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Modern Portfolio Theory in NFL Moneylines

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ABSTRACT

Sports Gambling is an industry that is quickly taking hold across the United States. With already several already legalized Sports Gambling, and more on the way, it would appear that Sports Gambling will be in the United States for years to come. With that being said, many average gamblers are woefully unaware of certain risks and tricks that are inherent in the industry. In this thesis, the theory known as Modern Portfolio Theory was examined on its use in the sports gambling world, specifically moneyline games in the NFL. Using expected returns and standard deviations extrapolated with moneyline betting lines for the 2020 NFL season, the Modern Portfolio Theory was tested. While the Modern Portfolio Theory does not fit perfectly, standard deviation and expected return showed promising results that can be built upon in upcoming research. Low standard deviation returned success more often than not, and expected return helped show discrepancies in Las Vegas probability and NFL network probabilities.

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Chapter 1

Introduction

The world is constantly evolving with technology in every sector. From FinTech to communications, research to even how sports games are played, technology is a true disruptor in this current world. This movement has subsequently moved stones on certain activities that were not accessible or even illegal. The history of gambling is somewhat convoluted and until recently, only legal in Nevada. Movies through the years have depicted dark underground poker rings, bookkeepers having extensive networks for illegal sports betting, and of course the safe haven that is Las Vegas as the hub for all gambling ventures. Gambling has had a strongly negative connotation that was perpetuated by law makers and popular culture. The image of a man gambling away his child's college fund or maybe a man owing to a bookie and nothing good happening afterwards.

This has all changed in just a couple years. In 2018, the Supreme Court reversed a long-standing federal law banning commercial sports gambling in the country. People did not take this for granted and quickly tech has jumped in. Technology has found a way to bring a roulette wheel, poker table, long lists of sports lines, and basically anything else you would want from a casino to the palm of your hand. Because of the 2018 ruling, there has been an unprecedented change in the legality of betting in almost half the states of America, with many more legal changes in motion across the country. With this, a deep look has been required into the reality of

gambling. Opinions are changing and the stigma of gambling is quickly evaporating. This sudden change has left the door open to limitless possibilities not just as a gambler but also as a massive new financial revenue stream.

Companies like FanDuel and DraftKings have taken full advantage of the opportunity. These two companies are the largest current online gambling sources, providing anything from table games, to slot machines, to any sports line you may be interested in. These two companies enjoy an 83% combined market share of the industry. FanDuel alone reported a revenue of $419 million USD in 2019 and more than 350,000 registered clients. $419 million dollars only tells part of the story. This number only represents the return that FanDuel received. In reality, the wagered amount of dollars is incredibly larger. According to Morgan Stanley via MarketWatch, estimates are as high as $15 billion US dollars in revenue per year by 2025. Sports betting in the United States is a rapidly growing industry that requires attention.

Now that the background is set, it is important to look into the betting itself. The greatest argument to tackle is the question of sport gambling being a legitimate investment. The fallacy of Vegas knowing anything is very problematic. While it is true that the Vegas lines are incredibly accurate, there are many inefficiencies studied in the NFL for example. Studies have shown that underdogs cover the point spread more than half the time, while home underdogs succeed against the point spread at an even higher factor. At the end of the day, while “gambling” has such a negative connotation of being built to lose, a trained and patient bettor may be able to search out opportunities for revenue. While Vegas algorithms are predicted better than any person could,

people are playing the game and as a result are not perfect. The research indicates there is money in this if a gambler decides to commit to finding a method.

This is where the thesis comes into the fold. There are many different proprietary ways that bettors and some investment companies use to predict possible ways to gain an edge in sports gambling, however this is obviously not something people would publish. As a result, a common bettor is forced to either rely on their gut, which is a losing fight, or find their own way of finding inefficiencies in the betting lines. After widely searching out published ways that are publicly available, I have seen that there has been no research into using the Markowitz Modern Portfolio Theory to possibly find an edge in sports gambling.

The basis of the Modern Portfolio theory is that by diversifying a portfolio of investments, you could improve your expected return and lower your anticipated risks. There is really no significant difference between stocks and teams except for the duration of the asset holding. Different games are inherently uncorrelated and picking a combination of underdogs and favorites could lessen inherent risk while also returning a consistent return. This is the heart of the thesis. No matter if this is successful or a failure, it would help the common bettor and give them their first real helpful public knowledge.

Chapter 2

Literature Review

The following literature review consists of published papers covering relevant topics that will help in understanding this thesis and its objective. The subjects covered are as follows: The growing popularity of Sports Gambling, How Vegas stays ahead and the explanation of Money Lines, and the Markowitz Modern Portfolio Theory. It is necessary to understand these concepts before reviewing the research.

Normalization of Sports Gambling

It is important to understand what is creating this new sports gambling phenomenon in order to comprehend the long-term ramifications and new opportunities that are appearing in this newly legal sector. Research done by D. McGee of the University of Bath in the U.K. has examined the normalization of sports gambling in younger people. He studied men from the ages of eighteen to thirty-five across several areas in the United Kingdom. His study suggested a fundamental change on the way sports betting is perceived by younger men. While the older generations may have a negative connotation of gambling, this study shows that a wide range of young men with different socio-economic backgrounds and varying levels of education see gambling very differently. The vast majority of the focus group sees gambling as a way to further enjoy the sports they are watching. Further study shows that it is primarily the mobile apps that bring the people into the action. Excessively easy to use and fraught with limited time promotions, these sites create a glamorous and accessible gambling experience. Assuming these

findings are ubiquitous across the U.K. and U.S., online sports gambling has gotten a strong foothold among a younger generation that has every opportunity to grow.

Vegas: The NFL Money Line

Beyond the factors contributing to the rising popularity in and economic opportunities from gambling, it is also important to understand the terminology and mathematics behind the numbers involved in this thesis. Wayne Winston, in August of 2020, wrote a chapter in his book titled Analytic Stories called: Is Vegas good at predicting NFL games? In this chapter, Winston broke down the important bets and how they are derived. In this thesis, the terms “money line bet” and “spread bet” will be looked into as ways to contribute to a modern portfolio.

The money line bet is the more basic of the two. It is a wager on a team winning outright. Winston uses the example of the 2019 Super Bowl to help explain this bet. The New England Patriots played the Los Angeles Rams in the biggest game on the NFL calendar. The money line bet on the New England Patriots was -150 and for the Rams +130. This means that for a bet on New England to net $100 profit, a wager of $150 would need to be placed. On the other hand, a wager to win $130 would only require a wager of $100. This line shows the Rams as the underdog and the Patriots as the favorites.

