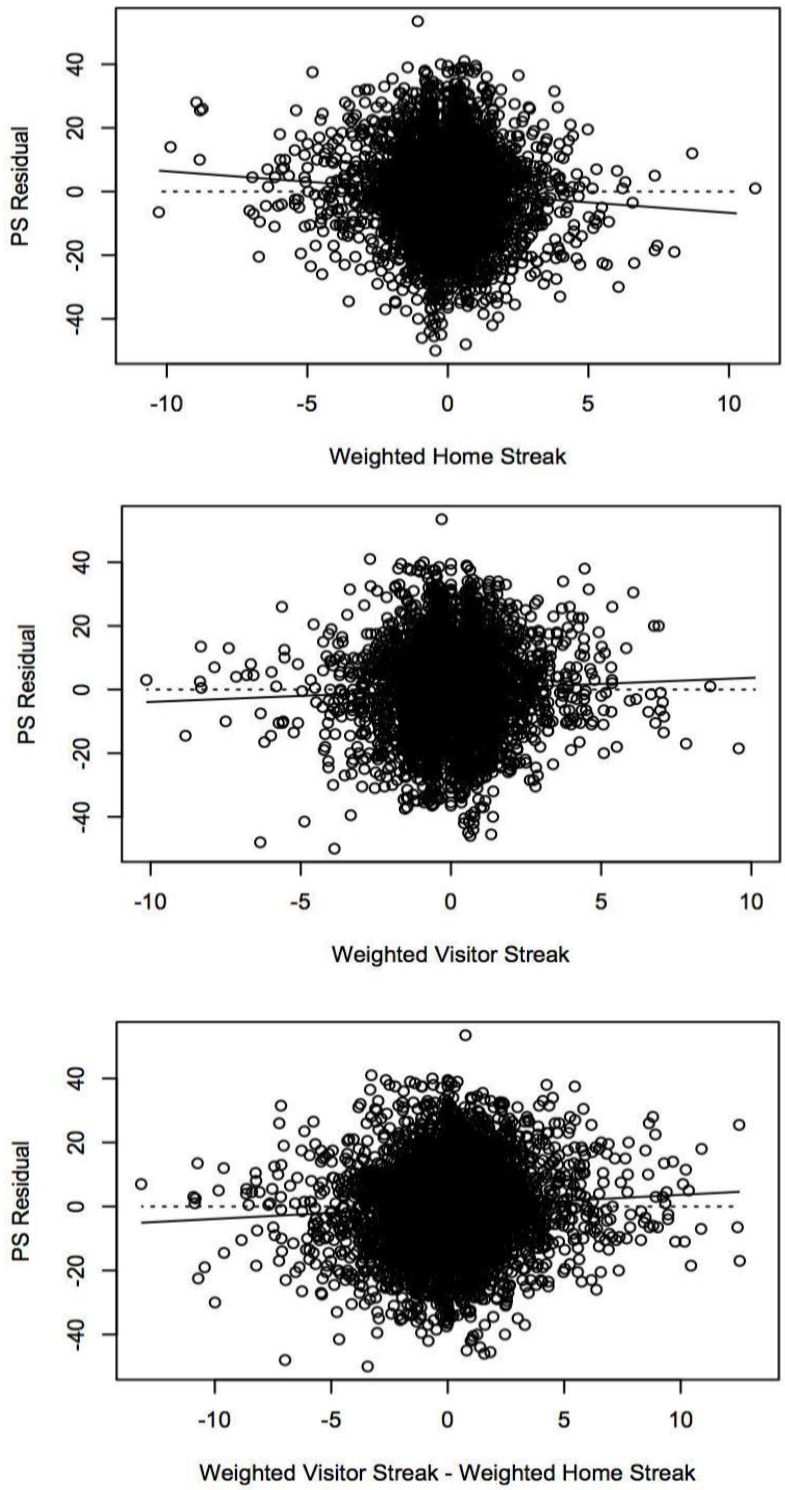


Figure 2. Point spread residuals (visitor score - home score + point spread) plotted by weighted streaks for home team, visiting team, and the difference between the two. Solid line represents regression line. Dotted line represents a slope of zero.

Betting Outcomes

Due to the significant results obtained through analyzing weighted streaks, analyses were conducted to assess whether this information can be utilized to inform betting. In order to test this, a betting method was devised where a bet would be placed every time the absolute value of a weighted streak was greater than a certain threshold. This threshold was set at 500 different points ranging from zero to 11 in the home and visiting team conditions and zero to 15 in the combined weighted streak condition. After it was determined which bets would be placed, the proportion of winning bets was calculated. These win proportions are displayed in Figure 3 with the graphs truncated after a threshold of six for the home and visiting team and a threshold of nine for the combination of weighted streaks due to the low number of extreme values.

