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Economics Capstone

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## The Effect of Weather on the NFL Betting Market

### 1. Introduction

Gambling has always been popular in society, and now with legalization happening in many states across the country, it will only continue to grow in its popularity. Many sports leagues have embraced gambling fully. Sportsbooks and Daily Fantasy sites can be routinely seen being advertised all over sports stadiums and even uniforms. Advertisements promoting gambling are on TV all the time and more places to bet, especially online, are being created at a rapid pace. Gambling in sports is now mainstream and that is never going to change.

The most popular sport to bet on in America is the NFL. The National Football League garners the most attention from the public out of all the major American sports. When the football season is approaching, everything stops. People's attention goes right to the NFL. Training camps, fantasy football, preseason etc. All leading up to Week 1 of the season. With all of this popularity for the NFL, it leads to it being the most bet-on sport in the United States. Millions of people place wagers on Thursday Night Football, Monday Night Football, and the Sunday slate of games on a weekly basis. On average, the sportsbooks turn a big profit over the betting public. Most people will have a negative end result by seasons' end, whether they care to admit it or not. Many people do not realize that there are ways you can "get an edge" on the house.

Nobody has given a real examination of the effect weather has on the results of an NFL game. Given that weather has a visible impact on the way a game is played, it is worth investigating to see if those changes in gameplay create a tangible impact on the results of the spread and the total. This paper examines the impact that certain weather types have on an NFL game's spread winner and total results.

Using data from the 2015-2019 regular season (2020 season not used due to other variances caused by the Coronavirus), this dataset shows every regular season game played in those years, the spread winner, the over/under result, and the weather that was occurring during each game. The weather data includes rain, wind, snow, temperature, and also various combinations of those weather types. There are also Precipitation, Wind, and Temperature variables. Precipitation includes any form of

precipitation (rain, snow). Wind includes any game that had wind involved in the weather forecast. Temperature includes any game where a temperature lower than 40 degrees was involved in the weather forecast. All of the spreads and totals that were used were set from the beginning of the week, not at kickoff. Lines set at the start of the week gives a more exact interpretation of what the sportsbooks think the number on a game should be. A line used from kickoff has been impacted by various factors in the market that include bets from the public. It is preferred to have the sportsbook's best guess on a game without it being moved by other influences.

Before beginning this study, it is important to create a hypothesis. I would hypothesize that adverse weather would lead to more underdogs covering and more totals going under. Adverse weather will make it harder for teams to score as the dynamics of the field and the actual football will be severely impacted. If a game were to go under, that would mean less points would be scored. In that circumstance, the points the underdog may be receiving in the spread are by default, more valuable. If less points are scored, then each individual point is worth more since they are harder to come by.

The results show that there is a significant "edge" to be had when wagering on an NFL games' total. There is no real "edge" when betting on an NFL games' spread. The biggest difference can be shown when a game has experienced precipitation. In that circumstance, NFL games went under the total at a 67.5% rate. That is over 2/3<sup>rd</sup> of the total sample of games where precipitation was present. Comparing that with games that had no adverse conditions, those games went under the total at only a 48% rate. That is roughly a 19% difference in games with precipitation and games with no adverse conditions. This result clearly shows that when there is any type of precipitation in an NFL game, scoring is lower.

To put a financial number on the success rate of betting games in adverse weather conditions. An experiment was conducted in which \$100 was wagered on each game that met the condition of having rain, wind, low temperatures, or a combination of them. It showed that a person who made those bets would have netted \$2,420 in profit. This experiment puts a dollar figure on the results of the study. A person would have made a significant profit if they were to have blindly bet games that had the above mentioned weather conditions.