The implied probability for the Patriots to win based on that line is sixty percent. The implied probability of the Rams, however, is 43.5 percent. In order for Vegas to stay ahead, they create a line with negative expected profit. The mathematical basis for the New England Line is:

$$100*(P) - 150(1-P)>0$$

Where P is equal to the probability the Patriots win the game based on the odds and -150 is taken from the set odds. P is greater than 0.06. By the same process, The Rams line is showed as this:

$$130*(1-P) - 100(P)>0$$

This time P is the probability of the Rams to win based on the odds: 130 comes directly from the bet. In this case, $P<0.565$.

The main takeaway from this is to understand that Vegas inherently has the upper hand. As seen from the two calculations, there is a space between P being less than 56.5 percent and being above sixty percent. Vegas must believe the true probability of the Patriots to win is in between these two numbers, but Vegas manipulates each line to always stay ahead.

Modern Portfolio Theory

Modern Portfolio Theory is the prevailing concept of risk management by diversification. In 1952 Harry Markowitz published “Portfolio Selection”, the article that first described this theory. The Modern Portfolio Theory is commonly used throughout the finance world and is based on mathematics. This theory postulates that by properly diversifying a portfolio with assets of different correlations, one can lessen or altogether eliminate unique, or company specific, risk. The risk left over is that of the market risk, which is inherent and cannot be eliminated. Charted on a graph with a y-axis denoting Expected Return and the x-axis denoting standard deviation, or risk, the theory states that you may move up or down the efficient frontier, which is simply a positively sloping curve indicating accepting greater risk for more return(up the curve), or taking less return for less risk(down the curve).(can you show the curve her as an exhibit?)

Importantly, this all comes down to combining unrelated assets into a diversified portfolio, thus moving the entire efficient frontier to the northwest of the graph, which means less standard deviation(risk) and more expected return. The following equations are the formula for the standard deviation of the portfolio and expected earnings of the portfolio:

$$\sigma P = \sqrt{(wA2 * \sigma A2 + wB2 * \sigma B2 + 2 * wA * wB * \sigma A * \sigma B * \rho AB)}$$

Where:

- σP = portfolio standard deviation
- wA = weight of asset A in the portfolio
- wB = weight of asset B in the portfolio
- σA = standard deviation of asset A
- σB = standard deviation of asset B; and
- ρAB = correlation of asset A and asset B

E(P)=(EA)(wA)+(EB)(wB).....

Where E is the expected return and w is its weight in the portfolio

Literature Review Conclusion

In summary, in a world poised to become synonymous with sports gambling, Vegas has the advantage. Every book making company uses its money lines to lock in negative expected returns from the gamblers. By understanding the contributing factors to the need of a simple are repeated betting process, the entire thesis makes more sense. (I am not sure what this last sentence means)

If the Modern Portfolio Theory is believed to help beat the market, it is possible to also beat Vegas. In a way, teams and stocks are very similar. However, there is no SEC commissioner keeping the bets even. Is the gambling market an inherently losing market or does a financial device help?

Chapter 3

Research Methodology

Data Explanation

A complete data set of the 2020 NFL season was used from the free archive site SportsBookReviews. This provided the moneyline for every game from week one through sixteen, excluding the 17th week which is not highly regarded for gambling, as a team's postseason hopes are generally locked in by then. The Thursday Night Football games are also not included in these calculations, as Cynthia Frelund and the NFL Network did not archive those probabilities. Each moneyline provides how much one would make on a successful bet on either team. This is the main basis for all following calculations.

Methodology

Each game played has a corresponding moneyline that provides the bettor a sense of the expectations of the game. For example, if Pittsburgh plays Cleveland, the moneyline could look like -350 for Pittsburgh and +250 for Cleveland. This tells you that as a negative odd, Pittsburgh is supposed to win this matchup, and a Cleveland wager will give the bettor more than the original bet.

This moneyline tells more than the immediate visual representation of favorite and underdog. By using known techniques, it is possible to write an equation into Excel that provides what is known as the implied probability of the moneyline. For a concrete example, take the week two matchup between Cincinnati versus Philadelphia. Philadelphia sports a -240 moneyline, whereas Cincinnati is placed at a moneyline of +200. Below is the equation for implied probability for favorites and underdogs:

Favorite Implied Probability= Absolute value of the Moneyline/(absolute value of the Moneyline+100)

Underdog Implied Probability= 1-[Moneyline/(Moneyline+100)]

The corresponding implied probability for Philadelphia is 70.59 percent chance to deliver the bet, and Cincinnati's probability is 33.33 percent. This gives a far more concrete idea of how Las Vegas expects the game to go. In this situation, Philadelphia is highly favored to win.

An important piece to pause and understand is the obvious discrepancy in the probability of the two moneylines. The two teams put together have over a 100 percent chance. Where this comes from is most likely the gambling industry receives such negative publicity and connotations. Since Las Vegas is not held to provide a "fair" moneyline, but the best moneyline for the book, Vegas covers their bases in this way. By overlapping the chances each team has, Vegas assures themselves that a 50/50 split in bets pockets them money. They do not care who wins, only the notion that if a book can correctly place a bet with 50/50 interest on both sides, they are guaranteed to win every time. This is where the saying "Vegas always wins" comes into play. Lastly on this point, this specific matchup is even more interesting than any other game of the season. This game resulted in a tie. Understanding that each team together, in fact, had over 100 percent chance to win, neither team actually did. If Vegas took this into consideration, both teams would have less than a 100 percent chance to win. However, this probability is supposed to make money, not necessarily be correct.

The implied probability of each game of the season allows the expected return to be calculated. Expected return is integral in calculating the portfolio probability in Modern Portfolio Theory. The method behind which to get the expected return for each team for each game was intuitive. With the implied probability acting as the likelihood for the event to occur and the moneyline odds of the return on a $100 wager as the outcome, the first part of the expected return was calculated by multiplying the two.

The second part is the inverse. The likelihood of success is subtracted by 1. The outcome would be complete loss, so in this case (-100). Adding the first and second part together, the expected return is calculated.

Using this technique, a very interesting, yet probably not completely curious result occurred. Using the implied probability alongside that of the moneyline odds to calculate the return for both events returned 0.00. Looking back, this is most likely because the odds are created for the express purpose of rendering a zero expected return on a $100 bet. It also shows that since the implied probability is calculated using the moneyline, thus it would make sense that using the odds coupled with the derived implied probability, the result is a clean zero expected return for the bettors who might not know this. Yet another strategy that Vegas uses to ensure a positive event for the sports books.

In order to be able to play off the implied probability set by Vegas, obtaining an outside probability of each game is needed. Cynthia Frelund is an analyst and sports personality working for the NFL Network. Every week, Cynthia publishes the probabilities for each NFL game. Using these projections accompanied with the moneyline compensation, expected returns were able to be calculated. To simplify, this essentially finds the value picks for each week. This means that it shows the most discrepancy with the implied probability and the NFL Network probability.

