Spring 2020

Using the Home-Underdog Theory to Test the Efficiency of the NFL Sports Gambling Market

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ABSTRACT.   NFL sports gambling markets are efficient if one strategy is not consistently profitable year after year. The analysis in this paper examines the efficient market hypothesis using the home-underdog theory. The data were collected for home-underdogs for the last 10 NFL seasons. Important filters were applied to examine potential variations of the home-underdog theory that may be profitable. There was no variation of the home-underdog theory that was consistently profitable year after year. There were 5 different variations that were profitable in the 10 years, but they were not profitable every year. The results provide evidence that the NFL sports gambling markets are efficient. Strategies that are profitable one year will not be in other years as sportsbooks become more aware of them.

"Gambling? Who said anything about gambling? It's not gambling when you know you're gonna win." - Alan Garner played by Zach Galifianakis from the movie "The Hangover."

I. Introduction

Profitable gambling opportunities, like the one described by Alan, were made possible for Iowans with the legalization of sports gambling. Sports gambling markets could be inefficient, which would indicate that a profitable gambling strategy could exist. A market is efficient when one strategy cannot consistently beat the market. According to Levitt (2004), bookmakers set distorted prices that take advantage of bettor biases in order to maximize profits, but very few bettors are able to consistently exploit the sports gambling markets. Wever and Aadland (2012) found that bettors exhibit herd behavior on the best-known elite teams, so large underdogs were underpriced because of the herd behavior. These studies agree that bettors have clear biases, and bookmakers take advantage of these biases. If true, there is true inefficiency in the sports gambling markets. This paper uses something

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called the home-underdog strategy to test the efficient market hypothesis of the sports gambling market.

    A.   Terminology

Term	Definition
Favorite	The team that is expected to win the game.
Underdog	The team that is not expected to win the game.
Point Spread	The number of points the favorite is expected to win by. E.g. the Minnesota Vikings to win by 4 points over the Detroit Lions. (Minnesota -4) vs (Detroit +4)
Over/Under	The projected sum of the scores of both teams. The O/U for the Minnesota/Detroit game is 44 points. A final score less than 44 points means the under bets win. A final score greater than 44 points means the over bets win.
Wager	A bet on a sporting event, generally accompanied by the amount. E.g. Dave wagered $110 on the Minnesota -4.
Sportsbook	General term for any oddsmaker or bookmaker that is offering lines on sporting events for bettors to bet on.
Straight Up	A bet that a team will be the outright winner of the game, not based on point spread.
Moneyline	The odds offered for each team to win straight up. (Minnesota -150) vs (Detroit +140) A bet on Minnesota requires $150 to win $100. A bet on Detroit requires $100 to win $140.
Cover	When the favorite wins by more than the spread, or the underdog loses by less than the spread or wins straight up. The team that is successful in this is the team that covers. E.g. Minnesota wins 28-21, then Minnesota covers the -4 spread.
Push/Wash Out	The results of the game are equal to the spread that was offered by the Sportsbooks. E.g. Minnesota wins 28-24. The results are bettors receiving their original wager back.

Vig / Juice	The commission the sportsbook charges for a bettor to make a wager. Both sides of the wager initially pay the vig, but the winning wager is paid their original wager amount plus their winnings. For example, wager $110 to win $100 which pays out $210. The commission is only collected on losing bets. The commission collected in this scenario is $10 per bet. Point spread bets generally have a 10% vig.
Opening Line	The first line offered for a specific game.
Closing Line	The final line offered before the start of the game.
Sharp Line	When the betting lines move due to a large wager by professional sports bettors. The sportsbooks move lines when bettors with significant success place a large wager.
Public	All of the sports bettors combined are the public. Whatever line has a majority of the bets is considered the side the public is betting on. The public, a majority of the time, bets on the over and the favorite.
Home Team	The team that is playing the game in their own city and stadium.
Away Team	The team that is playing on the road, not in their own city and stadium.
Home-underdog	A betting strategy that uses the combination of being both the underdog and the home team.
Middling	Middling is betting on both sides of a line, where the bettor has a chance to win both wagers. E.g. a bettor bets on the opening line of Minnesota -4, then the closing line has moved to Minnesota -7.5. The change in the line gives the bettor the opportunity to bet on Detroit +7.5. The bettor guarantees a win on Minnesota -4 or Detroit +7.5 and a loss on the other. The bettor loses the vig regardless of which team covers. Middling occurs when the bettor wins both wagers. Middling is a strategy that offers high returns with low risks.
Spread Reversal	When the point spread moves from favoring one team to favoring the other team. E.g. Minnesota's opening line was -4, but Minnesota's closing line was +1. Detroit's line went from +4 to -1.