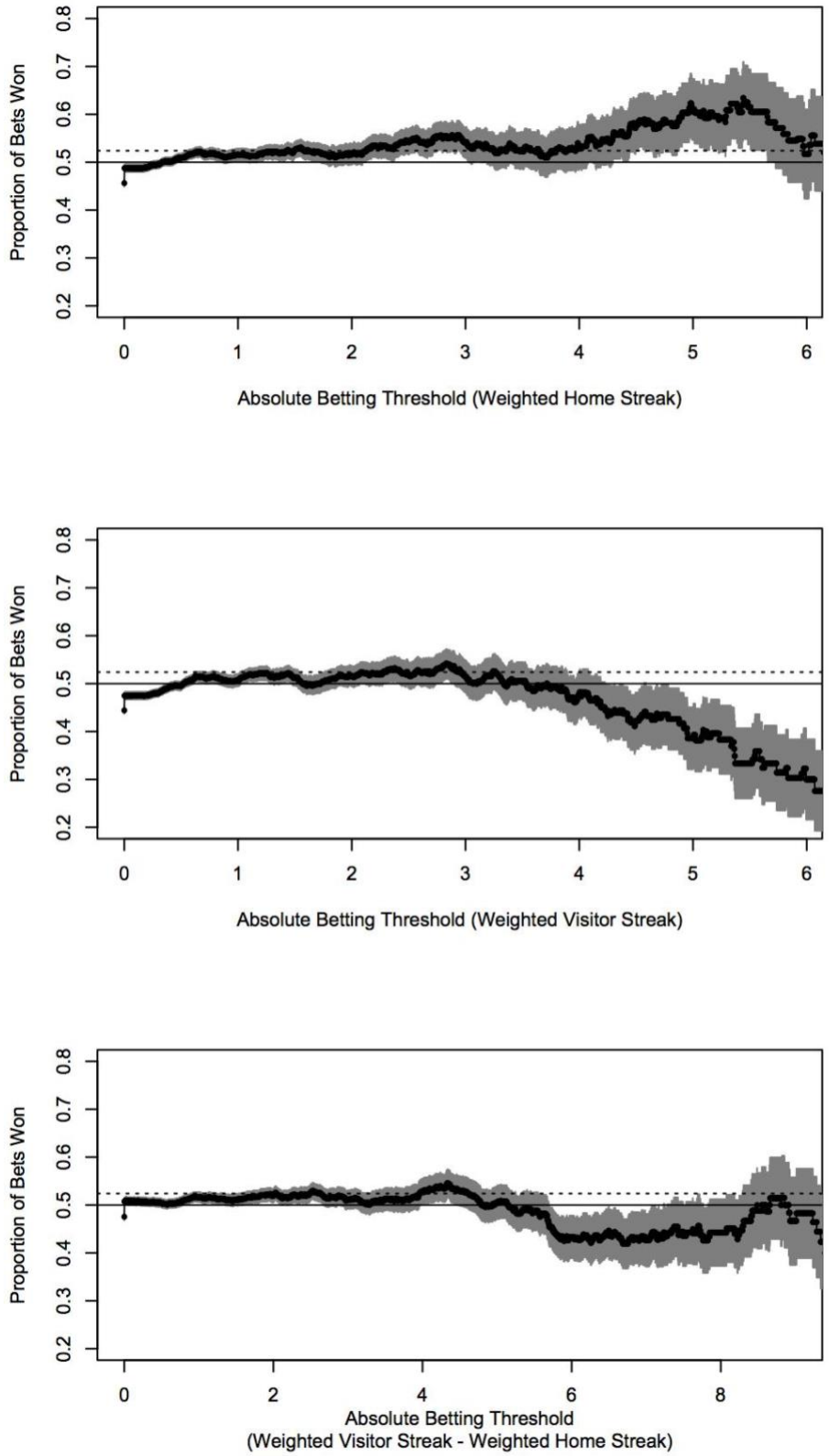
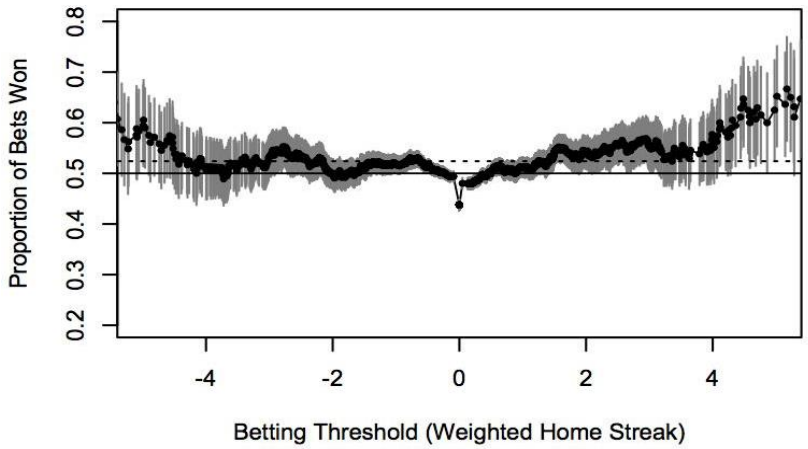
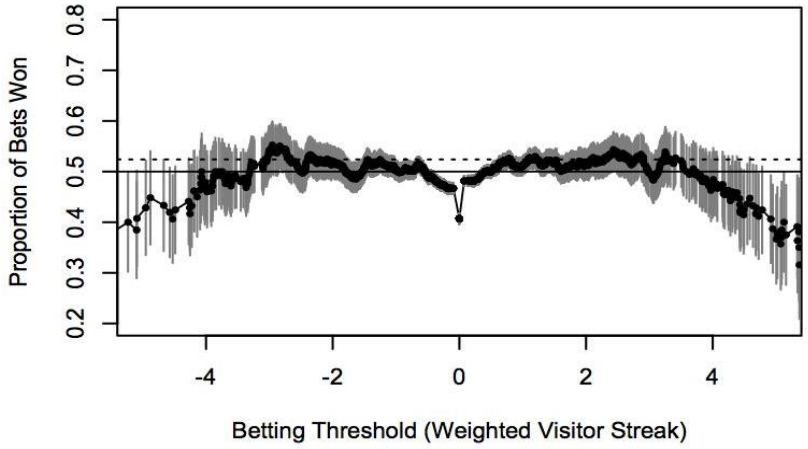


