**Predictive Modeling for PGA DraftKings Contests**

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**Abstract**

The daily fantasy sports and sports betting industries are growing rapidly. Daily fantasy golf is no exception. DraftKings, the most popular daily fantasy site, awards millions in prize money each week for PGA Tour daily fantasy contests. This paper develops a framework to be successful in these contests. Building off prior golf and daily fantasy research a simulation model is developed to predict the performance of golfers in an upcoming tournament. Using summary statistics from the simulation model, optimal DraftKings lineups are constructed based on the rules of constructing a lineup. These lineups were entered into two types of contests offered by DraftKings, guaranteed prize pool tournaments and double ups. The optimal lineups performed poorly in the double up contests but outperformed the competition in guaranteed prize pool tournaments. One model/optimal lineup combination generated a return on investment over 300% and several others had ROIs over 100%. The models also significantly outperformed optimal lineups that were constructed using Vegas odds for golfers prior to the tournament. The results of this research validated prior research that supported daily fantasy as a game of skill. The code used to get the data, build the models, and construct the lineups is all available online.

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Introduction

Background

The Fantasy sports and sports betting industries are growing rapidly. Nielsen (2018) reported that “Fantasy sports participation in the U.S. increased from approximately 8.3 million in 2012 to 15.6 million in 2017”. Sports betting is legal in 18 states and playing fantasy sports on sites like DraftKings and Fanduel is legal across most of the United States. Professional sports, like the PGA are beginning to embrace the interest in fantasy sports and gambling. In 2019, DraftKings became the official daily fantasy sponsor of the PGA Tour (Beall, 2019). The PGA recently announced they will host a secondary broadcast of its tournaments geared toward the golf bettor (Orme-Claye, 2021). As the betting and fantasy sports industries grow there are financial opportunities for individuals who can accurately project outcomes of sporting events or player fantasy point totals.

This research focuses on modeling fantasy outcomes for professional golfers in PGA Tour events specifically on the daily fantasy site DraftKings. DraftKings is a daily fantasy sports site where users enter lineups into pay to play contests. Users can win cash prizes in these contests based on the performance of the lineups they enter.

For DraftKings PGA contests, a user selects 6 golfers for a lineup. Each golfer has an individual salary that typically ranges from $6,000 to $12,000. The maximum salary cap for a lineup is $50,000. Golfers earn fantasy points based on their scores on individual holes, tournament finishing position, and additional scoring bonuses. Golf fantasy scoring is unique in that there are less statistical categories that earn a player points, but points are given for the outcome of the event. Compare this to a sport like fantasy basketball where players earn points for scoring, rebounding, assists, blocks, steals but nothing if the players team wins the game.

Another unique aspect of fantasy golf is that the number of opportunities a golfer will get to score will either be 36 or 72. In a standard stroke play event, golfers who make the cut will play 72 holes. Those who miss the cut will play 36. This difference in opportunities makes the range of outcomes for golfers extremely wide.This is true for even the game’s best players. Dustin Johnson was the PGA Tour player of the year in 2020. During the 2020 season Johnson’s DraftKings fantasy point totals ranged from 16.5 to 172.

This range is much wider than the 2020 MVPs in the three most popular American sports. NFL MVP Aaron Rodgers’ totals ranged from 5.8 to 33.76, NBA MVP Giannis Antetokounmpo’s from 25.5 to 83.5, and MLB AL MVP Jose Abreu’s from 0 to 52. The difference in these ranges compared to golf can be attributed to the amount and range of opportunities. A quarterback in the NFL is unlikely to have 72 opportunities to throw the ball or throw 36 more times than his opponents. Most basketball players will not come close to even touching the ball 72 times and baseball players are likely to only see 3-5 at bats per game.

Fantasy golf also presents less opportunity to recover from a poor performance within a fantasy lineup compared to the other three sports. Where in golf there are six available roster sports, NFL consists of nine, NBA has eight, and MLB has 10. These additional roster spots allow for more opportunities to recover from poor performances and increased opportunities for users to differentiate their lineups. The concept of differentiation as a DraftKings strategy will be touched on in the model results section of this paper.

An additional challenge for modeling golfer performance is not all courses are created equally. For example, a local county course is likely to play a lot easier than Augusta National the site of one of the four golf majors known as the Masters. In 2020, a total of 36 PGA Tour events were played. The winning golfers DraftKings point totals in those events ranged from 94 to 172. It could be argued this is due to the quality of players playing in an event as player fields will vary from one event to another. In 2020, player of the year Dustin Johnson only played in 14 of the 36 PGA Tour events. While field strength plays a part in the distribution of winning fantasy point totals, course difficulty appears to be a more important factor. At the bottom range of winning players fantasy point totals is Jon Rahm’s 94 DraftKings points at the BMW Championship event. According to Data Golf’s (n.d.) field strength table, the BMW Championship was the second-best event field in terms of their average player quality metric. A large portion of the academic research reviewed for this paper notes the importance of controlling for course difficulty when analyzing the performance of professional golfers.

Research Intent

Success in daily fantasy sports involves a combination of accurately projecting player outcomes, constructing lineups, game theory, and bankroll management. This research tackles the first two parts of this equation. The first part of this research takes a probabilistic modeling approach to project fantasy point totals for professional golfers playing in PGA Tour events. From these models, optimal lineups are generated and evaluated in terms of return on investment (ROI) in actual DraftKings contests.

Challenges

This research presents several challenges. This first challenge is understanding the problem and developing a general framework to solve the problem. Reviewing past research involving fantasy sports, professional golf, and sports analytics is important to overcoming these challenges. An extensive literature review was completed for this research. Several concepts and ideas from this review contributed to the framework used to develop the final projection model. For example, prior golf research has emphasized the randomness within professional golf, particularly when it comes to a single tournament. Having this understanding can help with what modeling techniques to use and how model results can be measured.

Once a framework is established, data needs are addressed. Is the data needed for the intended approach accessible? Where and how can it be accessed? Accessing the necessary data for this research involved developing several scripts to scrape data and call APIs from multiple sources. Using data from multiple sources, it was important to ensure the data was cleaned and organized. The data collection, cleaning, and organization is addressed in detail in chapter 3.

In the modeling portion of the research several challenges needed to be addressed. There is a time series aspect to modeling and predicting professional golf tournaments. When training models it is important to make sure data being used for training does not include data from the tournament being predicted or data from future tournaments. Addressing this challenge ensures data leakage is not occurring.

The time series aspect also presents the need to continuously update and retrain the model with data from the most recent completed tournament. A players most recent form has been found to be a contributing indicator of future performance (Data Golf, 2021). Not updating the models to include this data could hinder model performance.

The last big challenge to be addressed is determining how to measure and communicate results. Given the wide range of outcomes players can have for a single tournament, traditional model measures may not be appropriate. This challenge is addressed by looking at probabilistic forecasts and comparing models based on ROI to help see where the models succeed and where they fail.