As an example of the above statement, look to the week one matchup between the Arizona Cardinals and the San Francisco 49ers. Strictly going of the moneyline, San Francisco was -300 and Arizona was +250. This is an implied probability of seventy-five percent chance of winning for San Francisco and a 28.57 percent chance for Arizona. This would indicate that San Francisco is a heavy

favorite to win. This is where the NFL Network comes in handy. Looking at Cynthia Frelund's projections, San Francisco has a fifty-seven percent chance to Arizona's forty-three percent. This is nearly a twenty percent discrepancy in overall projections. A bettor could look at this and make a choice. It appears that Arizona is a value pick, as Vegas is offering more money for their victory than that of what the NFL Network projects. A $100 bet on Arizona would pay out a very attractive 250 percent on investment. If Vegas had the same odds for their moneyline, the same $100 bet would return a far more modest 133 percent, or +133 in American odds. As it happened, Arizona was the surprise victors of that game. The calculations and results can be seen in Appendix A.

The standard deviation of each team's payout is the next integral part of being able to calculate the portfolio deviation, which is the risk of the bet for the purposes of this thesis. A large standard deviation on a particular game shows that the outcome is more random. The outcome is very hard to predict as the implied probability and the NFL Network probability do not indicate anything of interest in the particular bet.

The subject of this thesis is two investigate if Modern Portfolio Theory holds true for sport's gambling. This theory derives a portfolio's overall risk (standard deviation) in the following equation:

Portfolio Standard Deviation=SQRT [(weight of asset 1)^2 * (Standard Dev Asset 1)^2 + (w2)^2 * (STD2)^2……..]

In this equation, the weights are entirely up to the bettor. Depending on factors such as certainty and amount of exposure wanted, a person could put a limitless amount of assets into this

equation with any number of varying weights. In this thesis, the assets are bets. The standard deviation of each game is a different matter. This number must be calculated using the numbers already derived. This is possible by using intuition.

In gambling, there are one of two outcomes: win or loss. One stipulation is of course not counting a push into the equation. A push is simply an outcome that neither won nor lost, and so money is returned. This is most common when betting on spreads and over/unders. However, in this case with moneyline gambles, a push only happens if the game ends in a tie. This has no effect on the pocket of a bettor and therefor being excluded from the calculations. In order to calculate the standard deviation of each game, it is required to calculate for both the win and loss of the bet.

The equation used ultimately finds the inherent risk of each bet. In order to account for both the win and loss possibility, the equation uses the probability of both, similar to the way expected return was calculated. One aspect important to note is that the STDEVA excel function was used to calculate. This function allows for specific inputs to be used to calculate the standard deviation, in this case the win and the loss. The formula is as follows:

STDEV of Asset=STDEVA[NFL Network Probability * ((moneyline/100)*the bet amount),1-NFL Prob * (-Bet amount)]

The comma denotes the second possibility of the bet.

As what could be expected, the bets where teams are closely rated, such as the week one matchup between of Atlanta vs. Seattle, the standard deviation of the two teams was much lower. NFL Network had a fifty-five percent Seattle to forty-five percent Atlanta probability and Vegas had a 53.49

percent to 51.22 percent in favor of Atlanta. This came out to an extremely low standard deviation of nine for Seattle and two for Atlanta for a $100 bet. It is important not to take this completely at its word, as there obviously is a winner and a loser for this game. But it illustrates how this standard deviation equation shows the closer games to be lower standard deviation. As an aside, looking at the expected return equation for these two teams, Seattle, the eventual victors of the game, were positive expected return compared to that of a negative expected return for Atlanta.

On the other hand, a game in which a team is heavily favored returned a very high number for the standard deviation. An example being the week four matchup between Kansas City and New England. While NFL Network had a probability of sixty percent to forty percent in favor of Kansas City, Vegas had it at 86.67 percent to 17.39 percent in favor a Kansas City. This gave way to an astronomical standard deviation of 247 for Kansas City and 177 for New England. Looking at the expected return, New England had a positive while Kansas City had a negative expected return. While the game was close, Kansas City won. It is important not to take these numbers blindly, but see them for what they are. There was such a discrepancy in NFL Network's and Vegas' numbers that New England was a value bet, not a verifiable victor.

After calculating the standard deviation for each team in each game, calculating a portfolio standard deviation using the Modern Portfolio Theory approach is possible. Using the above calculation, one can simply plug the standard deviation and the desired weight in and calculate the standard deviation of the portfolio. There is no limit to the number of bets per week nor the weights on said bets. The bettor can simply bet to their discretion. Randomly calculating 50/50 weighted portfolios, in every case, the portfolio standard deviation was less than at least one, and sometimes both of the individual. This is interesting in theory, but of course with an asset like a bet, there are inherent risks. This

is not saying that it is possible to diversify away risk in win/loss moneyline betting, but it is certainly an indicator that smart betting is possible.

Most importantly, it is essential to understand that the Modern Portfolio Theory is made to eliminate idiosyncratic risk, not systematic risk. Idiosyncratic risk is the risk associated with a specific asset. This, in theory, can be eliminated, such as in this case a non-value bet or a bet with a negative expected return. What is impossible to get rid of is the systematic risk. This is risk that is inherent to a particular way of investing. In this case, systematic is significantly more than other types of investing like the stock market and the fixed income market.

The last piece is using Modern Portfolio Theory to calculate expected returns. Since weights are different for different assets in a portfolio, the equation demonstrates that simply as follows:

Portfolio Expected Return=Percent Weigh Asset 1 * Expected Return Asset 1 + PW A2* ER A2

The weight is simply the percent of the total capital an individual is investing in that specific asset, and the expected return was already calculated for each game this season. The weight is easily thought of by thinking about a person with $10 dollars. If they put $5 in one game and $5 into another game, the weight would be fifty percent for each asset. Since with the equation, the weights will always be less than one, the expected returns will always be less than the original value. This works well for betting as the expected return is merely a hope and by no means a guarantee in betting. Some expected returns in the data are inflated simply because the NFL Network and Vegas disagree, but one of them has to be right.

Chapter 4

Summary of Data and Findings

Expected Return for each NFL team for each game was calculated to help discover a way to find where to bet. It is first important to reiterate the fact that these returns are unlike most other calculatable investments. There are few investments that offer simply all or nothing. What is meant by that is, with a bet, there are two possible outcomes, winning the bet for the amount the line was offering, or complete loss of the bet sum. This was alluded to above but must be discussed more in this section.

The expected return calculated for these games tend to be inflated. Upon reviewing, it would appear that the expected returns became especially inflated for heavy underdog teams. This is to say that frequently, when looking at the teams with the highest calculated expected return, it is usually because they are severe underdogs with a very large perspective payout. One such example would be the New England versus Kansas City game discussed in the last chapter. Because Vegas placed such a low probability of winning in the odds (implied probability of 17.39 percent) compared to that of the NFL Network (forty percent according to their model), the expected return for New England was 130 percent. As stated before, New England lost this game, and thus, one of the highest expected returns calculated over the season was not correct.