Figure 3. Win proportion variation across absolute betting thresholds for home team, visiting team, and combined weighted streaks. Solid line represents win proportion of 0.5. Dotted line represents win proportion of 0.524. Gray area represents standard error.

It was found that profitable bets with a win percentage greater than 52.4% could have been made in all conditions. The maximum observed win proportion was 0.62 at an absolute threshold of 5.45 for the home team, 0.54 at an absolute threshold of 2.84 for the visiting team, and 0.55 at an absolute threshold of 4.35 for the combined weighted streaks. There was a positive trend observed within the weighted home streak condition with greater streak length leading to higher win proportions. This trend was not observed for the visiting team, as an increase in weighted streak length typically lead to a decrease in win proportion. For the combined condition, win proportions generally hovered around 50%, but began to decline after a threshold of four.

Next, a second analysis of win proportion was conducted with a wider range of thresholds that encompassed all observed weighted streak values and did not rely on absolute value. For this measure, instead of betting when the absolute value of a weighted streak exceeded the threshold, bets were placed every time a weighted streak value was equal to or more extreme than the threshold. These thresholds were set at each weighted streak value in order to address the entire range of observed streaks. This allowed for a better representation of win proportion and a more accurate depiction of the betting process using weighted streak values. As with the absolute threshold analysis, all conditions produced profitable bets at some point. Win percentages remained around 50% for each condition, but did tend to increase as weighted streak lengths became more extreme. The maximum observed win proportion was 0.64 at a threshold of 4.48 for the home team, 0.55 at a threshold of -2.95 for the visiting team, and 0.55 at a threshold of -4.32 for the combined weighted streaks condition. The home condition again produced the most promising results, with an overall positive trend that was not as prominent in the other two conditions. These graphs, displayed in Figure 4, were once again truncated at negative five and five for the home and visiting teams and negative seven and seven for the combined condition as extreme streaks yielded small samples with varied results.





