Methodology

The data used is a compilation of battle logs taken from the Pokémon Showdown servers. Each battle log is stored as a .json file. The data spans across four months of the year 2015. The four months are March, June, September, and December. There are no lapses in the monthly compilations of the data, i.e. none of the daily data entries are empty. Overall, there were no dramatic overhauls done to Pokémon battling formats or the overall system for the data used in this study. However, some minor adjustments were made and such adjustments are publically documented.

Only ranked games are included in the dataset. Ranked battles are battles that count towards a players global ranking in Pokémon Showdown. For each battle, players stand to gain or lose ranking points depending on whether they win or lose the battle. A number of links redirect users to the host site of this game: Smogon University. This website offers a wide variety of resources, similar to those found at the Pokémon Showdown website. Most importantly the Smogon forums are a prominent site for discussion of Pokémon battling strategies.

Pokémon Battling Basics

The Pokémon battle starts with Pokémon being sent out. For the purposes of the data used, one Pokémon is sent out for each opponent, totalling two Pokémon being out at any given time. Following this, each Pokémon has 4 moves to choose from, along with the option to switch to a different Pokémon (when applicable). After both players make a decision, the moves are weighted for priority and speed to determine the order of play. If both players decide not to switch one Pokémon will attack the other, after which the next Pokémon will do the same if it has not fainted. After each move has been executed the turn ends and the process is repeated. When one of the Pokémon faints, the player whose Pokémon fainted will be prompted to select another Pokémon from the bench. The first player to lose all of their Pokémon loses the battle.

However, before the nitty gritty details are explained it is important to make a concession. The entirety of the Pokémon battling system- even that used in the data -is not included in this analysis. The number of cases that deviate from the rules detailed below are either not included in the competitive format, or are generally inconsequential to the scenarios and strategies considered in this study.

Battle Formats

The data used for this study include two different Pokémon battling formats. The two formats are known as Over Used and Random Battles, abbreviated as OU and Randbats respectively. Both formats have teams of six Pokémon and only allow one Pokémon to be out at any given time. While both battle formats are subsets of what are known as single battles, each has their own unique spin on the Pokémon battling format.

Random battles are the most frequently played format. In this format, neither player decides their initial team compositions. This means players cannot decide the species composing their team nor the move sets of each specie on their team. Instead, the Randbats format uses an algorithm to determine team compositions. It is important to note that there are restrictions to the Randbats format that center around team composition and move composition for specific Pokémon. This restricts teams to have six distinct Pokémon per team, while still allowing the same Pokémon and move sets to be found on opposing teams but not within one player's team.

By contrast the OU format includes team composition. By including team composition, players are able to decide what Pokémon to include on their team, the moves of each Pokémon, and other factors such as held items and abilities. However, there are still some restrictions placed on players. Specific species of Pokémon are barred from use, notably Pokémon classified as "Ubers" that include a large portion of legendary and mega-Pokémon. Additionally certain "hidden" abilities are restricted, limiting the possible Pokémon abilities a specific species may use for a given format.

Pokémon Types

Typeage is a unique characteristic to Pokémon battling. Currently there are 18 distinct types. These include normal, fire, water, electric, grass, ice, fighting, poison, ground, flying, psychic, bug, rock, ghost, dragon, dark, steel, and fairy. Both moves and Pokémon are given a type attribute, though moves are only one type. And While a move may only be one of the 18 types, a Pokémon can be at most two different types at once.

However, some of these combinations are not found in Pokémon. From the initially possible 171 Pokémon type combinations, 18 choose 2 plus 18 monotypes, there are actually only 133 types that a players may encounter or chose from (as 38 type combinations had not yet been used during 2015). It is also worth noting that some Pokémon are able to change type during a battle, but for the purposes of analysis these Pokémon will be considered after-the-fact.

The typeage of each Pokémon influence not only the potential weaknesses of each Pokémon, but also the amount of damage that type-specific moves are able to do. Each Pokémon has at least one and at most two types. If a Pokémon uses a damaging move whose type corresponds to type of the Pokémon that used it, that Pokémon gets a same type attack bonus, abbreviated as a "stab" bonus. This causes the move to do 50% more damage, potentially 100% if the Pokémon also has the ability Adaptability.