Modeling Approach

The final model approach involves a combination of regression, clustering, and simulation. A fixed-effects regression model is used to address the issues of difficulty from one hole to another. This technique has been used widely in prior research at the course/round level. After the difficulty of each hole is established, the holes are clustered into different categories based on difficulty of hole. A K-means clustering algorithm is used to establish the difficulty levels.

Once the holes are clustered into different categories, random sampling simulation is used to generate predictions for an upcoming tournament. A player’s prior scores are randomly sampled from the different hole categories established by the clustering algorithm. The distribution of how many samples to take from each category is determined by how easy or difficult a course has played in the past. The simulation is run thousands of times for each player in the upcoming tournament to establish the players range of possible outcomes.

Multiple models are developed using the described approaches. These models provide summary metrics for each player in each tournament. Optimal DraftKings lineups are generated based off the summary statistics. The models are evaluated based on how the optimal lineups would have performed in past DraftKings contests.

Organization of Study

The remainder of this paper will be organized into four parts. Chapter 2 will be an extensive literature review. Literature related to the skill aspect of daily fantasy sports, projecting daily fantasy performance, professional golf, and general sports analytics is reviewed. Chapter 3 breaks down the data and modeling methodologies that are used. Chapter 4 evaluates and compares the results of each model. Model ROI’s and DraftKings finish probabilities will be used to evaluate model performance. The models are also compared against a model that builds lineups using strictly Vegas odds. Multiple models are used to predict individual golfers fantasy performance for events played during the 2019 PGA season. While data was collected for the 2020 season, the 2020 season had its challenges due to COVID-19. The expectation is modeling on 2019 and prior season data will provide a more stable baseline for forecasting future seasons. Chapter 5 will end the paper with some final thoughts on the modeling performance, areas for improvement, and recommendations for future work.

Literature Review

Daily Fantasy Sports as a Game of Skill

The emergence of daily fantasy sports has spurred a back-and-forth debate on whether daily fantasy sports are games of chance and should be classified as gambling vs. a game of skill. In 2020, the IRS ruled that participation in daily fantasy contest is gambling and not a game of skill (Shriber, 2020). Various research studies have been completed suggesting otherwise. In a study completed by Easton and Newell (2019), randomly selected lineups were entered into 35 DraftKings Major League Baseball double up contests. A total of 0 lineups returned a profit. The authors state that if daily fantasy sports is indeed a game of chance, the odds of all 35 lineups losing is 1 in 312,681,518. Easton and Newell do acknowledge that randomness does play a part in determining winners of daily fantasy contests. The problem they have found is that the randomness of outcomes has been mistaken by others for the gambling definition of chance. The authors concluded that daily fantasy contests are not games of chance and encouraged lawmakers to make use of their research.

Getty et al. (2018) ran a series of statistical tests to determine if daily fantasy contests are games involving skill. The authors obtained anonymized user contest data from the daily fantasy site FanDuel across the four major American sports: MLB, NBA, NFL, and NHL. The tests included comparing win/loss records among users, comparing expected outcomes from users who play a lot to those that play a little, and comparing the FanDuel user results against randomly generated fantasy teams. The results of the tests solidified that skill plays a role in the outcome daily fantasy competitions. In an interview with one of the authors, Anette “Peko” Hosoi, Hosoi states, “In our analysis, the signal for skill in the data is very clear” (Chu, 2018).

Focusing strictly on daily fantasy basketball contests, Evans et al. (2018) also found evidence of skill and strategy in daily fantasy contests. The authors analyzed DraftKings daily fantasy basketball contests and found that winning players do implement different strategies than losing players. An interesting trend found for winning players was they tend to select more rookies and international players than losing players. This intuitively makes sense. It is likely losing players are more likely to select players they have heard of before, where winning players are conducting more research on lesser-known players like rookies and players from other countries. Like the other studies the research concluded that daily fantasy sports are games of skill. The research supporting daily fantasy sports as a game of skill provides evidence that building and using player projection models can lead to success in daily fantasy sports.

Daily Fantasy Sports Player Prediction Research

There has not been an overwhelming amount of research into projecting players daily fantasy point totals. This should not come as a surprise. While the origin of fantasy sports dates to 1962, daily fantasy sports did not get its start until 2006 (Newman, 2017).

Focusing on professional basketball, South et al. (2019) used a combination of Bayesian and lasso regression to build NBA daily fantasy projections. An interesting portion of this research was the authors adjustment for strength of opponent. This was done by comparing a player’s performance against a specific opponent to the players previous 10 game weighted average. Similar adjustments are needed when modeling professional golfer performance. The research also generated optimal lineups based on the player projections. Using a hypothetical simulation to measure performance, the modeling and lineup generation process turned a $500 investment into a $9000 profit. While the authors note the issues surrounding the simulation to measure performance, the research provides a good baseline for NBA daily fantasy player projection and lineup building.

Beal et al. (2020) used a combination of machine learning techniques with time-series features to predict fantasy point totals for NFL players. For each specific position, a players prior week’s fantasy point totals were used to predict there upcoming weeks fantasy point total. This modeling approach built upon and outperformed previous research done by Sugar and Swenson (2015). Beal et al. (2020) also used mixed-integer-programming optimization algorithm to generate optimal lineups. The results of the optimal lineups were compared against a target score to determine if a lineup would return a profit. Over a season of data, the lineups returned a profit 81% of the time when compared to the target score.

The only research found focusing specifically on daily fantasy golf was done by O’Malley (2018). O’Malley developed a new projection model each week that was specific to the tournament being played. The idea behind this method is that different tournaments will present different challenges to players. One tournament may reward players who drive the ball far, while another may favor driving accuracy. The models were built using a variety of statistical categories, a player’s course history, recent form, and potential weather variables. The research did conclude different courses favor different types of players. The results of this modeling approach yielded a profit on DraftKings, but the sample size was too small to conclude the results were significant.

Professional Golf Research

Connolly and Rendleman (2008) evaluated the roles of skill, luck, and streaky play for 253 PGA Tour golfers from 1998 to 2001. They found strong evidence that player skill levels change over time, luck plays a factor in winning tournaments, and little evidence of streaky play. A random-effects model involving smoothing splines, round-course effects, and player-course effects was used to measure skill and luck for each player in the sample. A significant finding from the model was the importance of adjusting scores based on the course and round it was played. For example, a player shooting a 67 in round 1 on Course A should not be treated the same as a player shooting a 67 in round 1 on Course B.

Broadie and Rendleman (2012) also identified the importance of adjusting scores for the level of competition and course difficulty in their paper “Are the Official World Golf Rankings Biased?”. The Official World Golf Rankings (OWGR) ranks professional golfer on a single scale. The OWGR is often criticized as a system that can be gamed. Meaning players will target weak field events on less competitive tours to improve their ranking in the system. Broadie and Rendleman compared the OWGR against their own methodology which they call score-based skill estimation (SBSE) to identify if the OWGR was in fact biased towards certain tours.