## **2. Literature Review**

The impacts that weather has on the NFL betting market are significant. It can also be shown that weather has an effect on many other aspects in our society. The stock market can be massively

affected by different types of weather patterns. Weather has shown to impact human behavior and sentiment. There is a systematic impact on NYSE prices based on what type of weather may be occurring. It proves that the stock prices are affected by human psychology and also that security markets do not reflect reliable economic information (Saunders 1993). New York City cloud cover is significantly correlated with index returns (Saunders 1993). These results can lead to the conclusion that systemic changes in stock prices have not been fully justified by pertinent economic news. The weather in New York City has a significant correlation with index prices, proving that investor psychology influences stock prices (Saunders 1993). Another study found that not only does adverse weather have a negative impact on securities markets, but also that sunshine or “optimal” weather does not have a strong correlation to high prices in securities markets (Akhtari 2011). In total, extreme and intermediate weather changes in New York City are strongly correlated with the DJIA return (Akhtari 2011). This same phenomenon is not as prominent in other countries. For example, in Korea, weather’s effect on the Korean market was weakened (Seong-Min 2009). Overall market efficiency was considered a much stronger indicator of the price of the Korean market (Seong-Min 2009).

These effects in the stock market show how much weather can impact all aspects of life. One major part of humans’ daily lives is travel. Adverse weather conditions have been shown to effect travel time, especially with public transportation systems. In Shanghai, it was shown that travel time variability, buffer time, misery, and frequency of congestion increased by an average of 29%, 19%, 22%, and 63%, under adverse weather conditions (Tang 2020). More specifically, during peak hours, the travel time reliability is negatively influenced by a greater extent under adverse weather conditions (Tang 2020). Weather has a similar impact on airlines as well. Adverse weather conditions led to an increase in departure delay of up to 23 minutes depending on the weather type and intensity (Borsky 2019). Weather conditions that are not ideal makes life more challenging and stressful for people. As you can see, subpar weather makes it more difficult for people to get from point A to point B, both with on-ground transportation and when flying. This has massive effects on both peoples’ social and work life.

As shown in the study on weather’s effect on stock prices, human behavior patterns change with certain types of weather patterns. This can be shown through weather and its effect on consumer spending. It has been proven that negative weather patterns lead to lower consumer spending (Murray 2010). The opposite is also true but nearly to the same extent. While there is a casual effect on a consumer’s willingness to pay in the event of sunlight, the impact is not nearly as strong as when adverse weather conditions are present (Murray 2010). The conclusion reached was that only negative

weather had a real effect on consumer spending (Murray 2010). ). This provides further insight into the underlying psychological mechanism. As with stock prices, positive weather (sunlight, high temperature etc.) did not have a positive effect on stock prices. Only negative weather had a real effect on the stock prices. The same goes for consumer spending. This correlation between the two studies is worth noting and could give more insight to our own psychological tendencies. Lower consumer spending is also combined with higher individual productivity for people. Bad weather increases productivity by eliminating cognitive distractions resulting from good weather (Lee 2014). When weather is bad, workers focus more on their work than alternate outdoor activities (Lee 2014). This correlation is not good for our economy. In bad weather, workers are producing more but consumers are spending less. Under adverse weather conditions, the supply is much higher than the demand.

These studies on various aspects of life show that weather has a strong impact on humans and the decisions we make. The results show that positive weather does not have an actual positive impact on our decisions. For example, sunlight does not lead to higher stock prices or higher consumer spending, but negative weather leads to lower stock prices as well as less consumer spending. This could speak to an overall low propensity to take risk. We do not change our behavior when there are positive conditions but will severely alter our behavior when conditions are not ideal. If we were more willing to take risk, we would most likely see an equal positive reaction in stock prices and consumer spending when there is sunlight. In evaluating the NFL betting market, the edges that have been found will only work if a person were to abandon their psychological tendencies in the event of bad weather.

### **3. Data**

The data used in this study is the opening spreads and totals that were posted on the Monday at the beginning of the week. The decision to use the spreads and totals from the beginning of the week instead of what was being posted at kickoff was made because the opening line can be considered the house's best "estimate" to what the spread and total should be. Once we near kickoff, that number can be moved due to a variety of factors. It was thought that the best number to use was the house's purest number. That way, we can see exactly how they feel about a game with no other outside influence. The seasons that were used for the study was from 2015-2019. 2020 was not used due to the covid-19 rules and restrictions placed on both fans and players. It was best to leave the 2020 season out of the dataset. Weather data was compiled for all regular season games from the 2015-2019 seasons and the forecasts used were at the time of kickoff.