This leads to a very important finding. The expected return is positive when the NFL Network gives a team a better percent chance to win than what Vegas' moneyline implied probability gives the same team. It was found that when a team has a positive expected return, it was because of the discrepancy of the two probabilities. In this thesis, expected return acts more as a way to find discrepancies rather than a way to lock in profit. The NFL is too volatile to have certain monetary returns. However, a gambler looking for a value pick could use the expected return to find games in which there is a higher value. Think of the expected return as a value finder and go from there.

This leads to discovering how frequently over this NFL season an expected return calculation returned a win. Of the 210 games calculated over the NFL season, 206 teams had a positive expected return. Before proceeding, understand that the games and the teams are different numbers. In order for there to be 210 games, 420 team returns were calculated. Having 206 teams with a positive return says that almost every game this season had a team that had a positive and negative expected return, except for four games with both teams having a negative expected return. It is only possible to have two teams with a negative expected return because, as mentioned above, each moneyline combination for a game has above a 100 percent chance. For clarity, the week one matchup between Chicago and Detroit placed an implied probability of 56.52 percent and 47.62 percent respectively. The NFL Network had 54 percent and 46 percent. In this rare case, both teams had a higher chance to win via the moneyline than the NFL Network thought for either team. This resulted in two negative expected return calculations. Two teams playing each other with positive expected return calculations is not possible because the way Vegas hedges over 100 percent would only create less value in a tight matchup rather than better value.

Of the 206 teams eligible for a successful positive return calculation, 69 teams succeeded. What is meant by succeeded is that the positive return calculation actually corresponded to a win in that game. This equates to 33.495 percent of games that had a positive expected return actually delivered on this calculation. At first glance, this is far from optimal. Maybe it could even be argued that simply betting on negative expected returns would be a good betting strategy. It is important not to let the numbers bog down the understanding that many teams with negative moneylines deliver far less money per bet. Roughly 33 percent of the time this season, Vegas was incorrect. The NFL Network successfully found a "good" bet.

The next findings summary will discuss standard deviation and how it may help a gambler find a good bet. Standard deviation is an assessment of risk for a certain event. In gambling, one could expect a very high standard deviation, as there are only two possibilities: the team wins and your payout is the moneyline odds gambled, or the bet losses and the entire bet amount is lost. For games with large

underdogs, this number tends to be very large. The reason for this is that the payout is so large if that team wins that the monetary difference between the two chances is very great. This creates a huge standard deviation calculation for that team.

Finding lower risk games sounds like a good way to pick a game to bet on. Calculating the number of teams with below 50 standard deviation returned 110 such teams over the season. Fifty standard deviation was chosen as the limit because it was simple and approximately the bottom quarter of all teams' standard deviation calculations. This is to be reviewed differently than expected return, as two teams playing each other can both have a standard deviation of under 50. Instead of viewing the 110 teams as about half of the games this season, simply think of them as times in which the number of teams was found to be lower than 50 standard deviation.

Of the 110 teams eligible for this this calculation, 61 teams were successful. This is to say that 61 of these 110 teams won the game. At 55.45 percent, it was more often than not that a team with a "low" standard deviation won the matchup. Over the 2020 NFL season, a team with under 50 standard deviation was an indicator of a successful bet.

Another area of interest was to combine both positive expected returns with low standard deviation. As mentioned, the higher expected returns tended to be inflated because a team was a heavy underdog. Using standard deviation in tandem with positive expected return would help to eliminate these inflated returns and concentrate on more evenly matched teams with a positive expected return. Finding games with both a corresponding positive expected return and under 50 standard deviation happened only twelve times in the entire season. This would indicate twelve separate games, as a matchup cannot have two positive expected return teams. Of these twelve games, the team won eight times. This is hardly something to put much stake into. However, at 66.66 percent success rate, it is something that could be used to further investigate a matchup and perspective bet.

As for using Modern Portfolio Theory in sports gambling, the results are not ultimately promising. Standard deviation was in some ways a good indicator of success, and by putting low standard deviation teams (under 50), a bettor would have won more than they lost. However, expected return cannot be used in sports gambling the way it can be used in other investments. It is impossible for an expected return to ever really be expected in sports gambling. The NFL is too volatile to ever expect a return. Through this research, specific indicators for a good bet have been highlighted, but the relationship to Modern Portfolio Theory is a reach at best.

The expected return and standard deviation calculated throughout are more indicators of a potentially profitable bet than they are data to be entered into an equation. It was discovered that expected return in this thesis points to games where Vegas and the NFL Network disagree. The higher the expected return, the larger the discrepancy. Standard deviation is more useful for finding teams that are heavy betting underdogs. The higher the standard deviation, the higher the moneyline. As a result, large standard deviations help eliminate "Hail Mary" bets, or teams with a very low chance to win. Neither of these calculations point towards Modern Portfolio Theory being usable to eliminate risk and lock in expected return

Chapter 5

Conclusion and Shortcomings

It is the conclusion of this thesis that Modern Portfolio Theory cannot be used in the same way it can be used on other investments. While the games are completely non-correlated, they are too volatile for a theory such as this to work completely. Beyond that, the calculations for the expected return are not numbers to be taken at face value. For reasons discussed above, expected return is more of a discrepancy finder between Vegas and the NFL Network than it is an actual return that one could expect.

The standard deviation calculations are very useful, and help show games in which teams may have a better chance of winning. Low standard deviation games were shown in the 2020 NFL season to be a more likely than not an indicator of a winning team. Making a portfolio of these teams would in fact lower the overall risk of the portfolio, but in doing so would require negative expected return bets, which would make little sense in the Modern Portfolio Theory as it is known in other investment strategies.

The Modern Portfolio Theory is not a perfect fit for moneyline gambling in the NFL. It is by no means a magic wand that takes away the chaos of the NFL week in and week out. There are some very useful tools that were found to aid a knowledgeable gambler, however. The expected return calculated in this way does highlight discrepancies in win probability between Vegas and, in this thesis, the NFL Network. Beyond that, combining such bets in a portfolio does mathematically help eliminate idiosyncratic risks and lower the standard deviation as a whole when betting on multiple games. NFL moneyline betting is an inherently dangerous and risky activity, but it is not the complete madness and "Vegas always wins" that some might expect. The numbers alone act very similarly to those of stocks and other assets. Of course, sports betting is all or nothing, which makes locking in an expected return impossible. The best this method can offer is educated guesses.