The SBSE system is comparable to the approach taken by Connolly and Rendleman (2008). The model considers course difficulty and level of competition to assign a player a mean score. The mean score represents the average score a player is expected to shoot on a “neutral” course. The model does not consider tour and is an unbiased approach to comparing players on a single scale. When comparing the two systems they found a large and statistically significant bias in the OWGR against players who primarily play on the PGA Tour. The OWGR was also compared to a proprietary ranking system known as the Sagarin Rankings, which also does not take tour into account. This comparison also resulted in a statistically significant bias against PGA Tour golfers.

Sen (2012) attempted to come up with a single metric that best explains success on the PGA Tour. He developed a metric called the Key Criterion of Success (KCS). The metric was a blend of different player statistics that measures a player’s overall performance. KCS was then compared to two other popular measures of success, earnings averaged per event and adjusted scoring average. Running an OLS regression for each PGA Tour season from 2004-2006, Sen found that KCS could explain 66% - 75% of the variance in adjusted scoring average and 48% - 61% of the variance in earnings averaged per event.

The KCS metric is limited by the statistics it uses not being adjusted for course or field strength. For example, one of the statistics used in KCS is a player’s average greens in regulation (GIR). GIR is defined as a player’s ball reaching the putting surface while the number of strokes taken is two fewer than par. If a player is playing a par 4, the ball would need be on the putting surface after stroke 2.A player playing on courses where a high GIR is tougher to achieve will be penalized more than a player playing on courses where GIR is easier to achieve. Sen acknowledges these limitations and notes them as future areas for improvement.

Golf is often viewed as a sport with more randomness and variation. Examples of this were given in the introduction of this paper. Shmanske (2007) explores this idea in his paper “Consistency or Heroics: Skewness, Performance, and Earnings on the PGA Tour. He compares adjusted scoring average, the variance in adjusted scoring average, and the skewness in adjusted scoring average to player earnings on the PGA Tour for the 2002 season. He found that adjusted scoring average can significantly explain yearlong earnings on tour but is not a strong predictor of individual tournament success. The variance and skewness were not great predictors of success for either. Shmanske’s concludes his paper with lots of interesting questions pertaining to the relationship between different skill sets and variation in scores. For example, it is likely that driving distance is a more stable stat round over round then putts per green in regulation. It could then be hypothesized that a wider putting distribution would lead to more variation in a player’s score compared to driving distance.

Golf blog websites DataGolf.com and Tournumbers.com have also done analysis on the impact of randomness in professional golf. Data Golf’s (2019) blog post titled *Golf is Really, Really Random*, does a statistical deep dive examining how easy it is for to be fooled by the randomness of a professional golfers score. Tournumbers (2019) blog post *Just How Random and Volatile is Pro Golf*, found that in PGA tournaments played from 2015-2018 over 18% of tournament winners were cut from the most recent prior event that they had played.

A popular topic when discussing performance on the PGA Tour is a player’s recent form. It is common for golf pundits to refer to a player as in form or out of form. In form meaning the player has recently played well, out of form meaning the player has been playing poorly. McHale and Forrest (2005) researched how much recent form contributes to players results in their next tournament. A logistic regression model was used to predict player performance in a single tournament. The model used a combination of predictors that accounted for players skill over the long term and how the player has performed more recently. They found a player’s performance over his last six events has a strong impact on a player’s performance in his next event.

Using different machine learning approaches and PGA Tour ShotLink data, Wiseman (2016) tried to predict the winning score of PGA Tour events. Wiseman specifically used ShotLink data from round 1 of a tournament to try and predict the winning score at the conclusion of the tournament. “ShotLink is a platform for collecting data on every shot hit by every player on the PGA Tour in real-time” (Wiseman, 2016). It should be noted this data is no longer freely available. The motivation for this research was the proposal of a new bet sports books could offer consumers. A Bayesian regression model yielded the best results. On 27 out-of-sample tournaments the model correctly predicted the exact winning score for 22% or the events. This research could be useful in predicting player performances for upcoming tournaments. By identifying the scoring conditions of a particular tournament, questions of player performance can be asked. Do certain players play better on difficult courses and vice versa?

Additional Sports Analytics Research

While analytics has been deeply rooted in baseball culture, American football has perhaps seen the biggest analytics rise in recent years. Two hot-box topics in American football involve fourth down strategy and the benefits of passing the ball vs. running the ball. Elmore et al. (2021) developed an R software package, NFLSimulatoR, to help answer these questions. Using random sampling of plays from prior seasons that fit certain criteria, optimal strategies for things like fourth down decisions and run/pass distributions can be determined. In chapter 4 of this paper, a similar simulation approach is taken to predict the performance of golfers in PGA tournaments.

Data and Modeling Methodology

Data Overview

Data was collected from espn.com and europeantour.com for all stroke play events from the 2016 through 2020 professional golf seasons. PGA Tour and Korn Ferry Tour (previously Web.com Tour) data was gathered from espn.com. European Tour and Challenge Tour data was gathered from europeantour.com. The data includes:

* Each participant’s score on every hole the participant played in an event.
* Each participant’s overall round score for every round the participant completed in an event.
* Each participant’s tournament averages for different statistical categories including driving distance, driving accuracy, greens in regulation, and putts per green in regulation.

In total 4,725,074 individual hole scores, 256,186 round scores, and 64,325 tournament averages for statistical categories were collected. It should be noted only 6% of the tournaments on the Challenge Tour had statistical category data available on europeantour.com. Given the limited statistical data available for the Challenge Tour it was not collected.

***Data Collection Process***

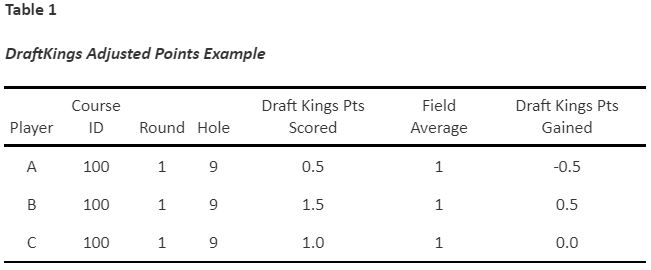
The data was collected using a combination of R packages. The “rvest” package (Wickman, 2020) was used for any web scraping that needed to be completed. The “jsonlite” package (Ooms et al., 2020) was used to call API’s. The “furrr” package (Vaughan & Dancho, 2021) utilized parallel processing to significantly speed up the data collection process.

The process for collecting data followed roughly the same structure for each site. First, gather the tournaments played in each season for each tour. Second, get the tournament id for each respective tournament. Third, get player ids for players playing in each tournament. Last, call APIs for each tournament id/player id combination. Functions were built for each step and wrapped inside functions from the “furrr” package. This was significantly useful for the API calls. By calling the APIs in parallel, the time to collect the data was greatly reduced.

***Data Wrangling and Pre-Processing***

After the data was collected it was wrangled into a three different data frames. One consisting of the individual hole scores, one consisting of individual round scores, and one consisting of the individual statistical categories.

