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Reverse Line Movements in NFL Gambling: Parallels to Financial Market Biases and the Imitation of Informed Bettor Strategies

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I. ABSTRACT

Participants in the NFL gambling market can largely be divided into two distinct groups: informed bettors ("Sharps") and uninformed bettors ("Squares"). Empirical and anecdotal evidence suggest that the dynamic between Sharp and Square bettors is very similar to that between institutional and retail investors. Professionals tend to be far better informed and utilize rational betting/investing strategies while individuals exhibit biases which perpetuate irrational strategies and therefore pricing inefficiencies. This study finds that uninformed participants in financial markets and the NFL betting market do share similar biases, and that these biases can be exploited by informed participants to generate positive excess returns. The ability of Sharp bettors to generate excess returns, much like professional investors, is well covered in academic research. This study adds to the existing literature by analyzing whether "Follower" bettors can achieve statistically significant excess returns and higher than expected winning percentages by identifying reverse line movements and imitating the bets of Sharp gamblers.

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III. MOTIVATION

George Soros is famous for his theory of reflexivity, which has served as the foundation for his legendary investing strategy for more than three decades. He believes that market participants are inherently biased, which creates pricing inefficiencies that can be taken advantage of by the unbiased and informed investor (Soros 88). Investing strategies based upon the exploitation of inherent investor biases have been the subject of much debate in the academic circle due to their stark contrast to the efficient market hypothesis. This hypothesis is commonly referred to as the "noise trader" theory.

The noise trader theory posits that irrational investors are making decisions based upon uninformed "pseudosignals" which creates an opportunity for rational traders to arbitrage the pricing inefficiency. Generally speaking, the bulk of uninformed market participants are individual investors while institutional investors comprise their informed counterparts (Lee et al. 1990).

Central to the noise trader theory is the concept that uninformed investors trade based upon sentiment rather than prudent information. In order to test whether individual investors trade based upon sentiment, academics commonly study closed-end mutual funds. Such funds provide an excellent testing ground as they tend to be held primarily by individuals (Lee et al. 1990). The closed end structure of these funds allows academics to study the premium or discount at which these funds trade relative to their underlying net asset value. The theory is that fluctuations in the level of premium or discount indicate irrational buying or selling pressure from individual investors (Lee et al. 1991). Rational

investors arbitrage away these pricing inefficiencies until costs such as commissions eliminate the remaining profit opportunity (Pontiff 1996).

Two specific biases which academic studies have identified in individual investors include overreaction to recent information regarding a security and the tendency to buy "attention-grabbing" stocks. The overreaction theory purports that individual investors value recent information too highly and drive stocks above or below their intrinsic value. In support of this, Bondt and Thaler (1985) found that portfolios comprised of stocks in the bottom decile of performance tend to outperform their winning counterparts over the next three years. A similar study by Chopra et al. (1992) also found that this contrarian investing strategy can generate statistically significantly positive returns for informed investors.

The second bias which irrational investors exhibit is a preference to purchase stocks which are highly visible. Barber and Odean (2007) found that "individual investors are net buyers of attention-grabbing stocks, e.g., stocks in the news, stocks experiencing high abnormal trading volume, and stocks with extreme one-day returns." The study does not investigate the viability of a contrarian strategy that identifies and sells "attention-grabbing" stocks, but does find the purchase of such securities by individual investors to be irrational and unprofitable. This result is profound as it could indicate greater short-term pricing inefficiency in stocks that receive abnormally high attention.

Institutional investors do not exhibit the same sentiment and biases that most individual investors do. Barber and Odean contrast their findings regarding individual

investors with evidence that professional investors "are likely to employ explicit purchase criteria—perhaps implemented with computer algorithms—that circumvent attention-driven buying." Feng and Seaholes (2005) reached a similar conclusion that experienced investors such as institutions tend to be less biased. The effect of institutional investors rationality is that stocks with greater institutional ownership are more efficiently priced (Boehmer and Kelley 2009).

Institutional investors' superior access to information, combined with their awareness of individual investor bias, allows them to achieve highly profitable trading strategies (Nofsinger and Sias 1999). A specific example of this is the ability of institutions to predict earnings breaks at least one quarter in advance of the break quarter. Evidence suggests that this is made possible by "obtaining information regarding the impending break from private communications with management" (Ke and Petroni 2004). Such communications provide a clear advantage over individual investors.

All of these studies indicate that institutional investors are superior to individual investors in their lack of bias as well as greater access to information. The question then becomes, however, whether non-institutional investors who are aware of these inherent discrepancies, can mimic the investing strategies of institutions and generate positive excess returns. While most strategies employed by large institutions are too complex or require too much capital to be replicated by individual investors, there are instances in which a "copycat" strategy appears to be profitable. One example of this is individual investors who attempt to imitate the holdings of Warren Buffett's legendary Berkshire Hathaway. Because Berkshire's holdings records are released on a monthly basis, it is not

difficult to create a portfolio comprised of their public investments. Martin and Puthenpurackal (2008) found that such a strategy can yield statistically significant excess returns.

Greater access to information and lack of bias have been shown to render institutional investors superior at generating returns compared to individual investors in the financial markets. In this paper, I will study whether uniformed participants in a different market—the NFL gambling market—exhibit similar biases and whether they can also be exploited by their informed counterparts. Furthermore, I will test whether individuals who are aware of retail gambler biases and the superior information possessed by professional gamblers can utilize reverse line movements to mimic bets placed by professionals and generate excess returns.