In following work and theses, there are many places to expand and elaborate. For simplicity, only one year of the NFL was studied. In a more intensive study, a decade or more could be far more useful in seeing overarching themes that may give more insight. Another offshoot that was impossible this year

because of Covid-19 is looking into home field advantage and how that may affect a team. This year, there were no fans and thus this was not something that was necessarily or useful to look into.

It would also be a worthwhile study to look at low standard variation calculations over a much bigger time interval. As mentioned before, one year was used for simplicity, but in order to verify the findings in this thesis, it would be extremely useful to look at the results over the past decade, and even longer. This would further verify as well as perhaps show more insight into strategies that work better for the sports gambling market.

Moreover, including more probabilities from other companies could help expand further discrepancies between that and Vegas. There are many companies out there offering similar modules to that of the NFL Network. Many are paid for and some are free. It would be interesting to investigate which company is most accurate in terms of their probabilities.

Appendix A

Team Moneylines and Probabilities

NFL Probability	VH	Team	Final	ML	Implied Probability
	V	Houston	20	375	21.05%
	H	KansasCity	34	-450	81.82%
29%	V	Miami	11	290	25.64%
71%	H	NewEngland	21	-350	77.78%
26%	V	Cleveland	6	270	27.03%
74%	H	Baltimore	38	-330	76.74%
31%	V	NYJets	17	250	28.57%
69%	H	Buffalo	27	-300	75.00%
52%	V	LasVegas	34	-150	60.00%
48%	H	Carolina	30	130	43.48%
55%	V	Seattle	38	-105	51.22%
45%	H	Atlanta	25	-115	53.49%
70%	V	Philadelphia	17	-230	69.70%
30%	H	Washington	27	195	33.90%
46%	V	Chicago	27	110	47.62%
54%	H	Detroit	23	-130	56.52%
68%	V	Indianapolis	20	-320	76.19%
32%	H	Jacksonville	27	265	27.40%
54%	V	GreenBay	43	105	48.78%
46%	H	Minnesota	34	-125	55.56%
59%	V	LAChargers	16	-130	56.52%
41%	H	Cincinnati	13	110	47.62%
43%	V	Arizona	24	250	28.57%
57%	H	SanFrancisco	20	-300	75.00%
37%	V	TampaBay	23	175	36.36%
63%	H	NewOrleans	34	-200	66.67%
59%	V	Dallas	17	-110	52.38%
41%	H	LARams	20	-110	52.38%
67%	V	Pittsburgh	26	-260	72.22%
33%	H	NYGiants	16	220	31.25%
58%	V	Tennessee	16	-170	62.96%
42%	H	Denver	14	150	40.00%
	V	Cincinnati	30	220	31.25%
	H	Cleveland	35	-260	72.22%
53%	V	LARams	37	110	47.62%
47%	H	Philadelphia	19	-130	56.52%
35%	V	Carolina	17	320	23.81%
65%	H	TampaBay	31	-380	79.17%
33%	V	Denver	21	250	28.57%
67%	H	Pittsburgh	26	-300	75.00%
39%	V	Atlanta	39	120	45.45%
61%	H	Dallas	40	-140	58.33%
63%	V	SanFrancisco	31	-335	77.01%
37%	H	NYJets	13	275	26.67%
61%	V	Buffalo	31	-240	70.59%
39%	H	Miami	28	200	33.33%
55%	V	Minnesota	11	160	38.46%

45%	H	Indianapolis	28	-180	64.29%
41%	V	Detroit	21	250	28.57%
59%	H	GreenBay	42	-300	75.00%
41%	V	NYGiants	13	190	34.48%
59%	H	Chicago	17	-220	68.75%
28%	V	Jacksonville	30	260	27.78%
72%	H	Tennessee	33	-310	75.61%
34%	V	Washington	15	270	27.03%
66%	H	Arizona	30	-330	76.74%
68%	V	Baltimore	33	-350	77.78%
32%	H	Houston	16	290	25.64%
73%	V	KansasCity	23	-420	80.77%
27%	H	LAChargers	20	350	22.22%
46%	V	NewEngland	30	180	35.71%
54%	H	Seattle	35	-210	67.74%
57%	V	NewOrleans	24	-200	66.67%
43%	H	LasVegas	34	175	36.36%
	V	Miami	31	120	45.45%
	H	Jacksonville	13	-140	58.33%
40%	V	LasVegas	20	270	27.03%
60%	H	NewEngland	36	-330	76.74%
51%	V	LARams	32	110	47.62%
49%	H	Buffalo	35	-130	56.52%
36%	V	Houston	21	170	37.04%
64%	H	Pittsburgh	28	-190	65.52%
56%	V	SanFrancisco	36	-160	61.54%
44%	H	NYGiants	9	140	41.67%
54%	V	Tennessee	31	-150	60.00%
46%	H	Minnesota	30	130	43.48%
66%	V	Washington	20	270	27.03%
34%	H	Cleveland	34	-330	76.74%
35%	V	Cincinnati	23	200	33.33%
65%	H	Philadelphia	23	-240	70.59%
45%	V	Chicago	30	120	45.45%
55%	H	Atlanta	26	-140	58.33%
31%	V	NYJets	7	500	16.67%
69%	H	Indianapolis	36	-700	87.50%
34%	V	Carolina	21	230	30.30%
66%	H	LAChargers	16	-270	72.97%
34%	V	Detroit	26	200	33.33%
66%	H	Arizona	23	-240	70.59%
59%	V	TampaBay	28	-265	72.60%
41%	H	Denver	10	225	30.77%
42%	V	Dallas	31	200	33.33%
58%	H	Seattle	38	-240	70.59%
47%	V	GreenBay	37	155	39.22%
53%	H	NewOrleans	30	-175	63.64%
56%	V	KansasCity	34	160	38.46%