Potentially useful features were also added. For example, the average DraftKings points scored for every hole in the dataset was calculated. That average is compared to all individuals who played the hole to determine how many DraftKings points the individual gained or lost to the field on that hole. Table 1 illustrates a simplified example of this. Similar features were added including strokes gained per hole, strokes gained per round, and driving distance over field average.



The data was then examined for missing data and errors. Other than statistical data from the Challenge Tour, the datasets were not missing many values. A small portion of date variables were missing from the data collected from espn.com. After evaluating the missing data, it was discovered these players had withdrawn from the tournament prior to playing the round of golf. This data was left in the dataset for reference but will be filtered out during any analysis or modeling.

Next, each of the three data frames were checked for duplicate data. For example, each player should only play a specific hole once per 18-hole round. Some discrepancies that came through were due to tournaments going to a playoff. In these situations, it is possible for a player to play a hole more than once. Both espn.com and europeantour.com typically indicated a playoff hole with a round indicator of “5” (professional golf tournaments are normally four rounds). Playoff holes that were not indicated as round “5” were corrected. The rounds and stats datasets followed a similar data correction process. Once the datasets were pre-processed, they were loaded as 3 tables (“holes\_tbl”, “rounds\_tbl”, “stats\_tbl”) into a locally stored PostgreSQL database.

***Additional Data Challenges***

Combining data from multiple sources brought some challenges. The biggest challenge was figuring out how to handle different spellings of player names between sites. For example, one of golf’s most popular players, who can easily be identified by his first name Rory, went as “Rory McIlroy” on espn.com and “Rory Mcilroy” from europeantour.com. Correcting the names was largely a manual process. Any name differences were corrected so the name coming from europeantour.com would match the name of the player on espn.com. Moving forward if the database gets updated with new tournament data a script was written to check for player names currently not in the database. This will make it easier to check if a similar name is in the database that is potentially the same player being added.

The player stats data also had its issues. Some observations for categories such as driving distance were returning 0. It is highly unlikely that a professional golfer is averaging 0 yards per drive throughout a golf tournament. These 0 values have the potential to cause problems down the line when things like averages for statistical categories are being calculated. To solve the issue the values were changed to missing/NULL in the database. Functions were added to correct these issues during the data collection process when any future data is added to the database.

Overview of the Modeling Methodology

Past research into professional golf emphasizes a few key factors: the randomness involved in professional golf, the importance of adjusting players scores based on competition and course difficulty, and the impact of a player’s recent form. Multiple simulation models were developed to explore the impact each of these factors has on DraftKings fantasy performance in individual tournaments.

***Accounting for Randomness***

To account for the randomness factor, all models involve a random sampling simulation of a metric referred to as “DraftKings points gained”. This metric will be referred to as DKPG for the remainder of this paper. A basic example of how DKPG is calculated is explained in the Data Wrangling and Pre-Processing section. A single simulation for one player in one tournament takes 72 samples from a player’s prior DKPG scores over the past 365 days leading up to the tournament being predicted. The 72 samples are broken down into four separate simulations, one for each 18-hole round of golf.

For each simulation, a players first two 18-hole simulations of DKPG are added together. Once this has been completed for all players in the tournament the players are ranked first to last based on their DKPG total. The highest DKPG total would be ranked first, the lowest DKPG total is ranked last. Players with a rank lower than 70 are cut for that simulation, meaning they will receive a score of 0 DKPG for their last two 18-hole simulations. In reality, players are cut based on the total strokes they have over the course of the first two rounds. This model assumes DKPG, and total strokes are 100% correlated when determining which players to cut. Players who are not cut have there last two 18-hole simulation scores added to their first two. The result is a player’s total DKPG for that simulation.

Other simulation techniques were considered to capture randomness. One iteration randomly sampled the actual DraftKings points players scored on a hole. A benefit of this approach is that results of the models would predict actual DraftKings fantasy point totals for each tournament. This approach was experimented with, but the results were favoring players that had more holes played on easier courses. The more skilled players were being penalized for consistently competing on tougher courses.

A second approach that was considered was performing simulations based on the distributions of a players DKPG scores. For example, if a players DKPG scores were normally distributed the scores could be simulated using the mean and standard deviation of that distribution. The issue here was each golfer had a different DKPG distribution. For most players, the distribution was not normal. Using a standard simulation technique assumed similar distributions for all golfers in a tournament. Applying different simulation techniques based on a player’s distribution was not feasible when testing 24 golf tournaments containing roughly 120 – 150 golfers per tournament. Both approaches were bypassed for the random sampling of DKPG scores technique. The sampling of DKPG scores effectively captured the true skill level of a golfer and allowed for a uniform approach across all golfers.

***Adjusting Player Scores for Competition and Course Difficulty***

The review of prior literature emphasized the importance of adjusting player scores based on competition and difficulty of the course. A similar approach to how Connolly and Rendleman (2008) adjusted for a player’s total strokes over the course of a round are taken to adjust a player’s DKPG scores. Connolly and Rendleman set up an ordinary least square fixed effects regression to adjust a player’s score based on the average score the player has on a “neutral” course and the effect the course/round the player is playing. The regression equation looks like this:

Where *i* indexes the golfer and *j* indexes a tournament-round (or a round played on a specific course for multi-course tournaments),  is the raw score in a given tournament-round,  is some player-specific function of "golf time" (i.e. the sequence of rounds for a golfer), and  is the coefficient from a dummy variable for tournament-round *j* (Data Golf, 2018).

To adjust a player’s DKPG the following steps are taken. First, a player’s total DKPG for each round the player has played is calculated. Second, a unique identifier variable is created for each tournament/course/round interaction. After these variables are established the following regression equation is set up:

Where *i* indexes the golfer and *j* indexes a tournament/course/round. is the coefficient from a dummy variable for each player in the dataset. Players that played less than 25 rounds in the dataset were lumped into a general “other” category. is the coefficient from a dummy variable for each tournament/course/round combination that was played within the dataset and is the error term.

The goal of this regression is to tease out the effect each tournament/course/round interaction () has on a player’s total DKPG (TPG). Each coefficient estimate of TCR is divided by 18 to calculate the effect each TCR interaction has on a per hole basis (TCR/hole). In an ideal world a dummy variable would be created for each tournament/course/round/hole interaction to gain a more accurate estimate of the difficulty of a hole. The problem with this approach is it is very computationally intensive.

A player’s adjusted DKPG scores at the hole level can now be calculated by taking the raw DKPG score and subtracting them by the corresponding TCR/hole. The random simulations described earlier can now be run using a player’s adjusted DKPG scores.

***Projecting Course Difficulty***

Golf is unique in that the difficulty of a course will vary from week to week. To account for this varying difficulty, holes are classified into three categories: easy, medium, and hard. The classification process combines the regression technique used to adjust DKPG scores with the K-Means Clustering algorithm (Hartigan and Wong, 1979).