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Balanced-Book Hypothesis	If lines are accurately priced then 50% of the bets should be on both sides of every line. E.g. 50% of the bets are on Minnesota -4 and 50% of the bets are on Detroit +4, likewise, 50% of bets are on the over of 44 and 50% of bets are on the under of 44.
% of Bets	The percentage of the total number of bets on a given side of a line. E.g. 60% of the bets are on Minnesota -4, while 40% of the bets are on Detroit +4.
% of Money	The percentage of the total amount of money on a given side of a line. E.g. 80% of the money is on Minnesota -4, while 20% of the money is on Detroit +4.
Conference Game (see figure 1-0)	The NFL is split into two conferences, the AFC and the NFC. The winner of the AFC plays the winner of the NFC in the Super Bowl. A game between two teams that are in the same conference is considered a conference game.
Divisional Game (see figure 1-0)	Both the AFC and NFC are split into 4 divisions. Every division contains 4 teams. There are a total of 8 divisions in the NFL. A game between two teams that are in the same division is considered a divisional game. Every team plays their 3 divisional opponents 2 times (1 home game & 1 away game) every NFL season.
Sunday Night Football Game	The main event of Sunday's slate of football games is Sunday Night Football. SNF has a broadcasting contract exclusively with NBC. Typically, SNF is the most viewed and most bet on NFL game of that week.

B. Legalization of Sports Gambling

In 2018 the Supreme Court removed the Professional and Amateur Sports Protection Act, which was first enacted in 1992 (Liptak and Draper 2018). The initial federal law prevented every state from legalizing sports gambling. Since the federal law was repealed, 20 states, including Iowa, and Washington D.C. have legalized sports gambling (Rovell 2020). 8 states are expected to legalize sports gambling by the end of 2020. 12 states are projected to legalize sports gambling by the end of 2021. The remaining 10 states are expected either never to legalize sport gambling or only do so after 2022. The majority of states (40 out of 50) will most likely legalize sports gambling by 2021.

C. How Do Sportsbooks Operate?

The vig charged on every bet is the basis for sportsbooks making a profit. According to the balanced-book hypothesis, the number of bets are equal on both sides of the line. For example, each side of the line is paying $110 to win $100. The winning bettors are paid $100 from the losing bettors' wager of $110 ($110 - $100 = $10). The sportsbooks retain the $10 on all losing wagers. If there are 1,000 bets on each side of the line, then the sportsbooks profit $10,000 ($10 * 1,000 = $10,000). The vig is the basis for how sportsbooks operate as a middle man between the losing bettors and the winning bettors. Sportsbooks are not profitable when the result of the game is a push. Both sides of the line receive their wagers back. Sportsbooks profit $0, and bettors profit $0. A push is the worst-case scenario for a sportsbook, because the vig cannot be collected.

D. How Are Betting Lines Adjusted?

Generally, betting lines will change from opening line to closing line. Lines can change in increments ranging from half a point up to double digits. The main reason for the changes in lines is that more information is available by game time. Information can be the number of bets coming in on each side of the line. For example, if 75% of the bets are on one side of the line, then the sportsbooks will adjust the lines to maintain a more balanced book. Information that influences a line the most is whether a specific player is active for the game. Suppose a key player is projected to be active but then ruled inactive before the game; then the lines will adjust accordingly. Similarly, if a key player is projected to be

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inactive, but the player is ruled active before the game, then the lines will adjust accordingly. Another reason for sportsbooks to adjust their lines is a bet made by a sharp bettor. These changes to the line are known as a sharp line. Sportsbooks tend to keep their lines within one and half points of each other. If sportsbooks do not have similar lines, then the arbitrage strategy known as middling is available to the public.

E.   How to Be Profitable in NFL Sports Betting

Assuming a bettor is wagering on point spreads that have a payout of (-110) e.g. betting $110 to win $100, then to break-even the bettor must win 52.4% of bets (Culver 2019). A bettor that has a betting strategy that is successful more than 52.4% of the time will be profitable. The break-even percentage is 52.4%, because of the vig that must be paid on every wager.