Pokémon Attributes

Generally, there are a number of factors that are specific to each Pokémon. Some of these factors are considered static, meaning that they do not and cannot change over the course of the battle. These types of factors are defined as "Fixed" attributes. However some factors -such as the stats of a Pokémon- that are fixed at the beginning of the battle *can* change over the course of a battle. There are also a number of factors that are able to generally change over the course of a battle. Such factors, by constrast, are defined as "Variable" attributes. The terminology is largely taken from Ho et al. for ease of translation and applicability. The attributes are detailed in the order given.

Pokémon Fixed Attributes

Fixed attributes include the typeage of a Pokémon, the four moves each specie Pokémon has, the item the Pokémon holds, the Pokémon's ability, the level of the Pokémon, and the Pokémon's baseline stats. However, there are exceptions to the rules for each of these attributes except for the level of the Pokémon. Every fixed attribute and its respective exception(s) will be considered in order.

First and foremost is the typeage of a Pokémon, detailed previously. However, one possible method for a Pokémon to change its type is specific to a Pokémon's ability. Both Protean and Color Change are abilities that are able to change a friendly Pokémon's typeage. The former ability changes the Pokémon Kecleon's type to that of the move that affected it, whereas the latter ability turns its type into the typeage of the move that just was just used by the Pokémon Greninja. These two abilities are specific to Kecleon and Greninja specifically. Furthermore, there are moves that able to make the opponents Pokémon into a water, grass, or ghost Pokémon -on top of their previous typeage- if they use the moves soak, forest's curse, and treat-or-treat respectively.

Each Pokémon's set moves are also fixed during a battle. The exception to this occurs when a Pokémon runs out of power points -denoted as PP- for all of its four moves, at which point it is only able to use the move struggle. Every move has a set limit to the number of times it can be used, though the number of times a move can be used varies across the set of moves. The struggle is real.

Pokémon are able to hold one item at the beginning of the match. Pokémon may also lose their held item either by being hit by the move Knock-off, which knocks the opponent's Pokémon's item off, or by using their held item. Held items are able to be consumed for a one-time effect. This scenario often includes the consumption of berries, which offer a variety of different effects to the Pokémon holding it. For example, if a Pokémon is given a status condition -a condition detailed in the following section- from an opposing Pokémon

while holding a Lum berry, the berry will be consumed and the Pokémon's status condition will be cured. This example highlights an important characteristic of some held-items: Some items may only be used once and are discarded after their initial use.

Similar to items, a Pokémon can only have one ability at a time. However, by contrast to a Pokémon's held item a Pokémon always has an ability. Nonetheless, Pokémon may have their ability swapped with another Pokémon's. This scenario only occurs a Pokémon makes physical contact with Yamask or Cofagrigus, at which point its ability is swapped with Mummy. Mummy will only change a physically-attacking Pokémon's ability; it has no other effect.

The level of a Pokémon varies between one and one-hundred. The higher the level, the better the baseline stats for a given Pokémon, specifically in comparison to lower levels of that given Pokémon. Baseline stats are divided into six categories. These categories include (baseline) health, attack, special attack, defense, special defense, and speed. There is further nuance with the inclusion of Pokémon natures and Individual Values, or IVs. These factors influence the base stats of each Pokémon. However due to the sheer number of trivial combinations of IV spreads and nature choices, these two factors will not be a pivotal aspect to the framework and analysis of Pokémon battling. Nonetheless, the votatility of these baseline stats will be considered as a variable attribute.

Pokémon Variable Attributes

Variable Attributes include boosts or reductions to a Pokémon's baseline stats, the status condition of the Pokémon, the volatile status of the Pokémon, the current health of the Pokémon, and whether the Pokémon is currently active.

The former-most attribute directly influences how effective an active Pokémon is able to be in battle. Pokémon are able to learn and use moves that can boost their own status or ones that reduce their opponents. However, these moves are only able to influence a Pokémon's attack, special attack, defense, special defense, or speed. For example, the move Swords Dance raises its users attack status so long as the Pokémon remains active. The move may be used multiple times, but is only effective until it boosts or lowers its target's baseline stat by 3 or 1/3 respectively.

Status conditions are composed of a variety of statuses. Pokémon that suffer a status condition are either burned, frozen, paralyzed, poisoned, badly poisoned, or have fallen asleep. A Pokémon can only suffer from one status condition at a time, although a Pokémon can suffer from multiple status conditions if it overcomes the first condition. Each of these statuses is distinct, though there are similarities between being poisoned or badly poisoned. A Pokémon that is just poisoned will take damage equal to 1/8th of its maximum HP at the end of each turn. By comparison a Pokémon that is badly poisoned takes n/16th of its maximum HP at the end of the nth turn the Pokémon has been badly poisoned. A Pokémon that is poison-type or steel-type is unable to be poisoned in any form, and if a Pokémon has the ability Poison Heal it is healed 1/8th of its maximum HP at the end of each turn.