IV. IMPORTANCE AND STRUCTURE OF THE NFL GAMBLING MARKET

One must look no further than the record $119 million wagered in Nevada casinos on the 2014 Super Bowl to understand the magnitude of sports gambling in the United States. The Nevada Gaming Control Board reports that legal gambling action on the Super Bowl has increased every year over the past five seasons, and some experts estimate that as little as 1 percent of bets placed on the big game are done so legally (NGCB 2014) (Hairopoulos 2011). The rest are wagered anywhere from black market betting rings to office pools, and when it's all said and done roughly half of all Americans have a stake in the game (Hairopoulos 2011).

These tremendous figures are not limited to the Super Bowl. According to revenue estimates from the Nevada Gaming Control board, approximately $3 billion was wagered on sports in Nevada in 2013 with a similarly huge percentage likely being gambled illegally (NGCB 2014).[1] Similar to financial markets, participants in the NFL betting market range from casual sports fans basing their picks on intuition and very limited research, to professional betting syndicates with millions of dollars and complex computer prediction systems at their disposal. Conventional wisdom dictates that professional gamblers, commonly referred to as "Sharps," enjoy a significant informational advantage over retail gamblers. Much like individual investors, retail gamblers (otherwise known as "Squares"), are thought to be highly biased in their betting decisions which creates inefficiencies for Sharps and sports books to exploit (Rodney and Weinbach 2010).

Furthermore, academic studies have found that by exploiting these biases, Sharps are able to achieve positive excess returns (Miller and Rapach 2013). Given these findings, it is intuitive that individuals mimicking Sharp bettors could also achieve significant profits. While the strategies of most Sharps are closely guarded secrets, some bettors believe that it is possible to ascertain where the "smart money" is being wagered by observing how the spread on the game changes over time.

The specific strategy which I will explore in this paper uses reverse line movements to identify teams that Sharps are betting on. I will test whether non-Sharps, who I will refer to as "Followers," can then win more than the expected 50 percent of

[1] Calculated based on $136 million in net revenue and standard 4.5% commission rate on total wagers placed

wagers and earn statistically significant positive returns by betting on the same side as the professionals. While some bettors have sworn by this strategy for years, to my knowledge it has not yet been studied in academic literature. I will explain more about the theory behind and execution of the reverse line movement strategy in section IV of this paper.

My findings provide evidence that bettors using variations of the reverse line movement strategy are able to achieve win rates that are statistically significantly higher than the expected 50 percent level and that they can earn positive excess returns, especially in the absence of commission costs.

These results, along with existing research on NFL betting, indicate that the market is governed by similar biases to those that exist in financial markets. Square bettors appear to have similar biases to those observed in individual investors, while Sharp bettors take advantage of these biases through comparable contrarian strategies to those used by institutional investors.

V. UNDERSTANDING THE POINT SPREAD

The sports gambling industry was revolutionized in the 1940s when legendary sports handicapper Charles K. McNeil invented the point spread method of book making (Boyle 1986). Book makers had previously offered only odds that a team would win outright (e.g. 4-to-1 that Green Bay would beat Chicago) which is the same way that baseball gambling works today. Under McNeil's system, however, bettors would wager on how many points a team would win or lose by. For example, the Chicago Bears would

be offered at -10 (10 point favorites) over the Green Bay Packers. Bettors taking Chicago would need the Bears to win by more than 10 points while bettors wagering on Green Bay would need the Packers to lose by less than 10 points or win outright. A 10 point Chicago victory would result in a "push" in which both sides of the wager would have their money returned in its entirety. The 10 points by which the Bears are favored is referred to as the "spread" or "betting line" and the winning side of a spread bet is said to have "won against the spread" or "covered the spread." The point spread system which McNeil introduced remains the most popular method of gambling on football and basketball games of all levels and is often credited as a primary reason for the explosive growth of the sports betting markets.

Empirical evidence shows that spreads offered by sports books are very accurate predictors of actual game outcomes and that it is very difficult to achieve win rates greater than the expected 50 percent level (Sauer et al. 1988). Compounding this, bettors must contend with the commission which sports books charge for their services. Also known as the "vigorish," "vig," or "juice," sports books typically follow the standard 10-for-11 payout structure. This means that the book collects the entirety of all losing bets while only paying out $10 for every $11 wagered on the winning side. This implies a juice of 4.55% on the total amount bet. In theory, if the book follows this standard and consistently balances their book (an equal amount of money being bet on the favorite and the underdog), they will earn a risk-free return of 4.55% on all money wagered.

VI. THEORY

A key attribute of the point spread is that sports books have the ability to change it over time as more information becomes available and bettor preferences become apparent. The books will typically post an "opening line" on Monday or Tuesday of every week for the NFL games played on the following weekend. Throughout the week, however, they will change the line based on information such as injury reports and bettor action.

This gives the books a certain degree of control over how much action both sides of a bet receive. If more money is being placed on Chicago at -10 than the sports book wants, they can raise the line to -10.5 or -11 in order to make a bet on Green Bay more attractive. Changes in the line throughout the course of the week are quite common. The data set used in this paper shows that the line changed from the open to the close in 76% of games played in the NFL since 2003. Similar frequencies of line changes have been documented in the NBA (Gander, Dare, et al. 1998). Line changes over the course of the week are documented by sports books and this information is easily accessible to bettors on numerous websites such as VegasInsider.com.

Also documented on these websites is the percent of bets being placed on both teams in a given matchup (but not the total dollars bet). Coupling this with the line movements and the assumption that sports books want to balance the notional amount bet on each side of the matchup is quite informative. Assuming that books are balanced and that every bet placed is of equal dollar value, logic would dictate that if more than 50 percent of bets are being placed on a given team, the book would move the line against

them (bigger favorite or smaller underdog) in order to encourage more action on the other side. To again use the example of Chicago versus Green Bay, this would mean that if 70 percent of bets are being placed on the Bears at -10, then we would expect the book to make them -10.5 or -11 point favorites. The Packers then become increasingly attractive at +10.5 or +11 point underdogs and the book should approach a relative level of parity on both sides. The line will in theory move until it is at the market clearing level.