F.   The NFL Schedule and Playoff Format

The NFL schedule consists of 4 weeks of preseason followed by 17 weeks of regular season. Every team in the league has 1 week in the 17 week regular season where they do not have a game. The week with no game is known as a bye week. Since every team has a bye week, each team plays 16 games. Six of the games are against divisional opponents, while the remaining 10 are games against conference and non-conference teams. Every week two teams play in the Thursday Night Football game. The Sunday games consist of 7 to 10 games at 1 PM Eastern Time. These games are followed by 3 to 5 games at 4 PM Eastern Time. Sunday Night Football is played around 8 PM Eastern Time. Monday Night Football is the following night and is one game played around 8 PM Eastern Time.

The NFL announced a new playoff format for the 2020 season, but all the data used in this study are from the old playoff format. For the playoff format used in the seasons reflected by my data, the team with the best record from each division moves on to the playoffs. Two teams from each conference, with the best record that did not win their division, make the playoffs as a wild card team. Each conference has 6 teams, the 4 divisional winners and 2 wild card teams, that make the playoffs. The divisional winners, in both conferences, are seeded 1 through 4 based on record, with the best record getting the 1 seed. The 2 wild card teams from each conference are seeded 5 and 6 based on their record, with the best record getting the 5 seed. In some NFL seasons, the playoff seeding

of some teams may be determined before the last week of the season. For example, regardless of whether a team wins or loses, they are locked in as the 3 seed. This situation gives a team the opportunity to rest their starters during week 17, in preparation for the playoffs.

II. Literature Review

A classic paper on the subject was done by Steven Levitt (2004). He investigated how the NFL gambling market functioned, by using empirical analysis based on the success of bettors that participated in a NFL betting contest for prize money. His main finding was that the balanced-book hypothesis did not hold true. Only 20% of the games had 50%-55% of the wagers on one side, while a majority of games had 66% of the bets fall on one side. These findings suggest that bookmakers intentionally skew lines towards bettor biases, so that one side has more bets, and that side loses more than 50% of the time. Sportsbooks will maximize profits by skewing the lines, compared to offering lines in accordance with the balanced-book hypothesis. Levitt found that sportsbooks were better at predicting outcomes than the average bettor, which allows them to manipulate the lines in order to maximize profits. One specific strategy cannot beat the sportsbooks representing market efficiency, but the true market inefficiency is the intentional manipulation of lines to maximize profits. A strategy that takes advantage of the manipulation is nearly impossible, because sportsbooks manipulate the lines differently based on the bettor biases towards the specific teams. Bettors do not have the information that the sportsbooks have, so identifying bettors' biases is difficult. Sportsbooks are constantly monitoring strategies and trends that take advantage of their manipulated lines. In 1997 Gray and Gray found that documented inefficacies disappear over time. They used a probit model to estimate game spreads and compared that to the sportsbook spreads. Their research looked at the home-underdog theory, and found it profitable 7 of the first 8 seasons. A drastic reduction in the success of the home-underdog strategy occurred in the following 11 seasons, with only 3 profitable seasons. The research showed that sportsbooks were aware of strategies and made adjustments. They concluded that the sports betting markets are efficient.

Wever and Aadland (2012) explain the herd behavior bettors exhibit towards well known elite teams. Their research found that large underdogs were underpriced, and bettors did not realize the underdogs were underpriced, which represented market inefficiency. Wever and

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Aadland used a model to predict the probability of the home team winning and compared the predicted probability to a critical probability, in order to decide whether to bet on the home team or the away team. When the game was too close to decide, then no bet was made. The winning percentage was 50% when the critical probability was .5. When the critical probability was set to .53 the winning percentage was equal to 58%.   They concluded that the markets are inefficient, but only when a small percentage of bets are made to exploit underpriced underdogs.

Fodor, DiFilippo, Krieger, and Davis (2013) examine NFL betting markets using the holdover bias. They conclude that markets are inefficient, but the inefficiency dwindles over time as more information becomes available. The holdover theory is that teams that made the playoffs in the previous year are overpriced in week one of the current season. Bettors weight the previous season's success more than previous season's success actually affect results. Sportsbooks inflate prices to take advantage of that. Their research found that 79.6% of the prior playoff teams were favored, but only 48.1% of these prior playoff teams actually won. Fodor, DiFilippo, Krieger, and Davis examined the effect of adding the spread, and found that 66% of the prior playoff teams failed to cover the point spread in week one. The sample size is 54 observations over 8 seasons, however the holdover strategy produces significantly profitable results.