44%	H	Baltimore	20	-180	64.29%
	V	Denver	37	-105	51.22%
	H	NYJets	28	-115	53.49%
46%	V	Indianapolis	19	-185	64.91%
54%	H	Chicago	11	165	37.74%
61%	V	NewOrleans	35	-160	61.54%
39%	H	Detroit	29	140	41.67%
59%	V	Arizona	21	-165	62.26%
41%	H	Carolina	31	145	40.82%
56%	V	Jacksonville	25	100	50.00%
44%	H	Cincinnati	33	-120	54.55%
40%	V	Cleveland	49	155	39.22%
60%	H	Dallas	38	-175	63.64%
43%	V	Minnesota	31	150	40.00%
57%	H	Houston	23	-170	62.96%
66%	V	Seattle	31	-210	67.74%
34%	H	Miami	23	180	35.71%
70%	V	LAChargers	31	300	25.00%
30%	H	TampaBay	38	-360	78.26%
80%	V	Baltimore	31	-1400	93.33%
20%	H	Washington	17	800	11.11%
23%	V	NYGiants	9	700	12.50%
77%	H	LARams	17	-1100	91.67%
56%	V	Buffalo	30	-170	62.96%
44%	H	LasVegas	23	150	40.00%
30%	V	Philadelphia	25	270	27.03%
70%	H	SanFrancisco	20	-330	76.74%
40%	V	Atlanta	16	190	34.48%
60%	H	GreenBay	30	-220	68.75%
40%	V	NewEngland	10	475	17.39%
60%	H	KansasCity	26	-650	86.67%
	V	TampaBay	19	-190	65.52%
	H	Chicago	20	170	37.04%
55%	V	Carolina	23	130	43.48%
45%	H	Atlanta	16	-150	60.00%
27%	V	LVRaiders	40	425	19.05%
73%	H	KCChiefs	32	-550	84.62%
70%	V	LARams	30	-330	76.74%
30%	H	Washington	10	270	27.03%
44%	V	Jacksonville	14	220	31.25%
56%	H	Houston	30	-260	72.22%
63%	V	Arizona	30	-320	76.19%
37%	H	NYJets	10	265	27.40%
28%	V	Philadelphia	29	300	25.00%
72%	H	Pittsburgh	38	-360	78.26%
19%	V	Cincinnati	3	525	16.00%
81%	H	Baltimore	27	-750	88.24%
29%	V	Miami	43	310	24.39%

71%	H	SanFrancisco	17	-370	78.72%
27%	V	NYGiants	34	280	26.32%
73%	H	Dallas	37	-340	77.27%
48%	V	Indianapolis	23	100	50.00%
52%	H	Cleveland	32	-120	54.55%
35%	V	Minnesota	26	245	28.99%
65%	H	Seattle	27	-290	74.36%
28%	V	LAChargers	27	275	26.67%
72%	H	NewOrleans	30	-335	77.01%
52%	V	Buffalo	16	-160	61.54%
48%	H	Tennessee	42	140	41.67%
53%	V	Chicago	23	110	47.62%
47%	H	Carolina	16	-130	56.52%
57%	V	Detroit	34	-165	62.26%
43%	H	Jacksonville	16	145	40.82%
41%	V	Atlanta	40	160	38.46%
59%	H	Minnesota	23	-180	64.29%
60%	V	Houston	36	170	37.04%
40%	H	Tennessee	42	-190	65.52%
53%	V	Washington	19	-105	51.22%
47%	H	NYGiants	20	-115	53.49%
56%	V	Cleveland	7	145	40.82%
44%	H	Pittsburgh	38	-165	62.26%
71%	V	Baltimore	30	-500	83.33%
29%	H	Philadelphia	28	400	20.00%
70%	V	Cincinnati	27	310	24.39%
30%	H	Indianapolis	31	-370	78.72%
53%	V	GreenBay	10	-155	60.78%
47%	H	TampaBay	38	135	42.55%
58%	V	LARams	16	-130	56.52%
42%	H	SanFrancisco	24	110	47.62%
28%	V	NYJets	0	320	23.81%
72%	H	Miami	24	-380	79.17%
31%	V	Denver	18	300	25.00%
69%	H	NewEngland	12	-360	78.26%
55%	V	Arizona	38	100	50.00%
45%	H	Dallas	10	-120	54.55%
53%	V	KansasCity	26	-240	70.59%
47%	H	Buffalo	17	200	33.33%
	V	NYGiants	21	200	33.33%
	H	Philadelphia	22	-240	70.59%
59%	V	Cleveland	37	-215	68.25%
41%	H	Cincinnati	34	185	35.09%
54%	V	Dallas	3	-105	51.22%
46%	H	Washington	25	-115	53.49%
53%	V	Detroit	23	100	50.00%
47%	H	Atlanta	22	-120	54.55%
47%	V	Carolina	24	275	26.67%

53%	H	NewOrleans	27	-335	77.01%
73%	V	Buffalo	18	-450	81.82%
27%	H	NYJets	10	375	21.05%
56%	V	GreenBay	35	-150	60.00%
44%	H	Houston	20	130	43.48%
56%	V	Seattle	34	-180	64.29%
44%	H	Arizona	37	160	38.46%
45%	V	SanFrancisco	33	130	43.48%
55%	H	NewEngland	6	-150	60.00%
71%	V	KansasCity	43	-340	77.27%
29%	H	Denver	16	280	26.32%
62%	V	TampaBay	45	-200	66.67%
38%	H	LasVegas	20	175	36.36%
48%	V	Pittsburgh	27	100	50.00%
52%	H	Tennessee	24	-120	54.55%
31%	V	Jacksonville	29	320	23.81%
69%	H	LAChargers	39	-380	79.17%
44%	V	Chicago	10	240	29.41%
56%	H	LARams	24	-280	73.68%
	V	Atlanta	25	105	48.78%
	H	Carolina	17	-125	55.56%
48%	V	Indianapolis	41	-190	65.52%
52%	H	Detroit	21	170	37.04%
32%	V	Minnesota	28	220	31.25%
68%	H	GreenBay	22	-260	72.22%
38%	V	NewEngland	21	185	35.09%
62%	H	Buffalo	24	-215	68.25%
63%	V	Tennessee	20	-350	77.78%
37%	H	Cincinnati	31	290	25.64%
48%	V	LasVegas	16	-105	51.22%
52%	H	Cleveland	6	-115	53.49%
13%	V	NYJets	9	1500	6.25%
87%	H	KansasCity	35	-5000	98.04%
49%	V	LARams	17	-170	62.96%
51%	H	Miami	28	150	40.00%
59%	V	NewOrleans	26	-250	71.43%
41%	H	Chicago	23	210	32.26%
41%	V	SanFrancisco	27	100	50.00%
59%	H	Seattle	37	-120	54.55%
27%	V	Dallas	9	375	21.05%
73%	H	Philadelphia	23	-450	81.82%
59%	V	LAChargers	30	-145	59.18%
41%	H	Denver	31	125	44.44%
44%	V	Pittsburgh	28	175	36.36%
56%	H	Baltimore	24	-200	66.67%
77%	V	TampaBay	25	-750	88.24%
23%	H	NYGiants	23	525	16.00%
	V	GreenBay	34	-260	72.22%