Empirical evidence, however, shows that lines will sometimes not move in this expected manner. Rather, the line will move to Chicago -9.5 or -9, which is in complete contrast to our above example. Such a change in the spread is referred to as a "reverse line movement" and indicates that our assumption of balanced books, equal sized bets, or both are invalid. The theory surrounding these line movements is that they are caused by Sharps betting heavily on one side of the line (the Packers in this example). If one operates under the assumption of balanced sports books, the occurrence of reverse line movements means that Sharps are placing much larger bets than Squares.

On the other hand, if one assumes that all bets are of equal dollar amount, then reverse line movements indicate that the books value the insight bettors taking the Packers significantly more than that of those betting on the Bears. This means that sports books are taking on a risk position that stands to profit if the Packers cover the spread and to lose if the Bears do so. In fact, sports books taking proprietary positions on games is well documented in academic research (Humphreys 2011) (Levitt 2004).

Ultimately, logic as well as anecdotal evidence suggest that because Sharps are more informed, the bets they place are larger in size and sports books highly value their

insight. Perhaps the clearest example of a prolific sports gambler whose bets can single handedly move sports lines is that of Billy Walters. Walters is a legendary sports handicapper who has amassed an estimated $200 million fortune, largely from his football and basketball betting operations. He began his career in sports gambling as an illegal book maker in Kentucky and eventually moved to Las Vegas in the 1980s where he became part of one of the first computer betting syndicates (Berzon 2014). Today he is considered to be one of the most notorious sports gamblers of all time and is described by his peers as “brilliant,” “respected,” and “feared”.

Walters uses a team of analysts to scour for information on injuries, weather, and statistics which he inputs into an advanced computer system in order to gain an edge over the sports books and the betting public. His systems generate a predicted spread for each game, and the larger the discrepancy between Walters’ predictions and the casino sports lines, the more he will bet. On any given Sunday during the NFL season, Walters will have an average of $2 million at risk—clearly orders of magnitude more than virtually any retail gambler. On the 2010 Super Bowl alone, he famously won $3.5 million. His track record speaks for itself as he claims to have never had a losing year in a career that spans more than three decades (CBS News 2011). This unprecedented level of success has certainly drawn the attention of sports books over the years. In a rare 60 Minutes piece documenting Walters’ career, CEO of CG Technology Lee Amaitis was asked if Walters has the ability to move betting lines. CG Technology manages multiple sports books across Las Vegas. Amaitis responded, “of course he does…he’s Billy Walters…of course he has the ability to move our lines.” Amaitis went on to say that it is an advantage to know what Walters is thinking (CBS News 2011).

An interesting comparison to be made is to that of George Soros famously speculating on the British pound sterling in 1992. Recognizing that the UK currency had entered into the Exchange Rate Mechanism at too high of a rate, Soros sold short $10 billion in pound sterling. The downward pressure which this exerted on the pound sterling forced the Bank of England to secede from the ERM and devalue the currency. Much like Walters, Soros recognized an artificially inflated asset and utilized his brute force as an investing behemoth to correct the valuation and profit from the inefficiency. By deflating the pound sterling, Soros earned an estimated $1 billion and the moniker of "the man who broke the Bank of England" (Litterick 2002).

While it is true that Billy Walters, much like George Soros, is the Sharpest in his field, he serves as proof of both the influence which Sharp gamblers have over betting lines and the large size of bets which Sharps are consistently placing. This strongly supports the theory that reverse line movements can indicate which side the smart money is flowing to. Bettors privy to this phenomenon have believed for years that they could gain an advantage by following the lead of line-moving Sharps. Due to lack of historical data on public betting percentages, however, the effectiveness of such a strategy has yet to be studied by academics.

Much like in financial markets, the advantage of professional gamblers is enhanced by noise created by retail gamblers. This noise skews lines in the direction of Square bias. A relatively well know example is that Squares tend to be biased towards favorites (Levitt 2004). In the data set used in this paper, approximately 80% of bets placed from 2003-2014 were on the favored team. Humphreys (2011) reached a similar

result. Knowing this, it stands to reason that an unbiased bettor could bet on the underdog at an inflated line and achieve positive returns (at least before commissions are considered). Indeed, academic studies have shown that variations of the underdog strategy can be profitable (Wever and Aadland 2011).

Biases such as this create profit opportunities for Sharps as well as the sports books themselves. As stated earlier, it is not uncommon for sports books to take positions on games rather than balance their books. If they believe that Square bettors will be biased toward a particular team, the book has the ability to set the spread at a level which is different from the efficient level. Humphreys (2011) found that "sports books consistently take positions on games, and that these positions are mostly on the underdog" (64). To use the Super Bowl as an example, in 2014 Las Vegas casinos earned a return of 16.5% by taking a proprietary position on the underdog Seattle Seahawks. This return is significantly more than the 4.6% expected under the balanced book assumption (NGCB 2014). Because of their bias, squares will still buy the line even though the odds are stacked in favor of the book. Gandar et al. (1998) used evidence from the NBA betting market to show that sports books base their opening spreads not just on their predicted outcome for the game, but also on their "perception of the betting market's evaluation of these outcomes" (387).

Much like the dynamic witnessed in closed-end funds, informed bettors tend to arbitrage away the inefficiencies created by the biased Square bettors until costs of arbitrage such as commissions eliminate the potential for further profit (Lee et al. 1990). Reverse line movements are the manifestation of this arbitrage activity. Lee et al. further

found that closed-end funds tend to be issued at premiums to their net asset values, and then revert to a discount within several months of the issue due to arbitrage. They attribute this phenomenon to overoptimistic investor sentiment, which is often caused by famous portfolio managers running the funds or the promise of innovative investment strategies. In a later paper, Lee et al. (1991) stated these findings more bluntly by alleging that "like casinos and snake oil, closed-end funds are a device by which smart entrepreneurs take advantage of a less sophisticated public" (84).