According to Mani (2018), the NFL market is inefficient, and the opening lines are more accurate at predicting the final score than the closing lines. This may show the influence of herd behavior described by Wever and Audland (2012). Mani suggests that uninformed bettors influence the price more on closing lines, making the closing lines more inaccurate predictors of the final score. His research found profitable betting strategies in betting on the home-underdog if the shift in the spread moves toward the favorite. Mani found that if the shift in the spread moves toward the underdog, it is profitable to bet on the away favorite. His OLS regression found that the changes in the spread were overvalued, and the score of the game changed less than the spread changed. The regression suggested that the opening line was a more accurate predictor than the closing spread.

Spinosa (2014) found that home-underdogs were consistently undervalued, and spreads of 7 or greater produced profitable betting results. Spinosa found that NFL gambling markets are efficient, but there are potentially a few market inefficiencies. Spinosa conducted a regression and an economic test to determine whether NFL betting markets were efficient. The OLS regression could not find sufficient

evidence to declare markets to be inefficient. The economic tests applied different betting strategies to find whether a profitable strategy exists. Home-underdogs with a spread greater than 7 points produced a winning percentage of 59.69%. Spinosa concluded that the small sample size limits the reliability of this strategy, therefore concluding that NFL gambling markets are efficient.

III. Data

The data were collected using *sportsbookreview.com* and *covers.com. Covers.com* has been providing lines and odds for sporting events for 25 years. *Covers.com* serves 20 million customers per year. *Covers.com* was cited by *USA TODAY, ESPN, The New York Times*, and *MSNBC* for sports betting lines. *Sportsbookreview.com* has been operating for 21 years providing lines and odds from 8 different sportsbooks. *Sportsbookreview.com* has had their sports betting lines cited by *Wall Street Journal, CNN, New York Post,* and *Yahoo. Covers.com* and *sportsbookreview.com* are reliable and accurate sources of data for sports betting lines. The variables for which data was collected from the *sportsbookreview.com* and *covers.com* are listed in the table below.

Date
Road Team
Home Team
Point Spread
Home Team's Moneyline
Over/Under
Road Team's Score
Home Team's Score
Sunday Night Game or Not
Spread Reversal or Not
Starters Week 17 or Not

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One of the limitations to the data is that different sportsbooks offer different lines. In an ideal world, the lines are the same across all sportsbooks. Games can end in a push, but sportsbooks have different lines, so what sportsbook a bettor wagered with could determine whether the bettor wins, loses, or pushes. Another limitation was the inability to access the percentage of bets and the percentage of money on each side of the line. That data would have provided insight on what side the public was betting and what side the money was on. This information would have given two additional trends to track, in order to potentially find a profitable betting strategy.

IV. Method

The first important step is to eliminate outlier games. The Thursday Night Football game causes teams to play on 3 days of preparation. This is incredibly short when compared to the 6 days of preparation most teams get for their game on Sunday. The disparity in preparation time causes the results of Thursday Night Football games to differ from Sunday games. Thursday Night Football games were not considered, because they were deemed outliers. Monday Night Football games are also deemed outliers because of the extra day of preparation for both teams. In order to compare results across weeks and seasons, I decided to hold the preparation days constant. The data was gathered by looking at the closing lines for all games on Sunday in order to determine any home-underdogs that existed. The next step was going through all 17 weeks and collecting all data for home-underdogs.

After collecting the data, I would look for any trends in the data by adding a variety of filters. The filter for divisional and non-divisional games monitors the effects of playing the same team twice a year versus only once. Teams that play in the same division have the most information on each other due to the frequency of matchups, therefore these games are different from non-divisional games. A filter for conference games examines any differences in the skill of each conference. Similar skilled conferences suggest that conference and non-conference record should be close to the same, however the greater disparity in record suggests that one conference is better than another. Sunday Night Football filter identified any effects of a major televised game, because primetime games have the largest number of bets placed on them. Point spread reversal filter looked at the effects of a change in the favorite. No starters week 17 filter examined the effects of a playoff-bound team resting their key players week 17. The sportsbooks would factor this in, but the filter monitored any manipulation of the lines

toward bettor biases. Over/under filter monitored trends in offensive shootouts versus defensive battles. The stipulation is that the bettor would know whether the over or under hits before the game, in which the bettor would bet on that result. The purpose of the filter was to examine if two good defensive or offensive teams were playing each, then a bettor could use this filter to examine a potential wager. Filters for 3 and 7 points were used, because they are important football scores. 3 points is within a field goal, while 7 points is within a touchdown. The over/under of 44.5 was used as a filter, because after the 10 seasons of research, the average over/under was 44.8. The data showed that 4 seasons had an average over/under below 44.5, while 6 seasons had an average over/under above 44.5. The month filter was used to examine home-underdogs success throughout the season. Any trend would show whether home-underdogs perform better at the beginning of the season or the end of the season.