Is a Pokémon is burned it takes 1/8th of its maximum HP in damage at the end of the turn. This has recently been changed to 1/16th of its maximum HP per turn, but this is just a passing point of note. Regardless of the amount of damage done to the burned Pokémon, the burned Pokémon's physical attacks do half damage. The exception to this rule is if the affected Pokémon has the ability Guts. A fire-type Pokémon cannot be burned.

In a similar vein to being burned, a paralyzed Pokémon has its speed reduced to 1/4th of its baseline speed. Furthermore, a Pokémon that is paralyzed has a 1/4 chance of not being able to move during its move. This event is referred to as being "fully paralyzed". Furthermore, electric-type Pokémon are unable to be paralyzed, and if a Pokémon has the ability Lightning Rod it's special attack is boosted by 1.5 its base level. Additionally, ground-type Pokémon cannot be paralyzed, just as they are not affected by electric-type moves.

A Pokémon that has fallen asleep is unable to use its moves except for the moves Snore and Sleep Talk. A Pokémon falls asleep for one to five turns. However, if a Pokémon purposely puts itself to sleep using the

move rest, it is asleep for exactly two turns. If a Pokémon has either of the abilities Vital Spirit or Insomnia it cannot be put to sleep.

Lastly, there is the status condition of being frozen. Similar to previous typed statuses, ice type Pokémon are immune to becoming frozen, as are Pokémon with the ability Magma Armor. There is no set number of turns that a Pokémon can be frozen, but if a frozen Pokémon is hit by fire-type moves or the move scald is thaws out and is no longer frozen.

Volative statuses are similar to status conditions, except that the volatile status will be negated by switching out the affected Pokémon, if applicable. Similar to status conditions, a Pokémon can only be affected by one volatile status at a time. Another important point to consider is that a Pokémon can suffer from both a volatile status *and* a status condition. That being said, the most common form of volatile status is confusion. A Pokémon is confused for one to four turns, during which time the confused Pokémon has a 50% chance to hurt itself instead of executing its move for the turn. A Pokémon may also be encored, meaning that it has to use the same move it just moved for 3 turns. Additionally a Pokémon may flinch if hit before executing its move for the turn.

Only currently active Pokémon are able to execute moves. Likewise, only active Pokémon may be damaged. Beyond this there is not anything else to detail in regards to the current health and activity of a Pokémon that is exclusive to variable attributes.

Environmental Variables

There are one class category to detail that is relevant to the analysis of Pokémon battling This category is the role of the environment in battling and is a central focus of the analysis of Pokémon battling. Though related to the different types of moves and abilities a Pokémon has, including both fixed and variable attributes, the environment is not specific to any one move, ability, or specie of Pokémon and as such must be highlighted separately from the previous attributions.

The most prominent environmental variables to consider are what are referred to as "set-up" moves. These moves include Stealth Rock, Spikes, Toxic Spikes, Sticky Web, Light Screen, and Reflect. The latter two are different from the rest of the set-up moves in that they only last five turns, eight is the user was holding Light Clay when the move was used. When these moves are employed, the active Pokémon's special defense and defense are raised by one stage -or is increased by 1.5- respectively between Light Screen and Reflect.

The former four set-up moves are a focal point of analysis and are in a category of moves known as entry hazard moves. These moves are of particular note because they can last for the entirety of a given battle. Once these moves are used, only certain moves or switches are able to eliminate them. Generally, using the move rapid spin or defog will eliminate the entry hazards, along with causing other effects. However, if a Pokémon uses defog both their and their opponents entry hazards will be eliminated, whereas rapid spin only eliminates entry hazards affecting the users team.

Both Stealth Rock and Sticky Web can only be active once during a battle -unless previous uses of either are eliminated by methods previously noted. However, each have dramatically different effects. Specific to the latter, Pokémon that enter the field after Sticky Web is employed have their speed lowered by one stage -or 2/3rd their baseline level. This only applied to grounded Pokémon however, or non-flying type Pokémon. By contrast, Stealth Rock will damage any Pokémon that enters the field after it is used. The amount of damage done to the Pokémon depends on the type effectiveness of rock-type moves, as Stealth Rock is a rock-type move. In ascending order, Stealth Rock will do 3.125%, 6.25%, 12.5%, 25%, and 50% of the affected Pokémon's maximum health for type effectivenesses of 0.25x, 0.5x, 1x, 2x, and 4x respectively.