VII. DATA

To perform my analysis of the profitability of gambling strategies based on reverse line movements, I used a sample of NFL betting data from SportsInsights.com. The data set spans 2,967 games from 2003-2014 and includes information such as opening lines, closing lines, and recent performance of both teams in every matchup. These data points are not necessarily uncommon, but the unique aspect of this data set is that it also includes the public betting percentages for each matchup, therefore making it possible to identify reverse line movements. Sports Insights compiled the information from four highly reputable online sports books: Pinnacle, 5Dimes, BetUS, and GT Bets.

To analyze whether Followers can profit from identifying reverse line movements and taking the same side as Sharp bettors, I tested both winning percentage and expected return. I chose to test three specific strategies, all of which were predicated upon reverse line movements. I began with a strategy of simply betting on all games that experienced reverse line movements. In this strategy, Followers bet on teams that are receiving less

than 40 percent of the total bets placed, but have had the spread move against them (became bigger favorites or smaller underdogs).

Additionally, I tested two variations of the reverse line movement strategy which fit the aforementioned criteria and also utilized one additional filter when selecting teams to bet on. The first of these strategies focused exclusively on games played between two opponents in the same Conference that also experienced a reverse line movement. The purpose of only betting on In-Conference games is that they tend to attract more action from retail gamblers. For context, the NFL is divided evenly into two Conferences: the American Football Conference (AFC) and the National Football Conference (NFC). Because playoff berths are determined separately within the AFC and NFC, games between conference opponents tend to have more playoff implications and therefore receive more attention from retail gamblers. The theory underlying this strategy is directly related to the findings of individual investor bias toward "attention-grabbing" stocks.

To test whether this theory held true in my data set, I utilized a filter available on Sports Insights which tracks number of bets on every game relative to the average bets per game on that day. Of games that received higher than average betting action since 2003, 76 percent of those games were played between conference opponents. Because total number of bets placed on games relative to the day's average is a retrospective measure, it cannot be used for as part of a real-time betting strategy. With such a high percentage of these games being In-Conference matchups, however, betting on In-Conference games serves as a reasonable proxy. With increased participation from retail

gamblers, the effect of their biases should be amplified and therefore inefficiencies increased. A 2004 study of NFL gambling by Levitt supports this theory as he found that "the dispersion of the fraction of wagers placed on the preferred team is actually greater in the games with more total bets" (231).

The final strategy which I tested was betting on teams that have performed very poorly in the two weeks prior to a game where a reverse line movement occurred, with poor performance being defined as losing by at least 10 points against the spread. This strategy takes advantage of Square bias against the poor performer by betting on the artificially inflated line (Gray and Gray 1997) (Sinkey and Logan 2012). The inspiration for this strategy came from the overreaction theory in financial markets which causes contrarian portfolios of prior losers to generate excess returns.

I tested both the observed win percentage and excess returns of each of these strategies for statistical significance. For win percentage, I used Pearson's Chi-Square to determine whether the strategies achieved win percentages greater than the expected 50 percent level in this sample. An obvious question to be raised here is whether the expected win percentage should actually be 50 percent given the possibility of "pushes." Because it is not possible to attain a theoretical value for the expected frequency of pushing (which would be required for the Chi-Square test), I excluded games that resulted in a push for this test. Once pushes have been omitted, the expected win percentage is necessarily 50 percent. Additionally, I tested the consistency of each

strategy by breaking the sample up into two periods of 2003-2008 and 2009-2014 and found the z-score for the difference in winning percentages within the two sub-periods.[2]

To test the significance of the excess returns generated by each strategy I performed a two-tail t-test of the average return per bet to test whether it was different from the expected 0 percent level. I included games that resulted in a push because a theoretical push percentage is not necessary for this test. Additionally, I calculated the t-statistic associated with the expected return per bet both before and after accounting for the juice in order to assess the effect of sports book commissions on otherwise potentially winning strategies. Also of note is that the actual payouts of winning bets in this sample are higher on average than the 10-for-11 rule would dictate. This is because the payout data came from Pinnacle, which is a "reduced juice" sports book. I tested the significance of the returns under the reduced juice payout structure as well. The equation for calculating the expected return is as follows[3]:

$$r_e = (r_w \times p_w) + (r_l \times p_l)$$

Finally, I calculated the realized annual in-sample return of each strategy using the Kelly Criterion for optimal bet size .[4] For all of the strategies studied, I assumed that the Followers were placing their bets on the closing line.

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[2] $z = \frac{(\bar{p}_1 - \bar{p}_2)}{\sqrt{\bar{p}(1-\bar{p})\left(\frac{1}{n_1}+\frac{1}{n_1}\right)}}$

[3] r_w and r_l are the payouts of winning and losing bets, respectively; p_w and p_l are the probability of winning and losing, respectively

[4] The Kelly betting criterion is a formula which gamblers use to determine their optimal bet size. It is most commonly used in Blackjack gambling, but is applicable in this situation as well. In these tests I used a shrinkage factor of 0.5 in order to account for parameter uncertainty, as suggested by Baker and McHale (2013).