The figure below shows all of the different factors I made filters for, in order to see any trends.

Divisional Game	Versus	Non-Divisional Game
Conference Game	Versus	Non-Conference Game
Sunday Night Football Games	Versus	All other Sunday Football Games
Point Spread Reversal	Versus	No Point Spread Reversal
No Starters Week 17	Versus	Starters Week 17
Over Win	Versus	Under Win
Point Spread > 7	Versus	Point Spread < 7
Point Spread Between 3 and 7	Versus	Point Spread Outside of 3 and 7
Over/Under > 44.5	Versus	Over/Under < 44.5
Point Spread < 3		
The month that the game was played. (September through January)		

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V. Results

A. Tables

The 10 tables below show the different filters of the home-underdog betting strategy that were examined. Each table shows similar trends, and the results over the last 10 NFL seasons. The red column is the sum of all seasons. A betting strategy needs a winning percentage above 52.4% to be profitable.

The first table shows all home-underdog cover statistics across 10 seasons, with the final column being a summation of all 10 seasons. The table below shows that betting on all home-underdogs would have been profitable in 4 of the 10 seasons. Betting on all home-underdogs would have resulted in a loss over the 10 seasons (51.24% < 52.40%).

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Observations	85	77	82	68	72	67	74	77	75	69	746
Home-underdog Cover Win	41	43	37	31	38	34	35	38	39	36	372
Home-underdog Cover Loss	44	34	41	34	34	32	36	36	33	30	354
Home-underdog Win %	48.24%	55.84%	47.44%	47.69%	52.78%	51.52%	49.30%	51.35%	54.17%	54.55%	51.24%

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The second table shows over/under trends for home-underdog wagers. The trend that was profitable was betting on the home-underdog when the over wins. The stipulation is that the bettor knows the over bet would win, which then the bettor would simply bet the over. The initial purpose of examining over/under trends was based on the assumption that an over meant the game was a shootout, while the under meant the game was a defensive battle. Further research indicated the home-underdogs perform better when the over/under is less than 44.5. These findings provide evidence that the over can hit in a defensive game, when the over/under is set low enough. The over/under trends did not explain home-underdog performance in high scoring games versus low scoring games. There are no distinct strategies based on over/under trends.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Over Cover Win	23	21	18	15	18	17	17	19	25	22	195
Over Cover Loss	23	13	17	15	17	14	20	19	18	14	170
Over Win %	50.00%	61.76%	51.43%	50.00%	51.43%	54.84%	45.95%	50.00%	58.14%	61.11%	53.42%
Under Cover Win	18	22	19	16	20	17	18	19	13	13	175
Under Cover Loss	21	21	24	19	17	17	16	17	15	16	183
Under Win %	46.15%	51.16%	44.19%	45.71%	54.05%	50.00%	52.94%	52.78%	46.43%	44.83%	48.88%
O/U > 44.5 Cover Win	17	24	12	19	18	20	22	18	15	8	173
O/U > 44.5 Cover Loss	24	17	17	19	17	21	14	18	18	8	173

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	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
O/U > 44.5 Win %	41.46%	58.54%	41.38%	50.00%	51.43%	48.78%	61.11%	50.00%	45.45%	50.00%	50.00%
O/U < 44.5 Cover Win	24	19	25	12	20	14	13	20	24	28	199
O/U < 44.5 Cover Loss	20	17	24	15	17	11	22	18	15	22	181
O/U < 44.5 Win %	54.55%	52.78%	51.02%	44.44%	54.05%	56.00%	37.14%	52.63%	61.54%	56.00%	52.37%

Table 3 examines any trends with having or not having starters week 17. Some teams will rest their starters week 17 in preparation for the playoffs. The lines should accurately reflect this information, but the sportsbooks could manipulate the lines based on bettor biases. The sample was very small, because the trend can only be examined the last week of the season for playoff bound teams. An interesting finding is the success of the home-underdog in Week 17 when the starters do play (56.10% > 52.40%). The data could indicate that home-underdogs perform better at the end of the season or at least the final week of the season. The sample size is tiny, with only 41 observations, so I would not recommend as a consistently profitable strategy to use.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
No Starters Week 17 Cover Win	2		0						2	1	5
No Starters Week 17 Cover Loss	3		2						0	0	5
No Starters Week 17 Win %	40.00%		0.00%						100%	100%	50.00%