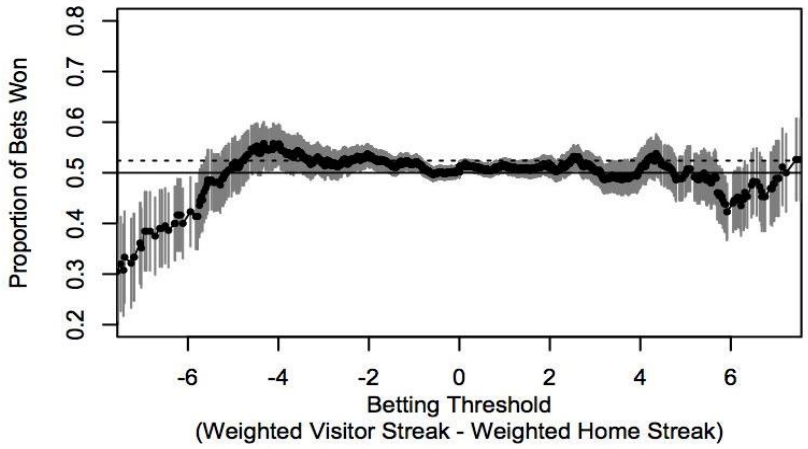


Figure 4. Win proportion variation across betting thresholds for home team, visiting team, and combined weighted streaks. Solid line represents win proportion of 0.5. Dotted line represents win proportion of 0.524. Gray area represents standard error.

Once it was determined that profitable bets were observed in previous analyses, a final analysis was conducted to determine the total amount that would have been won had actual bets been made. For this analysis, a bet of one dollar was assumed. Given the amount of bets placed and the amount of bets won, the total amount of money won was calculated and displayed in Figure 5. These values again were truncated at negative five and five due to low sample sizes at the extremes. There was a large scope of values represented, with a range of winnings from -192.60 to 143.40 dollars. For the home condition, the maximum amount won was observed at $143.40 at a threshold of 0.47, for the visiting team the maximum amount was $42.10 at a threshold of 0.78, and the combined condition yielded maximum total winnings of $37.00 at a threshold of 0.09. While there were some bets placed that would have resulted in losing money, in every instance the weighted streaks method yielded better results than a zero validity method which, given the total amount of possible bets to be placed and the total amount of observed pushes, would have resulted in winning 50% of bets and a net loss of $219.40, represented as a dotted line in Figure 5.