VIII. EMPIRICAL FINDINGS

Standard Reverse Line Movement Strategy:

Pearson Chi-Square		Return Significance (No Juice)		Return Significance (Standard Juice)		Return Significance (Reduced Juice)	
Sample Win %	53.1%	Sample Win %	52.1%	Sample Win %	52.1%	Sample Win %	52.1%
Expected Win %	50.0%	Sample Push %	1.8%	Sample Push %	1.8%	Sample Push %	1.8%
Observations	642	Sample Lose %	46.0%	Sample Lose %	46.0%	Sample Lose %	46.0%
Observed Frequency	341	Winner Payout	1.00	Winner Payout	0.91	Winner Payout	0.95
Expected Frequency	321	Push Payout	0.00	Push Payout	0.00	Push Payout	0.00
		Loser Payout	-1.00	Loser Payout	-1.00	Loser Payout	-1.00
		Expected Return	6.1%	Expected Return	1.38%	Expected Return	3.4%
		Standard Deviation	99.0%	Standard Deviation	94.5%	Standard Deviation	96.5%
		Observations	654	Observations	654	Observations	654
		Standard Error	3.9%	Standard Error	3.7%	Standard Error	3.8%
Chi-Square	**1.246**	**T Stat**	**1.580**	**T Stat**	**0.373**	**T Stat**	**0.902**

This strategy produced a winning percentage (omitting pushes) of 53.1% over the 12 season sample period. This winning percentage was not significant at the 10 percent level using Pearson's Chi-Square test. Once pushes were included the winning percentage fell to 52.1% and the t-statistic of 1.58 approached significance at the 10 percent level before juice was accounted for.

Unsurprisingly, the inclusion of sports book juice had a hugely negative impact on the profitability of the betting strategy. The expected return per bet falls from 6.1% without juice to just 1.4% under the standard 4.6% juice assumption. Under the reduced juice structure, the returns are increased to 3.4%, but are still relatively far from statistical significance. A bettor utilizing this strategy over the past 12 NFL seasons using a reduced juice sports book would have achieved an annual return on investment of 7.9%.

If the sample is broken up into six year sub-periods, the winning percentage of the strategy does not differ across them. This indicates persistence of the strategy over time. The win percentages in the two sub-periods and z-score of the difference is as follows:

2003-2008	Win %	53.0%
	Sample Size	279
	Chi-Square	0.52
2009-2014	Win %	53.2%
	Sample Size	363
	Chi-Square	0.73
	Difference (Z-Score)	**-0.031**

The remaining two strategies were intended to boost returns by isolating situations in which pricing inefficiencies created by individual investor bias would be larger.

Reverse Line Movements in In-Conference Games:

Pearson Chi-Square		**Return Significance (No Juice)**		**Return Significance (Standard Juice)**		**Return Significance (Reduced Juice)**	
Win %	54.7%	Sample Win %	53.8%	Sample Win %	53.8%	Sample Win %	53.8%
Expected Win %	50.0%	Sample Push %	1.6%	Sample Push %	1.6%	Sample Push %	1.6%
Observations	481	Sample Lose %	44.6%	Sample Lose %	44.6%	Sample Lose %	44.6%
Observed Frequency	263	Winner Payout	1.00	Winner Payout	0.91	Winner Payout	0.95
Expected Frequency	240.5	Push Payout	0.00	Push Payout	0.00	Push Payout	0.00
		Loser Payout	-1.00	Loser Payout	-1.00	Loser Payout	-1.00
		Expected Return	9.2%	Expected Return	4.3%	Expected Return	6.4%
		Standard Deviation	98.9%	Standard Deviation	94.4%	Standard Deviation	96.4%
		Observations	489	Observations	489	Observations	489
		Standard Error	4.5%	Standard Error	4.3%	Standard Error	4.4%
Chi-Square	**2.105**	**T Stat**	**2.059**	**T Stat**	**1.011**	**T Stat**	**1.464**

The results of these tests support my hypothesis of greater opportunity for profit by focusing on games with higher Square better participation. The Chi-Square statistic is approaching significance at the 10 percent level and returns are significant at the 5 percent level before juice is considered. Over the past 12 years this strategy achieved an annual return of 22.2% assuming reduced juice.

Once juice is accounted for, the returns are not significantly different from 0 percent at any conventional level using a two-tailed test. Returns when betting on a reduced juice book, however, are approaching statistical significance.

2003-2008	Win %	55.1%
	Sample Size	216
	Chi-Square	1.12
2009-2014	Win %	54.3%
	Sample Size	265
	Chi-Square	1.00
	Difference (Z-Score)	**0.165**

Again, the win percentages achieved in the sub-periods 2003-2008 and 2009-2014 do not differ from one another, indicating consistency in the strategy.

Reverse Line Movements on Recent Poor Performers:

Pearson Chi-Square		**Return Significance (No Juice)**		**Return Significance (Standard Juice)**		**Return Significance (Reduced Juice)**	
Win %	60.7%	Sample Win %	59.2%	Sample Win %	59.2%	Sample Win %	59.2%
Expected Win %	50.0%	Sample Push %	2.4%	Sample Push %	2.4%	Sample Push %	2.4%
Observations	122	Sample Lose %	38.4%	Sample Lose %	38.4%	Sample Lose %	38.4%
Observed Frequency	74	Winner Payout	1.00	Winner Payout	0.91	Winner Payout	0.95
Expected Frequency	61	Push Payout	0.00	Push Payout	0.00	Push Payout	0.00
		Loser Payout	-1.00	Loser Payout	-1.00	Loser Payout	-1.00
		Expected Return	20.8%	Expected Return	15.4%	Expected Return	17.9%
		Standard Deviation	97.0%	Standard Deviation	92.5%	Standard Deviation	94.8%
		Observations	125	Observations	125	Observations	125
		Standard Error	8.7%	Standard Error	8.3%	Standard Error	8.5%
Chi-Square	**2.770**	**T Stat**	**2.398**	**T Stat**	**1.863**	**T Stat**	**2.116**

Focusing on reverse line movements involving teams that have performed poorly over their past two games proved to be the most successful strategy of the three over the past eleven seasons. There is no data from 2003 because no games during that season fit the strategy's betting criteria. Winning percentage was significant at the 10 percent level and returns excluding juice were significant at the 2 percent level. Furthermore, this was the only test that exhibited statistically significant excess returns even when accounting for sports book commissions as returns assuming standard juice and reduced juice were significant at the 10 percent and 5 percent levels, respectively. This betting strategy yielded a 55.9% annual return from 2004-2014.