	H	SanFrancisco	17	220	31.25%
57%	V	Seattle	34	-165	62.26%
43%	H	Buffalo	44	145	40.82%
52%	V	Denver	27	180	35.71%
48%	H	Atlanta	34	-210	67.74%
41%	V	Chicago	17	235	29.85%
59%	H	Tennessee	24	-275	73.33%
51%	V	Detroit	20	155	39.22%
49%	H	Minnesota	34	-175	63.64%
55%	V	Baltimore	24	-105	51.22%
45%	H	Indianapolis	10	-115	53.49%
19%	V	Carolina	31	400	20.00%
81%	H	Kansas	33	-500	83.33%
61%	V	Houston	27	-300	75.00%
39%	H	Jacksonville	25	250	28.57%
45%	V	NYGiants	23	140	41.67%
55%	H	Washington	20	-160	61.54%
55%	V	LasVegas	31	-120	54.55%
45%	H	LAChargers	26	100	50.00%
83%	V	Pittsburgh	24	-1200	92.31%
17%	H	Dallas	19	750	11.76%
56%	V	Miami	34	220	31.25%
44%	H	Arizona	31	-260	72.22%
55%	V	NewOrleans	38	155	39.22%
45%	H	Tampa	3	-175	63.64%
52%	V	NewEngland	30	-380	79.17%
48%	H	NYJets	27	320	23.81%
	V	Indianapolis	34	-125	55.56%
	H	Tennessee	17	105	48.78%
27%	V	Cincinnati	10	260	27.78%
73%	H	Pittsburgh	36	-310	75.61%
41%	V	Washington	27	120	45.45%
59%	H	Detroit	30	-140	58.33%
42%	V	Houston	7	190	34.48%
58%	H	Cleveland	10	-220	68.75%
13%	V	Jacksonville	20	700	12.50%
87%	H	GreenBay	24	-1100	91.67%
57%	V	Philadelphia	17	-220	68.75%
43%	H	NYGiants	27	190	34.48%
58%	V	TampaBay	46	-265	72.60%
42%	H	Carolina	23	225	30.77%
42%	V	Denver	12	165	37.74%
58%	H	LasVegas	37	-185	64.91%
53%	V	Buffalo	30	135	42.55%
47%	H	Arizona	32	-155	60.78%
56%	V	Seattle	16	130	43.48%
44%	H	LARams	23	-150	60.00%
26%	V	SanFrancisco	13	350	22.22%

74%	H	NewOrleans	27	-420	80.77%
72%	V	Baltimore	17	-320	76.19%
28%	H	NewEngland	23	265	27.40%
43%	V	LAChargers	21	105	48.78%
57%	H	Miami	29	-125	55.56%
56%	V	Minnesota	19	-170	62.96%
44%	H	Chicago	13	150	40.00%
	V	Arizona	21	145	40.82%
	H	Seattle	28	-165	62.26%
47%	V	Philadelphia	17	115	46.51%
53%	H	Cleveland	22	-135	57.45%
45%	V	Atlanta	9	160	38.46%
55%	H	NewOrleans	24	-180	64.29%
53%	V	Detroit	0	-170	62.96%
47%	H	Carolina	20	150	40.00%
48%	V	NewEngland	20	-145	59.18%
52%	H	Houston	27	125	44.44%
74%	V	Pittsburgh	27	-550	84.62%
26%	H	Jacksonville	3	425	19.05%
54%	V	GreenBay	31	100	50.00%
46%	H	Indianapolis	34	-120	54.55%
52%	V	Cincinnati	9	105	48.78%
48%	H	Washington	20	-125	55.56%
46%	V	Tennessee	30	210	32.26%
54%	H	Baltimore	24	-250	71.43%
32%	V	Dallas	31	260	27.78%
68%	H	Minnesota	28	-310	75.61%
64%	V	KansasCity	35	-380	79.17%
36%	H	LasVegas	31	320	23.81%
61%	V	Miami	13	-210	67.74%
39%	H	Denver	20	180	35.71%
33%	V	NYJets	28	400	20.00%
67%	H	LAChargers	34	-500	83.33%
56%	V	LARams	27	180	35.71%
44%	H	TampaBay	24	-210	67.74%
	V	Houston	41	-160	61.54%
	H	Detroit	25	140	41.67%
	V	Washington	41	125	44.44%
	H	Dallas	16	-145	59.18%
53%	V	LasVegas	6	-175	63.64%
47%	H	Atlanta	43	155	39.22%
53%	V	Arizona	17	-120	54.55%
47%	H	NewEngland	20	100	50.00%
60%	V	NYGiants	19	-280	73.68%
40%	H	Cincinnati	17	240	29.41%
59%	V	Cleveland	27	-350	77.78%
41%	H	Jacksonville	25	290	25.64%
53%	V	Carolina	27	125	44.44%

47%	H	Minnesota	28	-145	59.18%
52%	V	Tennessee	45	125	44.44%
48%	H	Indianapolis	26	-145	59.18%
39%	V	LAChargers	17	180	35.71%
61%	H	Buffalo	27	-210	67.74%
62%	V	Miami	20	-370	78.72%
38%	H	NYJets	3	310	24.39%
62%	V	NewOrleans	31	-1600	94.12%
38%	H	Denver	3	900	10.00%
42%	V	SanFrancisco	23	200	33.33%
58%	H	LARams	20	-240	70.59%
54%	V	KansasCity	27	-170	62.96%
46%	H	TampaBay	24	150	40.00%
40%	V	Chicago	25	320	23.81%
60%	H	GreenBay	41	-380	79.17%
58%	V	Seattle	23	-300	75.00%
42%	H	Philadelphia	17	250	28.57%
	V	Baltimore	14	400	20.00%
	H	Pittsburgh	19	-500	83.33%
51%	V	Detroit	34	135	42.55%
49%	H	Chicago	30	-155	60.78%
27%	V	Cincinnati	7	400	20.00%
73%	H	Miami	19	-500	83.33%
54%	V	Indianapolis	26	-170	62.96%
46%	H	Houston	20	150	40.00%
30%	V	Jacksonville	24	400	20.00%
70%	H	Minnesota	27	-500	83.33%
58%	V	LasVegas	31	-360	78.26%
42%	H	NYJets	28	300	25.00%
57%	V	NewOrleans	21	-145	59.18%
43%	H	Atlanta	16	125	44.44%
44%	V	Cleveland	41	180	35.71%
56%	H	Tennessee	35	-210	67.74%
32%	V	NYGiants	17	475	17.39%
68%	H	Seattle	12	-650	86.67%
49%	V	LARams	38	-150	60.00%
51%	H	Arizona	28	130	43.48%
31%	V	Philadelphia	16	350	22.22%
69%	H	GreenBay	30	-420	80.77%
51%	V	NewEngland	45	115	46.51%
49%	H	LAChargers	0	-135	57.45%
20%	V	Denver	16	650	13.33%
80%	H	KansasCity	22	-1000	90.91%
51%	V	Buffalo	34	105	48.78%
49%	H	SanFrancisco	24	-125	55.56%
45%	V	Washingtom	23	220	31.25%
55%	H	Pittsburgh	17	-260	72.22%
77%	V	Dallas	17	340	22.73%