To start the regression is run three times. One for the 2016 season data, one for the 2017 season data, and one for the 2018 season data. The TCR/hole estimates from the regression are now used to adjust the field average DKPG scores for each hole. This is a change from earlier where individual player DKPG scores were being adjusted. Once the adjusted field DKPG scores are obtained all three seasons’ data is combined and run through the K-Means Clustering algorithm. The algorithm is only using the field average DKPG scores to classify holes into a particular cluster. A few iterations included other variables such as yardage length and par score of the hole. Results of these iteration either yielded similar clusters to using solely DKPG scores or results that were tough to classify when running the simulations. The K-means algorithm was run 9 different times each with a different number of clusters specified. It was found that clustering holes into more than three categories yielded insignificant differences between the clusters (Figure 1). The three-cluster grouping was a nice fit and allowed for holes to be easily classified into the categories of easy, medium, and hard.![Chart, line chart

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The results of the classification are used in two ways. First, it is used to project the difficulty of the course being played for an upcoming tournament. This is done by looking at the hole category distribution from tournaments played on the course in previous seasons. For example, the three previous times the Masters was played prior to the 2019 season the tournament averaged three easy holes, six medium difficulty holes, and ten hard holes. Since the distribution needs to add up to 18, one is subtracted from the medium difficulty holes. If the average distribution only adds up to 17, one is added to the medium difficulty category. Using this data, the 2019 Masters Tournament is projected to have three easy holes, five medium holes, and ten hard holes.

The second way the classification results are used is by categorizing a player’s holes that will be used in the simulations of an upcoming tournament. After the regression is run prior to simulating an upcoming tournament all holes being used within the simulation will be classified into one of the three categories. This can be done by looking at the adjusted field DKPG for each hole and comparing that value against the minimum and maximum value of the medium difficulty category. If the adjusted field DKPG is greater than maximum value it is classified as easy, if it is in between the minimum and maximum it is classified as medium, if it is lower than the minimum it is classified as hard.

With the adjusted DKPG scores calculated and the holes bucketed into three different categories, simulations can now be ran taking projected course difficulty into account. Using the 2019 Masters as an example, a single player simulation would have 12 scores sampled from the easy category, 20 from the medium category, and 40 from the hard category for a total of 72 holes.

***Accounting for Recent Form***

Research has shown that a player’s performance in their last six events is a significant indicator of how a player will perform in an upcoming tournament (McHale & Forrest 2005). To account for recent form within the simulations a player’s adjusted DKPG scores are multiplied by factors based on when the scores occurred. Adjusted DKPG scores that occurred in the six weeks leading up to the simulated tournament are multiplied by a factor of 1.60. Scores that occurred between six weeks and three months leading up to the tournament are multiplied by a factor of 1.30. The time frames chosen are based on the research of McHale and Forrest (2005). By using time periods of three months and six weeks it is likely a majority of player’s last six events are accounted for. A variety of factor weights between 1.25 and 2.00 were tested through small simulations. The different combinations yielded similar results when comparing simulated finish probabilities to actual finish probabilities. Given these results the weights of 1.60 and 1.30 were arbitrarily selected.

An issue with this approach is that a portion of simulations are not going to include samples of DKPG scores from the specified time periods. Running separate simulations to sample scores from these time periods was considered. Two issues led to this approach not being used. First, adding additional simulations significantly increased the time it took to run the simulations. Second, the number of scores to sample from got too small, particularly when accounting for course difficulty. For example, a player may only play 20 – 30 hard holes over a period of three months. A good or bad run in this small sample could overweight a golfers true skill level. Accounting for recent form is a difficult variable to weigh. This topic is discussed more in the conclusion of this paper.

***Running the Models***

A total of six models were run all using the random sampling simulation technique:

* The first model is a simulation of non-adjusted DKPG scores.
* The second model is a simulation of non-adjusted DKPG scores with the scores weighted for recent form.
* The third model runs the simulation on adjusted DKPG scores.
* The fourth model simulates adjusted DKPG scores with scores weighted for recent form.
* The fifth model simulates adjusted DKPG scores taking course difficulty into account.
* The final model simulates adjusted DKPG scores with scores weighted for recent form and takes course difficulty into account.

24 stroke-play tournaments involving a cut from the 2019 PGA Tour season were simulated. A stroke-play event is where the player who takes the fewest strokes throughout the tournament wins. Tournaments with a cut, trim the field down to the top 70 players in terms of fewest strokes after two rounds of play. The Masters tournament is an exception where the cut only includes the top 50 players.

Each model simulated all 24 tournaments 10000 times. Summary statistics were generated for each model, tournament, player combination. These summary statistics included the players average DKPG, the minimum DKPG a player had during the 10000 simulations, the maximum DKPG a player had during the 10000 simulations, the percentage of simulations a player finished in the top 20 for DKPG, and the percentage of simulations a player finished in the top 10 for DKPG. The summary statistics are used to generate optimal lineups for each model. These optimal lineups are used to evaluate model performance in terms of return on investment (ROI).

***Optimal Lineup Generation***

Optimal lineups were generated using the “ompr” package (Schumacher, 2020). To generate optimal lineups past salary data for each tournament was obtained from fantasylabs.com. Links can be found in Appendix A. Lineups entered in PGA DraftKings contests have two constraints. A lineup must consist of six unique players. The sum of those players’ salaries cannot exceed $50000. Four lineups were generated for each model/tournament combination. One based on maximizing average DKPG, a second based on maximizing minimum DKPG, a third based on maximizing maximum DKPG, and a fourth maximizing top 20 percentage for DKPG.

Model Evaluation and Results

Model Evaluation

The models were evaluated based on ROI performance and comparing predicted DKPG probabilities against actual DraftKings point total finishes. To evaluate ROI, each model generated four optimal lineups for each of the 24 tournaments. The lineups were evaluated based on how they performed in two popular types of contests that can be entered on DraftKings. The most popular contests are known as guaranteed prize pool contests (GPP’s). GPP’s feature top heavy payouts. The higher a lineup finishes in the standings the more prize money that lineup wins. The GPP used to evaluate the optimal lineup performances was a $12 single-entry GPP called the “Albatross”. This GPP is run consistently week to week for PGA tournaments. For this contest, a user can only enter one lineup into the GPP, compared to multi-entry GPP’s where users can enter more than one lineup. The number of entries into the “Albatross” ranged from 1000 - 10000 lineups where roughly 15-20% of lineups won a prize. Top prizes ranged from $1000 - $10000 and minimum prizes ranged from $18 - $25. The goal of GPP’s is to finish near the top and earn the high dollar prizes. Higher variance is awarded more than consistency.

The second type of contest the optimal lineups were evaluated on is known as a double-up. In this type of contest, a user enters a lineup and looks to double their buy-in. For example, the double up contest used to evaluate the optimal lineups is a $25 single-entry double up contest. In this contest when a lineup out performs approximately 55-57% of the other lineups in the contest that lineup earns a prize of $50. All lineups earn the same prize amount in these contests. The goal of double up’s is to generate lineups that consistently perform better than average.

Actual results from these contests were obtained from Rotogrinders.com results database. Actual DraftKings player point totals for the simulated tournaments were obtained from advancedsportsanalytics.com. Links to actual contest results and the player point totals can be found in Appendix A.