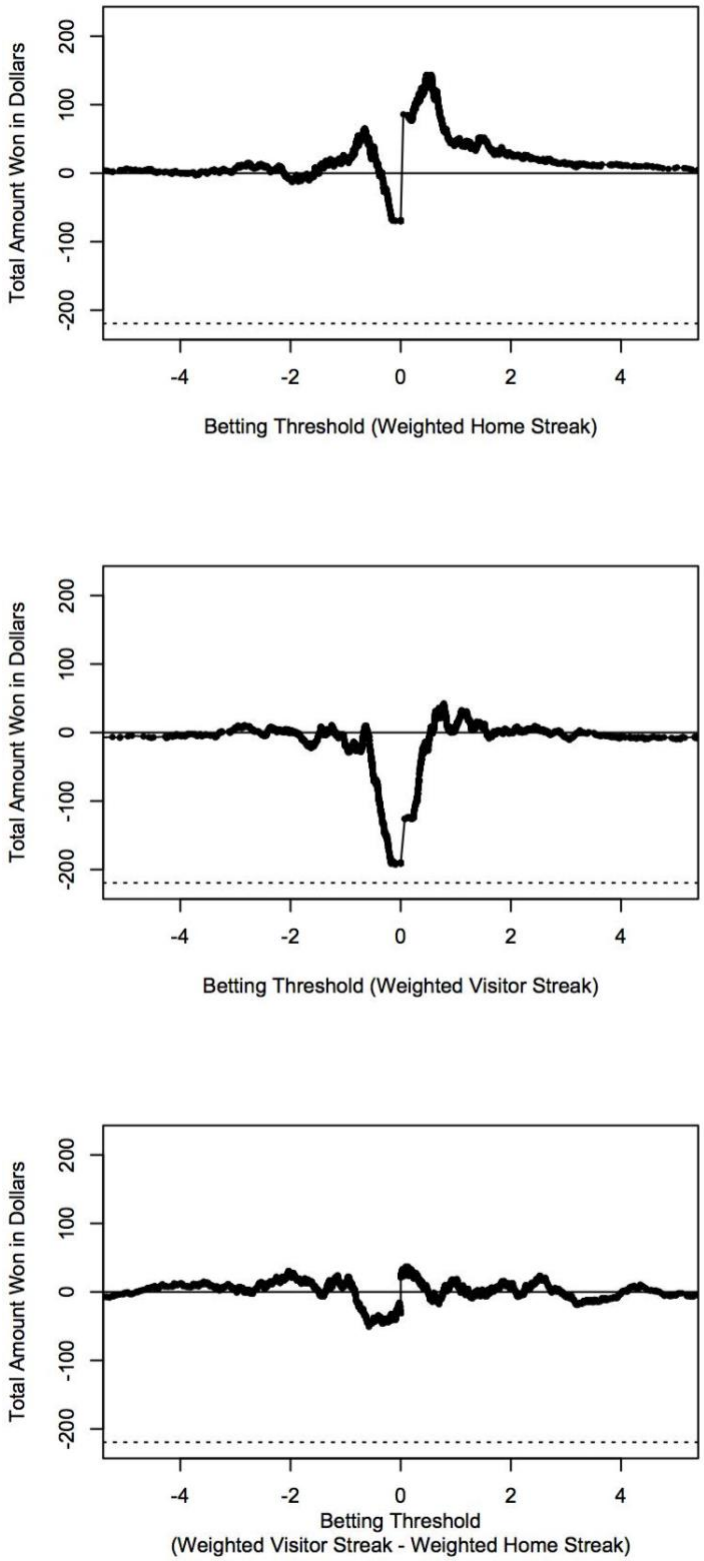


Figure 5. Total amount won from one-dollar bets by betting threshold for home team, visiting team, and combined weighted streaks condition. Dotted line represents profits from a zero-validity strategy where one-dollar bets are placed each game and teams are chosen at random.

DISCUSSION

The present study aimed to investigate whether the perception of momentum in the NFL could be used to inform betting. It was found that momentum, when measured by the number of games won or lost in a row, did not significantly affect betting outcomes. However, there did appear to be a significant effect of perceived momentum on point spread residuals when momentum was conceptualized as weighted streaks; suggesting that these streaks could potentially be employed to advise betting practices. To test this, weighted streak values were used to assess the proportion of bets won and the amount won had actual one-dollar bets been placed. A weighted streak betting system was devised which utilized thresholds set at a variety of different points. Both absolute thresholds and thresholds set at every observed weighted streak value were tested, the latter being used in subsequent analyses as it most accurately represents betting using a weighted streak system. It was found that in every condition, profitable bets would have been made. Even when bets would have lost money, this system was more profitable than a zero-validity system which would result in winning 50% of placed bets. The results were most promising when observing weighted home streaks, suggesting that the weighted streaks system may be most accurate for the home team. Overall, the results of this study reveal that it is possible to use perceived momentum in the NFL to make profitable bets.

This study had many strengths which increase the validity of the obtained results. The present study analyzed a large dataset with a sample of 4848 regular season games. This increases the real world applicability of these findings as the weighted streaks betting system was created using a large number of real games, allowing for greater generalizability. In addition to the data used for analyses, this study was novel in the sense that it went beyond the conventional notion of streaks, which are conceptualized as the number of games won or lost in a row (Arkes, 2010; Gilovich, Vallone, & Tversky, 1985; Lehman & Hahn, 2013; Vergin, 2000). Consistent with prior research, the present study found that conventional streak knowledge does not seem to affect point spread residuals, suggesting that this knowledge cannot be used to improve betting outcomes (Vergin & Scriabin, 1978). However, when streak calculations take win probability into account, as was the case in the present study, streak length is found to be significantly correlated with point spread residuals, suggesting that this weighted streak knowledge can produce profitable bets, as demonstrated by this study.

While there were many strengths to this project, there were also some limitations present throughout. For instance, the generally exploratory nature of this study could be to blame for the statistically significant results that were obtained. It is possible that these results were simply capitalizing on chance and do not represent an actual effect. Moreover, the weighted streak calculation conceptualized opponent strength as the team's average point differential across the season. This means that this system employs knowledge that will not be available during the season, likely reducing its accuracy early on. Future studies should address these limitations and should create a measure of weighted streaks that uses only information that will be available at the time of the game so that it can be used to inform bets. Studies could also develop a measure that gives credit for all past games, not just those won or lost in a row. This could lead to a more accurate representation of a team's strength, which could possibly lead to even more profitable bets.

CONCLUSION

This study reveals that it is possible to use weighted streak knowledge to produce profitable bets. Weighted streak length is statistically significantly correlated with point spread residual, which is information that can lead to successful betting endeavors. There is still work that needs to be done before this weighted-streaks system can be used to make actual bets, but the results are promising nonetheless. Whether sports momentum has an actual effect on game outcomes or is nothing more than a cognitive illusion, it is a very interesting phenomenon that, as the present study suggests, could allow individuals to beat the odds and make profitable bets in the NFL.

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