One problem with this strategy is that it appears to lack the same consistency as the previous two:

2004-2008	Win %	56.5%
	Sample Size	62
	Chi-Square	0.52
2009-2014	Win %	65.0%
	Sample Size	60
	Chi-Square	2.70
	Difference (Z-Score)	**-0.966**

The z-score is not exceptionally high due to the relatively small sample sizes, but greater consistency would be desirable. To better understand where the inconsistency was coming from, I further divided the sample into three sub-periods (although this rendered the sample sizes very small):

2004-2006	Win %	41.7%
	Sample Size	24
	Chi-Square	0.33
2007-2010	Win %	69.2%
	Sample Size	52
	Chi-Square	3.85
2011-2014	Win %	60.9%
	Sample Size	46
	Chi-Square	1.09

These results clearly showed that the strategy exhibited considerable underperformance during the 2004-2006 NFL seasons. While the cause of this is unclear, it is possibly exaggerated by the very small sample size. With just one-fifth of the total observations coming from this sub-period, it is possible that the results are skewed. Furthermore, it is encouraging that the two most recent sub-periods have both exhibited exceptionally strong performance, achieving win rates of over 60 percent. The cause of the underperformance in the first sub-period is deserving of further research.

IX. CONCLUSION AND IMPLICATIONS

The findings in this paper suggest that uninformed participants in financial markets and the NFL betting market possess similar biases, and that these biases can be exploited by informed participants to generate positive excess returns. The ability of Sharp bettors to generate excess returns, much like professional investors, is well covered in academic research. This study adds to this literature by analyzing whether "Follower" bettors can imitate the bets of Sharps and achieve statistically significant excess returns and higher than expected winning percentages.

I found that the reverse line movement strategy is most effective when focused on games that are likely to exhibit higher levels of Square bettor bias. In-Conference games draw more attention from retail gamblers due to their playoff implications, much in the same way that individual investors are biased toward purchasing stocks covered extensively by the media. My results indicate that focusing on these games increases profitability, which indicates that spreads on these games are less efficient due to increased Square participation.

Betting on teams that had recently performed poorly and also experienced a reverse line movement proved to be the most profitable of the three strategies. The inspiration for this strategy was the theory of uninformed individual investors overreacting to recent news regarding a security, which renders contrarian investing strategies profitable. My findings indicate that a contrarian strategy in NFL betting can take advantage of a retail gambler bias to overreact to recent team performance.

The downside of the reverse line movement strategy is that most of the inefficiencies have already been arbitraged away by Sharp gamblers. This is consistent with the first two strategies in this paper generating significant excess returns when ignoring commission costs, but falling below statistically significant levels once juice is accounted for.

It is true, however, that utilizing the reverse line movement strategy to bet on In-Conference games or bet on recent poor performers approaches or exceeds statistically significant levels even after accounting for commissions. Levitt (2004) also found that "competitive pressure does not appear to eliminate excess profits" in the same way that one might expect given the ability of Sharp bettors to arbitrage. While I cannot provide direct evidence of why profits seem to remain achievable for Followers, I can suggest two possible explanations. The first is rather obvious in that sports book juice significantly inhibits arbitrage by informed bettors. Therefore, lines are able to stabilize at non-market clearing levels. This potentially allows for bettors on reduced juice sports books to squeeze out extra returns that other might not be able to. The more likely explanation is that sports books commonly impose bet size limits on Sharp gamblers in order to protect themselves. These limits are likely still above the average bet size of retail gamblers, but are low enough to inhibit the ability of Sharps to fully arbitrage the biased spreads. Further research in this area could be quite enlightening.

It is also important to note that the strategies which I have outlined in this paper could potentially be far more profitable than my findings indicate. In this paper I made the rather pessimistic assumption that Followers were placing all of their bets on the

closing line. In reality, there is nothing prohibiting Followers from placing bets as soon as they identify a reverse line movement during the course of the week leading up to the games. In theory, they could place the bets as soon as such a line movement occurs, thereby securing a more favorable line before the arbitrage can fully occur. In fact, this concept is commonly used in practice and is referred to by bettors as “chasing steam.” Many gamblers regularly practice this strategy, but I never came across the topic in an academic paper during my research. Parallels could likely be drawn between chasing steam and high frequency traders front running institutional investors in financial markets. Academic testing of this strategy is warranted.

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XI. FIGURES AND TABLES

Figure 1: Percent of Bets Placed on Favorites

Sample: 12 years of public betting percentages on NFL games. Data from Sports Insights.