***ROI Results***

A total of 24 different model/optimal lineup combinations were hypothetically entered into each of the two types of contests discussed above for each of the 24 simulated tournaments. 7 of the 24 combinations yielded a positive ROI in the GPP contests, while none of the 24 yielded a positive ROI in the double up contests. This suggests the random sampling simulation modeling approach is highly variant and more suitable for GPP contests.

Though the double results were disappointing, the GPP results yielded some impressive results. The adjusted DKPG model that accounted for course difficulty lead the way with the lineup that was optimized based on average DKPG. This model/lineup combination generated an ROI of 308% over the course of the 24 tournaments that were simulated. Several other model/lineup combinations generated ROIs over 100%. Table 2 provides a summary of the top 7 model/lineup combinations in terms of ROI.

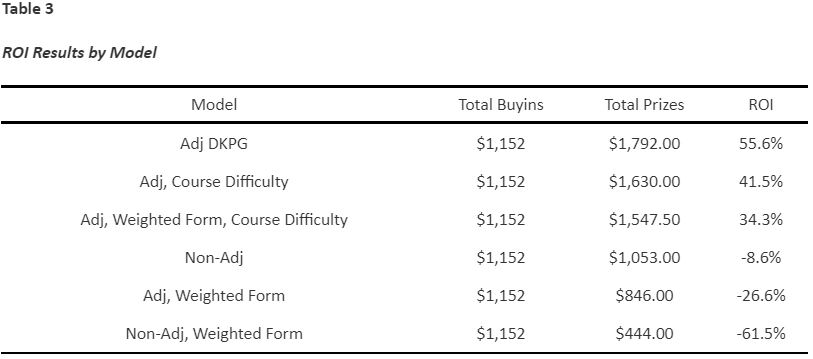
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These high returns are largely due to one or two high finishes over the course of the 24 contests. For example, the “Adj, Course Difficulty” model optimized on average DKPG took first place in the $12 GPP winning $1000 one week. While this does again emphasize the model’s inconsistency, it also emphasizes its upside. To have long-term success in GPP’s having a few high dollar finishes is more important than a high volume of low dollar cashes. An interesting takeaway was three of the top four model/lineup combinations in terms of ROI were a result of maximizing minimum DKPG. On the flip side, none of the lineups that were built around players maximum DKPG turned a profit. The sample size here is small but these results suggest that focusing on golfers with less downside is a way to maximize upside in DraftKings lineups.

Lineups generated from the adjusted DKPG models largely outperformed the non-adjusted DKPG models. Four of the bottom 5 model/lineup combinations in terms of ROI were from non-adjusted models and only one non-adjusted model lineup combo generated a positive ROI. These results reiterate the importance of adjusting player scores for competition and course being played. This does not come as a surprise given most golf research emphasizes this point.

The model that only considers the adjusted DKPG scores outperformed the other five models when taking an aggregate of all four lineups (Table 3). Figure 2 displays the adjusted DKPG models performance over the course of the 24 simulated tournaments. The model’s success was largely due to one exceptional performance for tournament #18 and a significant return for tournament #4. Colin Drew (2020), from dailyroto.com writes about the importance of having lineups finish in the top one percent in GPPs. These top one percent finishes are the reason the adjusted DKPG model lead the way in terms of ROI. Comparing the performance of the adjusted DKPG model to the adjusted, weighted form, and course difficulty model illustrates the importance having one extremely high performing week can have on ROI. Figure 3 shows the form/difficulty model having more consistency week over week, but the lack of an extremely high finish resulted in a lower ROI then the adjusted DKPG model. When comparing figure 2 and figure 3, it is important to take note of the y-axis scales of each figure.



![Chart

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generated](data:image/jpeg;base64,/9j/4AAQSkZJRgABAQEAeAB4AAD/4RD6RXhpZgAATU0AKgAAAAgABAE7AAIAAAAQAAAISodpAAQAAAABAAAIWpydAAEAAAAgAAAQ0uocAAcAAAgMAAAAPgAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAEphcnJvZCBQZWxrb2ZlcgAABZADAAIAAAAUAAAQqJAEAAIAAAAUAAAQvJKRAAIAAAADMzUAAJKSAAIAAAADMzUAAOocAAcAAAgMAAAInAAAAAAc6gAAAAgAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAAA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Sample size should not be overlooked when evaluating the ROI results. The 24-tournament sample being evaluated is relatively small. It is possible the positive ROI results were a result of being on the right side of variance. Multiple PGA seasons would need to be tested to gain a better understanding of the model’s true ROI. The ROI results do indicate that this type of modeling approach is more appropriate for GPP contests than double up contests.

***Comparing to a Model Using Vegas Odds***

In an ideal world, the models would be compared to other models developed specifically for projecting DraftKings fantasy points. Unfortunately, most of these models are behind subscription services and likely don’t provide projections for past tournaments. Historical Vegas odds data for 23 of the 24 tested PGA tournaments was obtained from Datagolf.com. While Vegas odds are not specifically built for daily fantasy purposes, they are a popular research tool among daily fantasy players. They are often used to identify value or sleeper picks by comparing the odds and salaries of players in the tournament (Chase, 2020). Using the historical odds data, the adjusted DKPG models can be compared against a sophisticated market. The data obtained were the closing top 20 odds from Bet365, a popular online sportsbook. Closing top 20 odds refer to the final odds the sportsbook offers on a player to top 20 prior to the tournament starting. Closing odds are generally thought to be the most correct/efficient lines.

Using the top 20 odds, optimal lineups were generated to maximize the top 20 odds for each of the 23 tournaments. These lineups were then hypothetically entered into the same double up and GPP contests as the adjusted DKPG optimal lineups. The results showed that the adjusted DKPG models significantly outperformed the Vegas odds model in GPP contests, and both failed to generate a positive ROI in double up contests. In GPP contests, the Vegas model only earned a cash prize in 2 of the 23 tournaments and generated a -67% ROI. Comparing the Vegas model to the 6 models developed in the study, all 6 models outperformed the Vegas odds model in terms of ROI.

***Model Finish Probabilities***

Daily fantasy games are continuously evolving. Access to optimizers and advanced statistics is becoming easier which is making the games more difficult to beat. This is where the idea of game theory comes into play. Using the projected probabilities from the simulation models can be a way to gain an edge on opponents in daily fantasy contests. Many fantasy strategy sites now offer ownership projections. These projections attempt to predict the percentage of lineups that contain a specific golfer. These are typically projected for GPP contests. Users can look to gain an edge on opponents by using the ownership projections in conjunction with the simulated probabilities. For example, let’s say Tiger Woods is projected to appear in 30% of lineups but model simulations predict Woods will only finish in the top 20 for DraftKings points 20% of the time. In this scenario, taking in underweight position on Woods in terms of the number of lineups a user enters him into relative to the field is a way for a user to gain an edge on opponents.