In this dataset, weather was broken down into many different categories. Table 1 represents how each type of weather was accounted for in the dataset. A -1 to 11 scale was used to represent each type of adverse weather condition, with -1 and 0 representing dome games and no adverse weather condition games, respectively. There are 1277 games in this sample. For the key, any level of precipitation (example: Light drizzle) is considered "Rain". Winds that exceed 10 miles per hour are considered "Wind". Temperature that is less than 40 degrees is considered "Temperature". If there is a combo of any of these three conditions, the key will consider it as one of the values between 5 and 11. If there are no adverse conditions, the key will consider it a 0 and if the game is played in a dome, it will be considered a -1. It was decided to break up outdoor games with no adverse conditions and dome games because there are still other variables that come into play when playing outside compared to indoors. A dome is a controlled environment played on a turf field with a set temperature. In an outdoor game, there are still other concerns that make the experience different. Those include but are not limited to field condition, minor gusts of wind, varying temperatures, etc.

**TABLE 1**

-1	0	1	2	3	4	5	6	7	8	9	10	11
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DOM E	No Adverse Conditio ns	Rai n	Sno w	Win d	Temperatu re	Rain + Tem p	Sno w + Tem p	Win d + Tem p	Rain + Win d + Tem p	Sno w + Win d + Tem p	Rain + Win d	Sno w + Win d
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Out of the 1277 sample of NFL regular season games, 248 of those games were played in a dome and received a -1. 737 games were played outdoors but had no adverse conditions. There were 49 games that were played in only rain, 2 games in just snow, 84 games in just wind (at least 10 mph), and 107 in just low temperatures (40 degrees or less). There were 15 games in the dataset that were played with rainy conditions as well as low temperatures, 5 games with snow and low temperatures, and 21 games with high winds and low temperatures. There were 2 games played where a combination of rain, wind, and low temperatures were present and there were also 2 games where a combination of snow, wind, and low temperatures were present. There were 5 games that had only rain and wind. 0 games met condition 11, which is weather that only showed snow and wind. Table 2 shows these results.

**TABLE 2**

WEATHER	SAMPLE	VALUE	% OF SAMPLE
DOME	248	-1	19.42%
No Adverse Weather	737	0	57.71%
RAIN	49	1	3.84%
SNOW	2	2	0.16%
WIND	84	3	6.58%

TEMP	107	4	8.38%
RAIN + TEMP	15	5	1.17%
SNOW + TEMP	5	6	0.39%
WIND + TEMP	21	7	1.64%
RAIN + WIND + TEMP	2	8	0.16%
SNOW + WIND + TEMP	2	9	0.16%
RAIN + WIND	5	10	0.39%
SNOW + WIND	0	11	0.00%
TOTAL SAMPLE	1277		

In this dataset, three dummy variables were created to further breakdown the statistics gathered from these regular season games. Those variables were Precipitation (Prec.), Wind, and Temperature (Temp.). Precipitation will read as a value of 1 if there was any level of precipitation during a game. Wind and temperature are not taken into consideration. If it rained or snowed, it will read as a game with precipitation regardless of what the wind and temperature was. The Wind variable would come back as a value of 1 if the game had high winds. It does not matter if there was precipitation or low temperatures. If wind was 10 mph or greater, then the variable will read as 1. The Temperature variable will read as a value of 1 if the temperature during a game was 40 degrees or less. The state of the wind or precipitation is irrelevant. If it was 40 degrees or less, temperature would read as 1. Table 3 shows how many games were shown to be played in precipitation, wind, or low temperatures.

**TABLE 3**

VARIABLE	SAMPLE
PRECIPITATION	80
WIND	84
TEMPERAURE	107

**4. Results**

After reviewing the data that was shown by the dummy variables, the more specific weather data was analyzed in order to generate some tangible results and conclusions. Table 4 shows the percentage of favorites and underdogs covering, as well as percentage of games going over or under the total. The sample size is broken into categories by the dataset key which is the -1 to 11 scale. Percentages and summary data are both presented in the table.