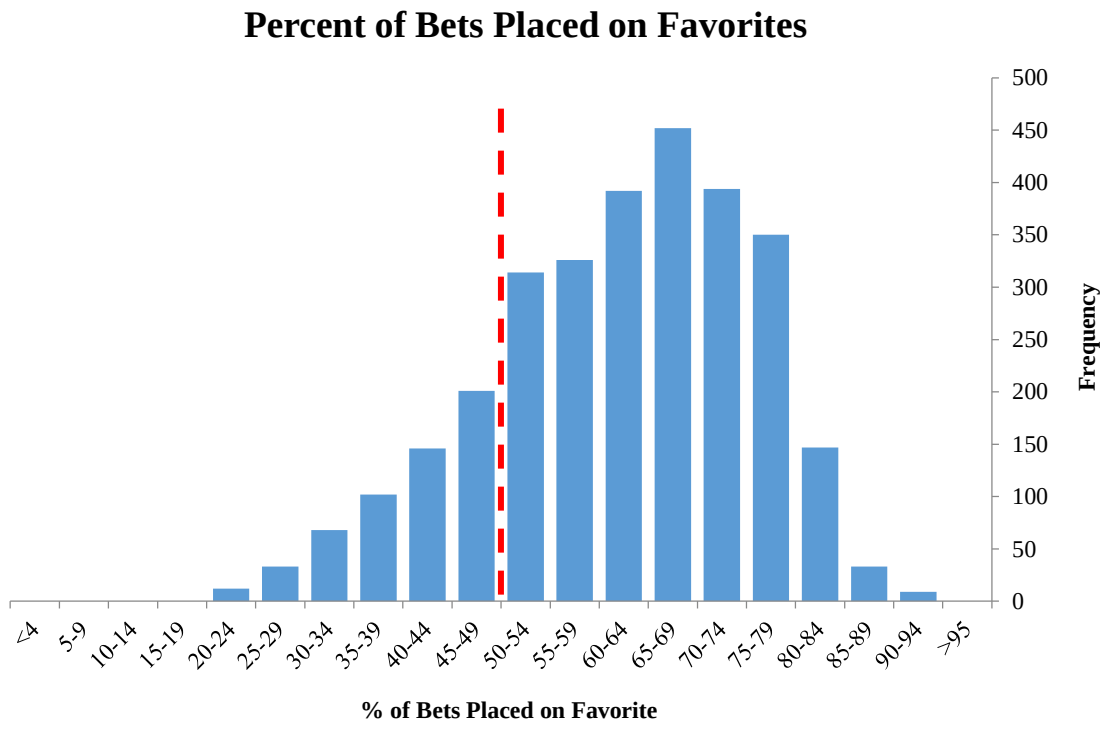

Figure 2: Super Bowl Betting Amounts

Sample: 10 years of legal Super Bowl betting amounts. Data from the Nevada Gaming Control Board.

Figure 3: Las Vegas Sports Books Super Bowl Profits

Sample: 10 years Las Vegas sports books profits as a percentage of total money wagered on the Super Bowl. Data from the Nevada Gaming Control Board.