Figure 4 illustrates how accurately each model projected top 20 DraftKings finish probabilities for the 24 simulated tournaments. Ideally, the figures would display a 45-degree line connecting each point. The models involving adjusted DKPG values all display a linear trend close to this ideal state. The models adjusting for course difficulty and/or recent form do appear to improve the predicted probabilities. The non-adjusted DKPG models struggle at the higher end probabilities which again emphasizes the importance of using adjusted scores.![Chart, line chart

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The adjusted DKPG models accurate finish probability projections indicate the models can be used to gain an edge in daily fantasy contests. Understanding how often a player will perform at a high level relative to other users’ perceptions can create a big advantage when constructing GPP lineups.

Conclusion

Research and Model Conclusions

The intent of this research was to develop a model that accurately forecasted golfers DraftKings fantasy performances and use the model to generate successful DraftKings lineups in terms of ROI. Six random sampling simulation models were developed that mixed and matched regression and clustering techniques. The most successful models utilized the fixed-effects regression technique to adjust players past scores for the field and course being played. Given the emphasis on adjusting player scores found in past research this was not a surprise. While the adjustments for course difficulty and recent form did not improve model performance in terms of ROI, they did appear to improve player probability projections.

Over a course of 24 tournaments the models forecasted the top 20 probabilities of player finishes moderately accurately. Optimal lineups from three of the six models generated a positive ROI when applied to GPP contests. While the models were successful in these areas, they fell short when applied to double up contests. This indicates an inconsistency in the overall modeling approach. The models that generated positive ROI’s in GPP contests benefitted from 1 or 2 tournaments that yielded large returns. This is a formula for success in daily fantasy. It should be noted the models’ success over the 24 tested tournaments does not guarantee long term success. Use of the adjusted DKPG models in GPP’s should be paired with a solid bankroll management strategy to help handle the volatility of entering these types of contests.

Model Improvements and Future Work

It is difficult to assess the effect accounting for course difficulty and recent form had on the models. Neither of the adjustments improved the models in terms of ROI but both did appear to provide a more linear trend when comparing predicted vs. actual probabilities. Both adjustments made assumptions when back testing. The course difficulty adjustment assumed that a course would play the same as its average over the past three seasons. Further research may find that these averages are skewed by a year where the course played difficult due to weather conditions or easy based on a stronger field than normal. Looking at things such as previous weather conditions and using upcoming weather forecasts could improve the accuracy of how difficult or easy an upcoming tournament will play. The recent form weighting adjustment was largely arbitrary. While recent scores were adjusted there was no guarantee those recent scores would be sampled in a player’s simulation. A popular narrative in golf is that a player is trending in the right or wrong direction. The research of McHale and Forrest (2005) does support this narrative. The random sampling technique does not pick up on a how a player is trending based on performance in recent events. To account for recent form, a time-series modeling approach could be beneficial. A modeling approach that assesses each golfer individually could help pick up on trends that wouldn’t be captured in a random simulation.

Other future work to improve model performance could involve adjustments to account for course fit. Course fit adjustments could complement or replace course difficulty adjustments. These course fit adjustments could analyze courses using different statistical categories. For example, some courses may be better suited for players who drive the ball far while others may be more suited to players who are more accurate.

Final Thoughts

The random sampling modeling approach combined with the optimal lineup generation provided a straight forward framework that has the potential to be a profitable daily fantasy strategy. While a comparison to other fantasy models was not possible, the adjusted DKPG models significantly outperformed a model using Vegas odds. While this approach does not guarantee to be a profitable long-term strategy, the research can conclude that this approach can yield large returns when applied properly. These results support prior research that concluded daily fantasy involves aspects of skill and is not a game of chance.

All code from this research can be found in the GitHub link located in Appendix B.