**TABLE 4**

WEATHER VALUE	SAMPLE	FAV	UND	PUSH	FAV %	UND %	O	U
-1	248	116	120	12	46.77%	48.39%	116	116
0	737	329	358	50	44.64%	48.58%	365	365
1	49	23	24	2	46.94%	48.98%	17	17
2	2	1	1	0	50.00%	50.00%	1	1
3	84	41	40	3	48.81%	47.62%	41	41
4	107	55	45	7	51.40%	42.06%	55	55
5	15	10	5	0	66.67%	33.33%	4	4
6	5	4	1	0	80.00%	20.00%	0	0
7	21	11	10	0	52.38%	47.62%	6	6
8	2	0	2	0	0.00%	100.00%	0	0
9	2	1	1	0	50.00%	50.00%	0	0
10	5	3	2	0	60.00%	40.00%	2	2
11	0	0	0	0	0.00%	0.00%	0	0



The data shows that the majority of the games (985 games) that were played either in a dome, or with no adverse conditions had no significant difference on whether a favorite or underdog covered, or whether and over or under hit. Using the percentages from this part of the dataset as a baseline to determine if there is any significant edge to be found when other types of adverse weather is present is how a potential betting advantage can be found. Games that were categorized as a 2, 6, 8, 9, 10, or 11 can be disregarded in the results due to the fact that the sample size for those weather values is too small. In analyzing this data, it is clear that the instances where weather had an impact on the result of the spread was when there was rain (value 1) present, or a combination of both rain and low temperatures (value 5). In conditions of only rain, the favorite covered at a 65.31% rate. When low temperatures were added, the rate went to 66.67%. The hypothesis made in the introduction was that there was an "edge" to be had when wagering on the underdog in a game with adverse weather conditions. This turned out to be not true. For most of the games in the sample, there was no real edge to be had. The only small edge was at value 5, which was only a 15 game sample. Being that 15 games out of the entire sample of adverse weather games is not very large, it is tough to make the assertion that there is even an advantage to be found in that. It is more likely that adverse weather does not play any significant role in the outcomes of a spread.

Adverse weather conditions had a significant impact on the results of the total. As mentioned above, rain had an impact on the total, leading to more games going under. When evaluating the impact of temperature, there is no statistical edge in games that experienced just low temperatures. Low temperatures only had an impact if it was combined with rain or wind. Temperature's impact was greater with wind present as opposed to rain. When it was just windy, the under hit at a 50% clip. But when wind was combined with low temperatures, the under hit 71.43% of the time. Temperature only increased the under rate by about 1.36% when it was present with rain. The results show that rain and wind have a strong impact on the results of a total in an NFL game. Temperature alone has no impact on the result, but when it is combined with rain or wind, the data shows that it makes an under result slightly more probable.

For this experiment, \$100 was wagered at -110 (the "vig") for each game that was a value of 1, 3, 5, or 7. The -110 means that for a bet made to win \$100, you must risk \$110. This is the standard "vig" on American sportsbooks. There were 169 total games that met the requirements of values 1, 3, 5, and 7. If a person were to wager \$100 the under in each of those games, they would have compiled a record of 99-68-2 and would have made a profit of \$2,420. \$100 is a pretty small bet on the spectrum of bets

placed, so if the number were five or ten times higher, a bettor would have made as much as \$24,000. The table below breaks down the bets and how much money each value would have netted a bettor.