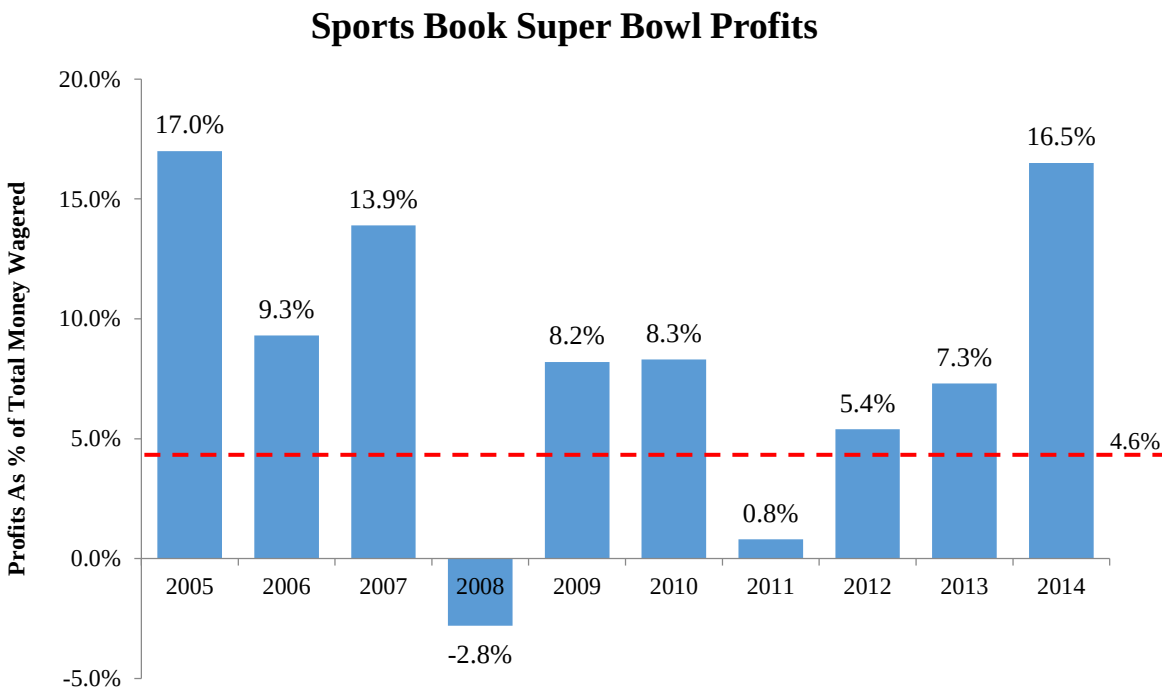

Table 1: Example of Data Structure

Play	Home Team	Visitor Team	Event Date	Home Score	Visitor Score	>60% Team Score	<40% Team Score	Actual Spread	Closing Line	Closing Line Result	Reduced Juice Payout	Standard Payout	No Juice Payout
New England Patriots	New England Patriots	Tennessee Titans	10/5/2003	38	30	30	38	-8	0	1	92.6%	90.9%	100.0%
New York Jets	New York Jets	Buffalo Bills	10/12/2003	30	3	3	30	-27	0	1	92.6%	90.9%	100.0%
Dallas Cowboys	Dallas Cowboys	Philadelphia Eagles	10/12/2003	23	21	21	23	-2	-2	P	0.0%	0.0%	0.0%
Cincinnati Bengals	Cincinnati Bengals	Baltimore Ravens	10/19/2003	34	26	26	34	-8	1	1	92.6%	90.9%	100.0%
San Diego Chargers	Cleveland Browns	San Diego Chargers	10/19/2003	20	26	20	26	-6	3.5	1	92.6%	90.9%	100.0%
Oakland Raiders	Oakland Raiders	Kansas City Chiefs	10/20/2003	10	17	17	10	7	3.5	0	-100.0%	-100.0%	-100.0%
New York Giants	Minnesota Vikings	New York Giants	10/26/2003	17	29	17	29	-12	5	1	92.6%	90.9%	100.0%
New Orleans Saints	New Orleans Saints	Carolina Panthers	10/26/2003	20	23	23	20	3	-2.5	0	-100.0%	-100.0%	-100.0%
Cleveland Browns	New England Patriots	Cleveland Browns	10/26/2003	9	3	9	3	6	4.5	0	-100.0%	-100.0%	-100.0%
San Diego Chargers	Chicago Bears	San Diego Chargers	11/2/2003	20	7	20	7	13	1.5	0	-100.0%	-100.0%	-100.0%
Washington Redskins	Washington Redskins	Seattle Seahawks	11/9/2003	27	20	20	27	-7	3	1	92.6%	90.9%	100.0%
Cleveland Browns	Kansas City Chiefs	Cleveland Browns	11/9/2003	41	20	41	20	21	9	0	-100.0%	-100.0%	-100.0%
Houston Texans	Cincinnati Bengals	Houston Texans	11/9/2003	34	27	34	27	7	4	0	-100.0%	-100.0%	-100.0%
San Diego Chargers	San Diego Chargers	Minnesota Vikings	11/9/2003	42	28	28	42	-14	5.5	1	92.6%	90.9%	100.0%
Philadelphia Eagles	Green Bay Packers	Philadelphia Eagles	11/10/2003	14	17	14	17	-3	5	1	92.6%	90.9%	100.0%
Jacksonville Jaguars	Tennessee Titans	Jacksonville Jaguars	11/16/2003	10	3	10	3	7	9.5	1	92.6%	90.9%	100.0%
Oakland Raiders	Kansas City Chiefs	Oakland Raiders	11/23/2003	27	24	27	24	3	11	1	92.6%	90.9%	100.0%
Houston Texans	Houston Texans	New England Patriots	11/23/2003	20	23	23	20	3	5	1	92.6%	90.9%	100.0%
New Orleans Saints	Philadelphia Eagles	New Orleans Saints	11/23/2003	33	20	33	20	13	5	0	-100.0%	-100.0%	-100.0%
San Francisco 49ers	Green Bay Packers	San Francisco 49ers	11/23/2003	20	10	20	10	10	4	0	-100.0%	-100.0%	-100.0%
Detroit Lions	Detroit Lions	Green Bay Packers	11/27/2003	22	14	14	22	-8	6.5	1	92.6%	90.9%	100.0%
Buffalo Bills	Tennessee Titans	Buffalo Bills	12/14/2003	28	26	28	26	2	5	1	92.6%	90.9%	100.0%
Jacksonville Jaguars	New England Patriots	Jacksonville Jaguars	12/14/2003	27	13	27	13	14	6	0	-100.0%	-100.0%	-100.0%
Atlanta Falcons	Tampa Bay Buccaneers	Atlanta Falcons	12/20/2003	28	30	28	30	-2	6.5	1	92.6%	90.9%	100.0%
San Francisco 49ers	Philadelphia Eagles	San Francisco 49ers	12/21/2003	28	31	28	31	-3	7	1	92.6%	90.9%	100.0%
New Orleans Saints	New Orleans Saints	Dallas Cowboys	12/28/2003	13	7	7	13	-6	0	1	92.6%	90.9%	100.0%
New York Giants	New York Giants	Carolina Panthers	12/28/2003	24	37	37	24	13	4.5	0	-100.0%	-100.0%	-100.0%
Chicago Bears	Kansas City Chiefs	Chicago Bears	12/28/2003	31	3	31	3	28	7.5	0	-100.0%	-100.0%	-100.0%
Jacksonville Jaguars	Atlanta Falcons	Jacksonville Jaguars	12/28/2003	21	14	21	14	7	2.5	0	-100.0%	-100.0%	-100.0%
Arizona Cardinals	St. Louis Rams	Arizona Cardinals	9/12/2004	17	10	17	10	7	10.5	1	92.6%	90.9%	100.0%
New York Giants	Philadelphia Eagles	New York Giants	9/12/2004	31	17	31	17	14	8	0	-100.0%	-100.0%	-100.0%
Jacksonville Jaguars	Buffalo Bills	Jacksonville Jaguars	9/12/2004	10	13	10	13	-3	2.5	1	92.6%	90.9%	100.0%
San Francisco 49ers	San Francisco 49ers	Atlanta Falcons	9/12/2004	19	21	21	19	2	3	1	92.6%	90.9%	100.0%
Chicago Bears	Green Bay Packers	Chicago Bears	9/19/2004	10	21	10	21	-11	8	1	92.6%	90.9%	100.0%
Arizona Cardinals	Arizona Cardinals	New England Patriots	9/19/2004	12	23	23	12	11	7	0	-100.0%	-100.0%	-100.0%
Cincinnati Bengals	Cincinnati Bengals	Baltimore Ravens	9/26/2004	9	23	23	9	14	1.5	0	-100.0%	-100.0%	-100.0%
Buffalo Bills	Buffalo Bills	New England Patriots	10/3/2004	17	31	31	17	14	4.5	0	-100.0%	-100.0%	-100.0%