23%	H	Baltimore	34	-410	80.39%
	V	NewEngland	3	190	34.48%
	H	LARams	24	-220	68.75%
56%	V	GreenBay	31	-420	80.77%
44%	H	Detroit	24	350	22.22%
66%	V	Tennessee	31	-370	78.72%
34%	H	Jacksonville	10	310	24.39%
54%	V	Dallas	30	-160	61.54%
46%	H	Cincinnati	7	140	41.67%
54%	V	Arizona	26	-160	61.54%
46%	H	NYGiants	7	140	41.67%
52%	V	Houston	7	-125	55.56%
48%	H	Chicago	36	105	48.78%
44%	V	Denver	32	175	36.36%
56%	H	Carolina	27	-200	66.67%
57%	V	Minnesota	14	270	27.03%
43%	H	TampaBay	26	-330	76.74%
57%	V	KansasCity	33	-340	77.27%
43%	H	Miami	27	280	26.32%
54%	V	Indianapolis	44	-145	59.18%
46%	H	LasVegas	27	125	44.44%
35%	V	NYJets	3	750	11.76%
65%	H	Seattle	40	-1200	92.31%
52%	V	Atlanta	17	100	50.00%
48%	H	LAChargers	20	-120	54.55%
64%	V	NewOrleans	21	-360	78.26%
36%	H	Philadelphia	24	300	25.00%
51%	V	Washingtom	23	125	44.44%
49%	H	SanFrancisco	15	-145	59.18%
51%	V	Pittsburgh	7	110	47.62%
49%	H	Buffalo	23	-130	56.52%
53%	V	Baltimore	47	-175	63.64%
47%	H	Cleveland	42	155	39.22%
	V	LAChargers	30	155	39.22%
	H	LasVegas	27	-175	63.64%
35%	V	Carolina	16	375	21.05%
65%	H	GreenBay	24	-450	81.82%
60%	V	Buffalo	48	-250	71.43%
40%	H	Denver	19	210	32.26%
39%	V	Houston	20	310	24.39%
61%	H	Indianapolis	27	-370	78.72%
38%	V	Detroit	25	320	23.81%
62%	H	Tennessee	46	-380	79.17%
19%	V	NYJets	23	1200	7.69%
81%	H	LARams	20	-3000	96.77%
59%	V	TampaBay	31	-270	72.97%
41%	H	Atlanta	27	230	30.30%
52%	V	NewEngland	12	-125	55.56%

48%	H	Miami	22	105	48.78%
55%	V	Seattle	20	-265	72.60%
45%	H	Washington	15	225	30.77%
47%	V	Chicago	33	130	43.48%
53%	H	Minnesota	27	-150	60.00%
21%	V	Jacksonville	14	650	13.33%
79%	H	Baltimore	40	-1000	90.91%
54%	V	Cleveland	20	-280	73.68%
46%	H	NYGiants	6	240	29.41%
41%	V	Philadelphia	26	225	30.77%
59%	H	Arizona	33	-265	72.60%
53%	V	KansasCity	32	-140	58.33%
47%	H	NewOrleans	29	120	45.45%
57%	V	SanFrancisco	33	-220	68.75%
43%	H	Dallas	41	190	34.48%
78%	V	Pittsburgh	17	-1200	92.31%
22%	H	Cincinnati	27	750	11.76%
38%	V	Minnesota	33	250	28.57%
62%	H	NewOrleans	52	-300	75.00%
64%	V	TampaBay	47	-700	87.50%
36%	H	Detroit	7	500	16.67%
40%	V	SanFrancisco	20	225	30.77%
60%	H	Arizona	12	-265	72.60%
55%	V	Miami	26	-140	58.33%
45%	H	LasVegas	25	120	45.45%
54%	V	Denver	16	110	47.62%
46%	H	LAChargers	19	-130	56.52%
64%	V	Cleveland	16	-280	73.68%
36%	H	NYJets	23	240	29.41%
36%	V	Cincinnati	37	275	26.67%
64%	H	Houston	31	-335	77.01%
48%	V	Indianapolis	24	-110	52.38%
52%	H	Pittsburgh	28	-110	52.38%
65%	V	Chicago	41	-450	81.82%
35%	H	Jacksonville	17	375	21.05%
46%	V	Carolina	20	-120	54.55%
54%	H	Washington	13	100	50.00%
35%	V	NYGiants	13	375	21.05%
65%	H	Baltimore	27	-450	81.82%
35%	V	Atlanta	14	450	18.18%
65%	H	KansasCity	17	-600	85.71%
47%	V	LARams	9	105	48.78%
53%	H	Seattle	20	-125	55.56%
52%	V	Philadelphia	17	-170	62.96%
48%	H	Dallas	37	150	40.00%
49%	V	Tennessee	14	150	40.00%
51%	H	GreenBay	40	-170	62.96%
59%	V	Buffalo	38	-350	77.78%
41%	H	NewEngland	9	290	25.64%

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ACADEMIC VITA

EDUCATION

The Pennsylvania State University State College, PA
Smeal College of Business May 2021
Bachelor of Science in Finance
Minor in Chinese Dean's List 4/4 semesters
Schreyer Honors College Scholar

University College London London, United Kingdom
School of Management and Economics Spring 2020

Work Experience

Dakota Funds Bryn Mawr, PA
Institutional Sales Intern May 2019 – December 2019

- Dakota Funds is a third-party marketing firm that specializes in selling boutique funds to RIA's, family offices, and other financial managers
- Attended meetings with fund managers both in person and over the phone while creating notes for our team on Salesforce
- Tasked with training other interns on Salesforce and keeping assigning projects
- Once the internship concluded and I worked during my school semester remotely

MSG Promotions Southampton, NY
Corporate Hospitality Intern for the US Open at Shinnecock Hills May 2018 – July 2018

- Lead the construction, maintenance, and all services in my corporate hospitality tent throughout the US Open
- Individually assisted corporate customers to ensure excellent and personalized experiences
- Trained 20 volunteers that helped with the upkeep and accommodation of the tents

Additional Academic Experiences **School Year Abroad** Beijing, China

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Student June 2016– August 2016

- Enrolled in a vigorous immersive Mandarin language course
- Studied Economic relationship between China and the United States as well as the economic structure of China as a whole
- Stayed with a non-English-speaking host family

Data Analytics Research Project State College, PA
Research with Dr. Russell Barton December 2018 – May 2019

- Completed a research paper analyzing the relationship between traffic patterns and pedestrians using Excel and Mini Tab programs
- Wrote a research paper for a 400 level Finance credit

Business Plan for GoPSURV State College, PA
Created a Five-Year Business Plan January 2019– May 2019

- Drafted a 5-year business plan complete with financial revenue projections and future ventures
- Consulted the CEO and CFO of the company and presented the plan to the board

ADDITIONAL EXPERIENCE/HONORS/SKILLS/INTERESTS **Scholarship**