**TABLE 5**

Value	Total	Over	Under	PUSH	Loss (O)	Win (U)	Total (+/-)
					*110	*100	
1	49	17	32	0	-\$1,870	\$3,200	\$1,330.00
3	84	41	42	1	-\$4,510	\$4,200	-\$310.00
5	15	4	10	1	-\$440	\$1,000	\$560.00
7	21	6	15	0	-\$660	\$1,500	\$840.00
TOTAL	169	68	99	2	-\$7,480	\$9,900	\$2,420

## 5. Discussion

Gambling is very popular in the United States. That popularity is only going to increase, as states have moved to legalize the activity. This action is going to eliminate some of the stigma associated with gambling and bring a wider net of consumers into the market. The NFL is the most popular sport to bet on in America. Millions and millions of wagers are placed on NFL games every season. Nonprofessional bettors lose most of the time. In this paper, I examine how the weather effects the outcome of both the spread and the total of an NFL regular season game. The goal is to try and find an edge that regular bettors could potentially exploit to make a profit against the house.

The results from this experiment show that there is an edge that could be used to turn a profit when betting on the NFL. There is evidence that the results of the total are impacted by adverse weather conditions, in particular, rain and wind. Temperature also seems to have an impact on the results, but that impact is only seen when it is combined with rain or wind present. From the 2015-2019 seasons, games that had only rain present hit the under side of the total at a 65.31% rate. When low temperatures were also present, the under hit at 66.67% rate. In theory, the spread of a game can be looked at as a coin flip. The number that is set for the total can be interpreted as there being a 50% chance of going under it, and a 50% chance of going over it. When rain is present, there is over a 15%

increase in the number of times the game's total goes under, providing an edge for bettors to potentially exploit. If a game has rain in the forecast, a bettor should be inclined to bet under the total.

This study also showed that the presence of wind also had an impact on the results of the total, but this result was very prevalent when it was combined with low temperatures. In 84 games with high winds, the under hit 50% of the time while the over hit at 48.81%. The remaining games pushed (the total score was the same as the set total). The impact was seen when the high winds were combined with the low temperatures. The under hit at a 71.43% clip when both adverse conditions were present.

There are many reasons why these adverse conditions lead to more games hitting the under on the total. Rain for example, makes it more difficult to grip a football. If the quarterback cannot get the proper grip on the ball, it will have a great impact on both his accuracy and the distance that he can throw the ball. The rain will also make the ball harder to catch for receivers. The rain makes the throw and catch process much more difficult, which can be a reason why less points are scored when rain is present. It also makes the field that is being played on much more slippery. This can also impact defenses as their footing and ability to move will also be impacted, but the same is true for the offense. When the slippery conditions are combined with more challenging throwing conditions, it can make scoring points for the offense much more difficult. These are two potential explanations as to why rain causes more unders to hit.

Wind and lower temperatures can also create difficulties for NFL offenses. Cold temperatures can create many issues for players. Muscles get tighter and that includes the hands of the quarterback and receivers. Cold temperatures can lead to similar types of difficulties as rain would. When these temperatures are combined with wind, it will have an impact on a quarterback's ability to throw. The ball will move in the air in unpredictable ways, which will make it more difficult for a quarterback and his pass catcher to connect on a pass. These types of conditions will have an affect on not only the ball but also how a team decides to play the game. Cold temperatures and winds make teams more inclined to run the football. This is because passing is now more unpredictable, and the "smash mouth" type of style is more strenuous for a defense to contend with when it is very cold out. These are potential reasons as to why wind and cold temperatures leads to unders hitting.

Further research must be done on human psychology and the general risk aversion most people operate with. In the stock market, prices dip when weather is adverse, but they do not rise to the same extent when conditions are ideal. This would indicate that activity declines in the adverse conditions but

does not swing the other way when conditions are ideal. The same can be said for consumer spending. Humans will spend less money under adverse weather conditions, however when the weather is optimal, humans willingness to spend money does not rise to the same extent. It levels off at a certain point. Why do humans lower their risk in adverse conditions, but do not heighten their level of risk under optimal conditions? That would be the question I would recommend further research on. In order to utilize the edge that my study found, a person needs to be willing to take on an element of risk. Based on how consumers react with both stocks and consumer spending, it would be likely that most bettors would not use this to their advantage. In ideal conditions (Rain/wind/low temp), there is a clear edge on the under hitting. The question is whether a person will take on heightened levels of risk and bet under on games that have those adverse conditions present.

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