Starters Week 17 Cover Win	3	1	2	3	3	1	3	3	2	2	23
Starters Week 17 Cover Loss	2	3	1	4	2	2	2	0	1	1	18
Starters Week 17 Win %	60.00 %	25.00 %	66.67 %	42.86 %	60.00 %	33.33 %	60.00 %	100 %	66.67 %	66.67 %	56.10 %

Table 4 examines trends in point spreads based on two thresholds. The first threshold is the touchdown threshold, which is 7 points. The trends examined are spreads greater than a touchdown and less than a touchdown. The second threshold is a field goal threshold, which is 3 points. Results of the table show that betting on home-underdog spreads that are less than 3 points is profitable over 10 seasons (53.52% > 52.40%). The data would indicate that home-underdogs perform better in competitive games where the spread is small. This strategy has a sample size of 355 observations. The strategy is not consistently profitable every season; in only 6 of the 10 seasons is the strategy profitable.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Spread < 7 Cover Win	36	39	32	28	32	28	32	34	31	34	326
Spread < 7 Cover Loss	36	25	38	26	29	26	31	36	32	28	307
Spread < 7 Win %	50.00 %	60.94 %	45.71 %	51.85 %	52.46 %	51.85 %	50.79 %	48.57 %	49.21 %	54.84 %	51.50 %
Spread > 7 Cover Win	5	4	5	3	6	6	3	4	8	2	46
Spread > 7 Cover Loss	8	9	3	8	5	6	5	0	1	2	47

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	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Spread > 7 Win %	38.46%	30.77%	62.50%	27.27%	54.55%	50.00%	37.50%	100%	88.89%	50.00%	49.46%
Spread < 3 Cover Win	19	25	18	19	20	13	18	22	18	18	190
Spread < 3 Cover Loss	16	17	21	14	15	14	17	19	15	17	165
Spread < 3 Win %	54.29%	59.52%	46.15%	57.58%	57.14%	48.15%	51.43%	53.66%	54.55%	51.43%	53.52%

Table 5 examines point spreads between 7 and 3 and point spreads outside of 7 and 3. Clearly, point spreads between 3 and 7 are not profitable. A profitable strategy of betting on spreads outside of 3 and 7 does exist (52.68% > 52.40%). The strategy has a sample size of 448 observations. The data would indicate that home-underdogs perform better in competitive games, or games where they are considered a large underdog. The strategy is not consistently profitable every season; in only 4 of the 10 seasons is the strategy profitable.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Spread Between 3 and 7 Cover Win	17	14	14	9	12	15	14	12	13	16	136
Spread Between 3 and 7 Cover Loss	20	8	17	12	14	12	14	17	17	11	142
Spread Between 3 and 7 Win %	45.95%	63.64%	45.16%	42.86%	46.15%	55.56%	50.00%	41.38%	43.33%	59.26%	48.92%

	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Spread Outside 3 and 7 Cover Win	24	29	23	22	26	19	21	26	26	20	236
Spread Outside 3 and 7 Cover Loss	24	26	24	22	20	20	22	19	16	19	212
Spread Outside 3 and 7 Win %	50.00 %	52.73 %	48.94 %	50.00 %	56.25 %	48.72 %	48.84 %	57.78 %	61.90 %	51.28 %	52.68 %

Table 6 investigates trends involved with divisional and conference relationships. Divisional games in 3 of the 10 seasons are not profitable, while 5 of the 10 seasons are profitable. The other 2 seasons are a little below the breakeven point of 52.4%. The extreme variability in the success of home-underdogs in divisional games suggests the unpredictability of divisional matchups. The home-underdog in 7 of the 10 seasons was profitable in either the conference or non-conference games but not profitable in the other. All trends in this table are not profitable over the 10 seasons.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Divisional Game Cover Win	12	14	10	15	11	12	12	16	14	17	133
Divisional Game Cover Loss	19	13	18	11	13	11	10	13	10	12	130
Divisional Game Win %	38.71 %	51.85 %	35.71 %	57.69 %	45.83 %	52.17 %	54.55 %	55.17 %	58.33 %	58.62 %	50.57 %