Similar to Sticky Web, spikes only affect non-flying type Pokémon. However, spikes will inflict damage to Pokémon that switch in instead of afflicting them with a volatile or status condition. The amount of damage is dependent upon the number of layers of spikes active on the field. Spikes may be applied a maximum of three times. One layer of spikes will damage the opposing Pokémon by 1/8th of its maximum HP, while two layers will deal 1/6th, and three layers will do 1/4th of the opposing Pokémon's maximum health.

Lastly is toxic spikes that, just like spikes and sticky web, only affect grounded Pokémon. However, toxic spikes are able to be applied two times. The first layer of toxic spikes will poison opposing Pokémon that switch in, while two layers of toxic spikes will badly poison Pokémon that switch in (that is if the Pokémon that switches in is able to be poisoned). Just like most other entry hazards, toxic spikes only affects grounded Pokémon.

Model Specification

As Pokémon battles have only two outcomes, we may estimate the probability of winning using a standard probit model. Let Y denote the outcome of any battle for a given player. Y takes the value of 0 if the player loses the battle and 1 if the player wins. To address the question of whether any entry hazards positively impact a player's liklihood of winning, we develop a number of different binomial probit models. Beginning with whether a specific move was used by a player in a battle, let the ith move be denoted M_i. For models with entry hazards only, we have $i = 1, ..4$. But over all models tested $i = 1, ..., 9$ to include moves that are able to supplement or supplant entry hazards. Similarly, we denote the jth Pokémon as P_j, where $j = 1, ..., 415$. Furthermore, there are 39 different Mega-Pokémon that are usable in the OU format, so we denote the usage of the kth Mega-Pokémon as Mp_k. In later model specifications, specific moves will be interacted with Pokémon selections. As an example, the specification of the model for the move stealth rock would include the full roster of moves and Pokémon, or $\sum_{i=1}^{9} M_i + \sum_{j=1}^{415} P_j$ along with an interaction of each Pokémon that can potentially learn that move with the count of stealth rocks for that battle. The lth Pokémon that can learn Stealth Rock is denoted stP_l. Similar notation is used for other move-specific Pokémon subsets.

Letting ϵ denote the error term, we begin with the simplified model. This model only includes whether a specific move was used. We have:

$$(1): Y = \alpha + \sum_{i=1}^{9} M_i + \epsilon$$

However, the repeated use of a move can lead to additional benefits. It is possible that the repeated use of a move has a lower marginal impact on a player's win liklihood. To test this hypothesis, we expand the initial model to include squared terms for each move. Thus we have:

$$(2): Y = \alpha + \sum_{i=1}^{9} M_i + \sum_{i=1}^{9} M_i^2 + \epsilon$$

These models have not yet included the vast variety of species composing teams. However, before examining the interactions between a team's composition of Pokémon and specific moves, there needs to be a formal model of just the marginal impact of a single Pokémon on a team. Respective to the indexing outlined previously, we have:

$$(3): Y = \alpha + \sum_{j=1}^{415} P_j + \epsilon$$

Thirty eight different Pokémon can turn into Mega-Pokémon however. To test whether a Pokémon negatively or positively impacts the marginal probability of winning, the next model specification includes Mega-Pokémon within the roster of competitive Pokémon.

$$(4): Y = \alpha + \sum_{j=1}^{415} P_j + \sum_{k=1}^{39} Mp_k + \epsilon$$

The next specification is the combination of models (1) and (4). Then, the last specification includes the interaction of having a specific Pokémon with the use of the move stealth rock. Respectively, the models are given by:

$$(5): Y = \alpha + \sum_{i=1}^{9} M_i + \sum_{j=1}^{415} P_j + \sum_{k=1}^{39} Mp_k + \epsilon$$

$$(6): Y = \alpha + \sum_{i=1}^{9} M_i + \sum_{j=1}^{415} P_j + \sum_{l=1}^{93} (M_1) * (stP_l) + \sum_{k=1}^{39} Mp_k + \epsilon(6)$$

After these six model specifications, the combination of all six models will be given to cross-check results and check for potential robustness for move and Pokémon combinations. The inclusion of interactions may be particularly key in identifying outlying results.