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Appendix A

Actual DK Results

* 401056510, Sony Open, 1/10/2019 – 1/13/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-10/sport/golf/slate/5c377ac647efe743bb6db4cf/contest/5c3c6359b1699a43c0c272dc>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-10/sport/golf/slate/5c377ac647efe743bb6db4cf/contest/5c377e4f47efe743bb6dcfd5>
* 401056512, Farmers Insurance, 1/24/2019 – 1/27/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-24/sport/golf/slate/5bf78895305a4914aa46dc3a/contest/5c4edfb213de105761ab5cc6>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-24/sport/golf/slate/5bf78895305a4914aa46dc3a/contest/5c49f05f13de105761845dd0>
* 401056513, Waste Management, 1/31/2019 – 2/3/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-31/sport/golf/slate/5c530541d8e8c957f2fc3f74/contest/5c58e8fad8e8c957f28c8d40>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-01-31/sport/golf/slate/5c530541d8e8c957f2fc3f74/contest/5c530aa8e14fcc57edb7c66d>
* 401056515, Genesis Open, 2/14/2019 – 2/17/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-02-14/sport/golf/slate/5c657e7226d7e0094f834336/contest/5c6aa266c5f17e094ac14d1c>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-02-14/sport/golf/slate/5c657e7226d7e0094f834336/contest/5c657f1526d7e0094f846d70>
* 401056520, Honda Classic, 2/28/2019 – 3/3/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-02-28/sport/golf/slate/5c77ca9eb5ff6b6507311407/contest/5c7cfa39b5ff6b6507562805>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-02-28/sport/golf/slate/5c77ca9eb5ff6b6507311407/contest/5c77cb0bb5ff6b6507331aae>
* 401056521, Arnold Palmer Invitational, 3/7/2019 – 3/10/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-07/sport/golf/slate/5c8104c2b5ff6b6507735401/contest/5c862a6b3cbd17138e6d9d73>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-07/sport/golf/slate/5c8104c2b5ff6b6507735401/contest/5c81053fb5ff6b65077358e6>
* 401056522, Players Championship, 3/14/2019 – 3/17/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-14/sport/golf/slate/5c8a3e1db5ff6b6507c4f28a/contest/5c8f64726370650f57135f4c>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-14/sport/golf/slate/5c8a3e1db5ff6b6507c4f28a/contest/5c8a3f413cbd17138e929b30>
* 401056523, Valspar Championship, 3/21/2019 – 3/24/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-21/sport/golf/slate/5c939c5dc92a46205908210b/contest/5c998de594d552663ac53488>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-03-21/sport/golf/slate/5c939c5dc92a46205908210b/contest/5c939c65c92a46205908219e>
* 401056526, Valero Texas Open, 4/4/2019 – 4/7/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-04/sport/golf/slate/5ca5f72bcd96d266bf990316/contest/5cab1148c31adb60a63f0ce2>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-04/sport/golf/slate/5ca5f72bcd96d266bf990316/contest/5ca5f75bcd96d266bf991033>
* 401056527, Masters, 4/11/2019 – 4/14/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-11/sport/golf/slate/5caf353aea1a4f610c3b7273/contest/5cb76ab862b4df0fac123240>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-11/sport/golf/slate/5caf353aea1a4f610c3b7273/contest/5caf446fea1a4f610c487b6d>
* 401056528, RBC Heritage, 4/18/2019 – 4/21/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-18/sport/golf/slate/5cb87a55b10e762c96371ba1/contest/5cbe09fb4d966f2c9cf7886b>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-04-18/sport/golf/slate/5cb87a55b10e762c96371ba1/contest/5cbe09e7db640e2c919e3594>
* 401056550, Wells Fargo Championship, 5/2/2019 – 5/5/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-02/sport/golf/slate/5ccace8390fe696483cda81a/contest/5ccffc9068f594647db95128>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-02/sport/golf/slate/5ccace8390fe696483cda81a/contest/5ccace8790fe696483cda8b9>
* 401056551, AT&T Byron Nelson, 5/9/2019 – 5/12/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-09/sport/golf/slate/5cd4149fd6aee2647805346c/contest/5cd934309dd1b309a4e59575>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-09/sport/golf/slate/5cd4149fd6aee2647805346c/contest/5cd414a0d6aee2647805350b>
* 401056552, PGA Championship, 5/16/2019 – 5/19/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-16/sport/golf/slate/5cdd3fc434322b7a856018f2/contest/5cdd411234322b7a85613a84>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-16/sport/golf/slate/5cdd3fc434322b7a856018f2/contest/5cdd4064c6320a797bf27688>
* 401056553, Charles Schwab, 5/23/2019 – 5/26/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-23/sport/golf/slate/5ce68c898c3f9c6c6bd9ec01/contest/5ced725061feda37db4285aa>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-23/sport/golf/slate/5ce68c898c3f9c6c6bd9ec01/contest/5ce68c8b8c3f9c6c6bd9ec7d>
* 401056554, The Memorial Tournament, 5/30/2019 – 6/2/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-30/sport/golf/slate/5cefbd36684be46471a07fe6/contest/5cefbd43feb5dc637643357e>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-05-30/sport/golf/slate/5cefbd36684be46471a07fe6/contest/5cefbd38b24dc269002f21f9>
* 401056555, RBC Canadian Open, 6/6/2019 – 6/9/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-06/sport/golf/slate/5cf8f344a23f586ea15cf02f/contest/5cfe1740ef748c13c2266527>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-06/sport/golf/slate/5cf8f344a23f586ea15cf02f/contest/5cf8f3465018834ee1c86e46>
* 401056556, U.S. Open, 6/13/2019 – 6/16/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-13/sport/golf/slate/5d0254c66f64c02ff6cf12fe/contest/5d07a7441edd284bf17381d5>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-13/sport/golf/slate/5d0254c66f64c02ff6cf12fe/contest/5d07a73d1778404c09287252>
* 401056549, Travelers Championship, 6/20/2019 – 6/23/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-20/sport/golf/slate/5d0b6475640b3f223959e326/contest/5d0b64792ed26f2245af7d3a>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-06-20/sport/golf/slate/5d0b6475640b3f223959e326/contest/5d0b647de76e46223ff87ecd>
* 401056558, 3M Open, 7/4/2019 – 7/7/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-04/sport/golf/slate/5d1de907df3b6a192d6f727f/contest/5d273c9df3ae85727df944ac>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-04/sport/golf/slate/5d1de907df3b6a192d6f727f/contest/5d1de908df3b6a192d6f731f>
* 401056548, John Deere Classic, 7/11/2019 – 7/14/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-11/sport/golf/slate/5d2723390a6f054863f8d22a/contest/5d2e41927a21a563a3baf8ae>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-11/sport/golf/slate/5d2723390a6f054863f8d22a/contest/5d27233d1943d94903747787>
* 401056547, The Open Championship, 7/18/2019 – 7/21/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-18/sport/golf/slate/5d3006b37a21a563a3bf6049/contest/5d3006b77a21a563a3bf618c>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-07-18/sport/golf/slate/5d3006b37a21a563a3bf6049/contest/5d3006b61790bb63afbaa6dd>
* 401056545, Wyndham Championship, 8/1/2019 – 8/4/2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-08-01/sport/golf/slate/5d42c7472cd1667f1b415a49/contest/5d42c7482622557f5d48f40a>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-08-01/sport/golf/slate/5d42c7472cd1667f1b415a49/contest/5d42c7482cd1667f1b415ae6>
* 401056544, The Northern Trust, 8/8/2019 – 8/11-2019
  + $12 GPP
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-08-08/sport/golf/slate/5d4c041f8dcefc3f02e114c3/contest/5d4c042632a3463fcd53d711>
  + $25 Double Up
    - <https://rotogrinders.com/resultsdb/site/draftkings/date/2019-08-08/sport/golf/slate/5d4c041f8dcefc3f02e114c3/contest/5d4c042a32a3463fcd53eab1>

Player Point Totals

<https://www.advancedsportsanalytics.com/pga-raw-data>

Player DraftKings Salaries

* 401056510, Sony Open, 1/10/2019 – 1/13/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=01102019>
* 401056512, Farmers Insurance, 1/24/2019 – 1/27/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=01242019>
* 401056513, Waste Management, 1/31/2019 – 2/3/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=01312019>
* 401056515, Genesis Open, 2/14/2019 – 2/17/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=02142019>
* 401056520, Honda Classic, 2/28/2019 – 3/3/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=02282019>
* 401056521, Arnold Palmer Invitational, 3/7/2019 – 3/10/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=03072019>
* 401056522, Players Championship, 3/14/2019 – 3/17/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=03142019>
* 401056523, Valspar Championship, 3/21/2019 – 3/24/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=03212019>
* 401056526, Valero Texas Open, 4/4/2019 – 4/7/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=04042019>
* 401056527, Masters, 4/11/2019 – 4/14/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=04112019>
* 401056528, RBC Heritage, 4/18/2019 – 4/21/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=04182019>
* 401056550, Wells Fargo Championship, 5/2/2019 – 5/5/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=05022019>
* 401056551, AT&T Byron Nelson, 5/9/2019 – 5/12/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=05092019>
* 401056552, PGA Championship, 5/16/2019 – 5/19/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=05162019>
* 401056553, Charles Schwab, 5/23/2019 – 5/26/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=05232019>
* 401056554, The Memorial Tournament, 5/30/2019 – 6/2/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=05302019>
* 401056555, RBC Canadian Open, 6/6/2019 – 6/9/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=06062019>
* 401056556, U.S. Open, 6/13/2019 – 6/16/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=06132019>
* 401056549, Travelers Championship, 6/20/2019 – 6/23/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=06202019>
* 401056558, 3M Open, 7/4/2019 – 7/7/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=07042019>
* 401056548, John Deere Classic, 7/11/2019 – 7/14/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=07112019>
* 401056547, The Open Championship, 7/18/2019 – 7/21/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=07182019>
* 401056545, Wyndham Championship, 8/1/2019 – 8/4/2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=08012019>
* 401056544, The Northern Trust, 8/8/2019 – 8/11-2019
  + <https://www.fantasylabs.com/pga/contest-ownership/?date=08082019>

Appendix B

GitHub Link

<https://github.com/jpelkofer/Golf_Capstone_Project>