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Non-Divisional Game Cover Win	29	29	27	16	27	22	23	22	25	19	239
Non-Divisional Game Cover Loss	25	21	23	23	21	21	26	23	23	18	224
Non-Divisional Game Win %	53.70%	58.00%	54.00%	41.03%	56.25%	51.16%	46.94%	48.89%	52.08%	51.35%	51.62%
Conference Game Cover Win	29	31	25	25	29	25	25	28	31	29	277
Conference Game Cover Loss	34	24	32	24	23	24	26	28	22	23	260
Conference Game Win %	46.03%	56.36%	43.86%	51.02%	55.77%	51.02%	49.02%	50.00%	58.49%	55.77%	51.58%
Non-Conference Game Cover Win	12	12	12	6	9	9	10	10	8	7	95
Non-Conference Game Cover Loss	10	10	9	10	11	8	10	8	11	7	94
Non-Conference Game Win %	54.55%	54.55%	57.14%	37.50%	45.00%	52.94%	50.00%	55.56%	42.11%	50.00%	50.26%

Table 7 explores the relationship of sportsbooks adjusting the lines. Results of the spread reversal are consistent with Mani's (2018) conclusion that opening lines are more accurate than closing lines. This provides a profitable betting strategy (54.55% > 52.40%); however the sample size is small, with only 55 observations.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
Spread Reversal Cover Win	4	9	3	2	0	3	1	4	3	1	30
Spread Reversal Cover Loss	7	7	5	1	1	0	2	2	0	0	25
Spread Reversal Win %	36.36%	56.25%	37.50%	66.67%	0.00%	100%	33.33%	66.67%	100%	100%	54.55%
No Spread Reversal Cover Win	37	34	34	29	38	31	34	34	36	35	342
No Spread Reversal Cover Loss	37	27	36	33	33	32	34	34	33	30	329
No Spread Reversal Win %	50.00%	55.74%	48.57%	46.77%	53.52%	49.21%	50.00%	50.00%	52.17%	53.85%	50.97%

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The Sunday Night Football trends are examined in table 8. Similar to Table 3, Table 8 has a small sample size, with only 53 observations, however Table 8 shows a profitable strategy when betting on the Sunday Night Football game (55.77% > 52.40%).

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
SNF Cover Win	4	3	2	2	3	3	5	0	4	3	29
SNF Cover Loss	4	2	4	1	4	2	3	1	2	0	23
SNF Win %	50.00%	60.00%	33.33%	66.67%	42.86%	60.00%	62.50%	0.00%	66.67%	100%	55.77%

A trend that measures the differences in months was researched in table 9. September was proven to be a profitable month to wager on the home-underdogs (57.69% > 52.40%). January was also profitable, but the sample size was only 21 (61.90% > 52.40%). The data suggests home-underdogs perform well at the beginning and end of the season. All other months were not profitable.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Sum
September Cover Win	7	11	11	5	5	7	10	13	11	10	90
September Cover Loss	10	5	5	4	6	8	7	9	5	7	66
September Win %	41.18%	68.75%	68.75%	55.56%	45.45%	46.67%	58.82%	59.09%	68.75%	58.82%	57.69%

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October Cover Win	7	11	9	12	8	7	10	6	11	9	90
October Cover Loss	7	10	12	11	7	7	8	7	12	4	85
October Win %	50.00%	52.38%	42.86%	52.17%	53.33%	50.00%	55.56%	46.15%	47.83%	69.23%	51.43%
November Cover Win	11	8	5	6	15	11	7	8	3	6	80
November Cover Loss	6	5	13	7	7	5	9	11	8	10	81
November Win %	64.71%	61.54%	27.78%	46.15%	68.18%	68.75%	43.75%	42.11%	27.27%	37.50%	49.69%
December Cover Win	16	13	12	5	7	9	8	11	10	8	99
December Cover Loss	21	14	11	8	12	12	12	9	7	8	114
December Win %	43.24%	48.15%	52.17%	38.46%	36.84%	42.86%	40.000%	55.00%	58.82%	50.00%	46.48%
January Cover Win				3	3				4	3	13
January Cover Loss				4	2				1	1	8
January Win %				42.86%	60.00%				80.00%	75.00%	61.90%

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Table 10 examines the averages of all the samples over the season and does not examine any trends. Statistical evidence that sportsbooks are incredibly successful at setting lines is that the favorite's point spread was 0.20 higher than what the favorite won by in the game. Additionally, the projected over/under was 0.08 higher than the actual over/under for the game. The table of averages below shows the ability of sportsbooks to accurately predict the point spreads and over/under. Sportsbooks exploited bettor biases by setting the favorites spread higher than the true spread and the over/under higher than the true over/under.

Variable Trend	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	Avg
Average Road Team Score	26.53	24.22	23.78	22.60	24.40	24.43	26.31	24.43	24.97	23.39	24.51
Average Home Team Score	19.93	20.57	19.45	20.32	19.67	20.34	21.64	21.06	21.15	19.71	20.38
Average Difference in Score	-6.6	-3.65	-4.33	-2.28	-4.73	-4.09	-4.67	-3.37	-3.82	-3.68	-4.13
Average Away Team Spread	-5.09	-4.45	-4.38	-3.82	-4.31	-4.69	-3.93	-3.83	-4.67	-4.01	-4.32
(Average Away Team Spread) - (Average Difference in Score)	1.51	-0.80	-0.05	-1.54	0.42	-0.60	0.74	-0.47	-0.84	-0.33	-0.20
Average Over/Under	44.85	46.25	43.96	45.34	44.76	46.04	45.91	44.65	43.83	42.49	44.81

Average Total Score	46.46	44.79	43.23	42.93	44.07	44.78	47.95	45.49	46.12	43.10	44.89
(Average Over/Under) - (Average Total Score)	-1.61	1.46	0.73	2.41	0.69	-1.26	2.04	0.84	2.29	0.61	0.08

B. Discussion

After looking at all of the tables, I conclude there are not any home-underdog betting strategies that are profitable every season. Some variations of the home-underdog betting strategy are profitable, but those strategies are not profitable every year. Betting on the home-underdog in 5 different variations has proven to be profitable in a ten-year span.   The 5 variations are point spreads less than 3 (53.52%), point spreads outside of 3 and 7 (52.68%), point spreads reversals (54.55%), Sunday Night Football games (55.77%), games in the month of September (57.69%). Any other variations of the home-underdog strategy were not profitable through the ten-year span.

One trend that I found to be very interesting was the success rate of home-underdogs during the months of September or November. In 9 of the 10 seasons, the home-underdog was extremely profitable in one of the months and extremely negative in the other month. The percentages were polar opposite with the successful month having a winning percentage of 63.5%, and the not successful month having a winning percentage of 36.9%. The one season that was not included was profitable in both September (68.75%) and November (61.54%). A new strategy could be betting on all home-underdogs in September, and if that month was not profitable, then doubling down on all home-underdogs in November. If September was profitable, then no bets would be made in November. This strategy would have been consistently profitable throughout the 10 years. The risk with doubling down your bets is if both months are not profitable, then the bettor will be down substantially.

C. Limitations

The research conducted was limited by points spreads not being universally the same. A majority of the observations were a win or loss

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in every sportsbook. Some observations gathered may have been ruled as a loss, win, or push, but that ruling may have not been accurate across all sportsbooks. There are a small number of observations where the final result of the game was the same or nearly the same as the point spread. The deciding factor in these wagers is what sportsbook the bettor wagered with and the point spread the bettor received when the wager was made.

Another limitation in this study is that betting lines are likely to adjust. The study conducted in this paper used only closing lines. Mani (2018) found that the opening lines were more accurate than closing lines. The closing line can be better or worse than the opening line, depending on the direction and magnitude of adjustments. The home-underdog strategy could be better or worse depending on when the wager is made.

The last limitation in the research conducted is that the percentage of bets and the percentage of money was not known. If that information was available, then 4 potential trends could have been tested. Two of the trends would have been the home-underdog strategy success rate when the public is betting on the favorite versus when the public is betting on the underdog. The other two trends to test would have been the home-underdog strategy success rate when a majority of the money is on the favorite versus when a majority of the money is on the underdog.

VI. Conclusion

The research in this paper found that sports gambling markets are not inefficient using the home-underdog strategy, but some variations of the home-underdog strategy can produce profitable results. The home-underdog strategy was not consistently profitable through the years observed, which indicates that the NFL gambling markets are efficient. The variations of the home-underdog strategy were not consistently profitable every year, but over the ten year span these variations were profitable. The variations of the home-underdog strategy that were found to be profitable come with the caveat that sample sizes were often small and that sportsbooks are likely to adjust to any winning strategy.

VII. Future Work

Future research should examine any trends in the movements of spreads between opening line and closing line, which was first discovered by Mani (2018). Trends in success rate based on the

month should continue to be monitored to see if sportsbooks adjust. Future research should consider the number of bets and the amount of money on each side of a line. I believe this would give the best insight to bettor biases, which could allow for an optimal strategy of exploiting bettor biases.

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