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A New Method for Ranking Quarterback Fantasy Performance with Assessment Using Distances Between Rankings

Evan Boyd
pikapp8989@gmail.com

A NEW METHOD FOR RANKING QUARTERBACK FANTASY PERFORMANCE WITH ASSESSMENT USING DISTANCES BETWEEN RANKINGS

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Evan Boyd
Approved by
Dr. Laura Adkins, Committee Chairperson
Dr. Gerald Rubin
Dr. John Drost

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ABSTRACT

Each year around the first week of September, NFL fans are fulfilled with the familiar emotions of watching their team compete for the ultimate prize: Fantasy League Championship. No, the NFL did not rename the Super Bowl. To some, this prize is even more personal than if your favorite childhood NFL team were to win the big game in February. To put it simply, the popularity of fantasy football has grown tremendously over time and the opportunity to best your friends, family, coworkers, whomever it may be that attempts to create the greatest fantasy football roster of all time, absolutely cannot pass you by if you consider yourself a fan of the NFL. To most of these football fanatics, Sunday means more than just watching a game. It means making sure you have the picture perfect lineup for your fantasy team and (hopefully) watching your players rack up more fantasy points than your competition. However, completing the previous task is rarely the case. I have taken what many fantasy football league managers consider to be the "Captain" of their team, the quarterback, and created a weekly projection for each individual matchup to ensure that you make the right decision on which quarterback will lead your team to victory. In doing so, this led to a ranking system based upon weekly fantasy production. I then compare my ranking for the upcoming week to the rankings produced by ESPN analysts using distance-based ranking models in hopes to have created a superior cheat sheet to guide your team to become Fantasy League Champions.

CHAPTER 1
INTRODUCTION TO FANTASY FOOTBALL

1.1 Structure of a League

Fantasy football is a segue for NFL fans to create their ultimate dream team and face opponents ranging from their best friends to their grandparents. The league manager usually sends out invitations to fill an eight to fourteen team league, along with the structure of the league (number of teams, rules, length of season, etc.) that is completely customizable by the league manager. This is where it becomes extremely difficult for analysts at ESPN, Yahoo!, and other sports companies to give the best advice possible to fantasy football enthusiasts hoping to win the championship game at the end of the season. However, there is a standard league setting, which is what will be used in my research and analysis in order to make appropriate comparisons, so that predictions, rankings, and analysis can be applied on a common ground. The typical structure is as follows: once all invitations are accepted, the manager sets a draft date for owners to select their players before the regular season of the NFL begins. Each member of the league will have an equal opportunity to select fourteen players to fill their roster consisting of one quarterback, two running backs, two wide receivers, a tight end, a flex spot (option of a running back, wide receiver, or tight end), a defense/special teams unit, and a kicker. These are the necessary positions that should to be filled with a player during each week of competition, commonly known as the starters. In addition to these starters, the roster also consists of five bench players to fill the fourteen available spots. Also, in order to prevent a team from filling those five bench spots with players of the same position, a maximum of four quarterbacks, eight running backs, eight wide receivers, three tight ends, three defense/special teams units, and three kickers has been set as a restriction for the rosters [3]. Only the players an owner selects to fill the nine starting positions are those that will contribute fantasy points for their teams overall

score in any given week. Although the players in the bench spots can also produce fantasy points, they will not count toward the score for a team in the weekly matchup.

1.2 Setting a Lineup

Each week an owner will set a lineup by choosing the members of their team they want to be the starters that they believe will gain more points than their opposition. If they have seleted a lineup that indeed does this, they will receive a win. The overall idea of fantasy football is to win as many weeks as possible, and ultimately the championship at the end of the year. The bench spots are used in order to give the manager flexibility to utilize different players depending upon their opposition for a certain week, or to ensure they have each of the nine overall positions filled if their usual starter is on a bye week, which each NFL team must include in their schedule during one week of the 17 week season. The bench spots are also what can drive owners mad. For example, say an owner has Colin Kaepernick, the quarterback for the San Fransisco 49ers, and Aaron Rodgers, the quarterback for the Green Bay Packers. The owner can only choose one of these players to fill the quarterback slot in the lineup for a given week. Assuming that both are healthy and neither have a bye week for the given week, who should they choose? Now, this is entirely up to the owner. Knowing the defensive matchup that each quarterback will face that week, they must make a decision to select the one who will give them the most fantasy points. What is frustrating to owners is that a player on their bench can earn more fantasy points than the player they selected to be in their starting lineup. With that being said, this is why I have chosen to research this topic. I wanted to create a ranking system that would accurately predict who to start and who to sit on the bench when setting a lineup. I have focused on the quarterback position considering that it is viewed as the most important part of the team. After all, they touch the ball more than any other player on the field, therefore leading to the opportunity to gain more fantasy points than any other position. I have gathered ESPN's weekly quarterback rankings to make a comparison between the calculated rankings I derived, to the actual

Category	Points	Per
Passing Yards	1	Every 25 PY
Rushing Yards	1	Every 10 RY
Passing Touchdowns	4	Each PTD
Rushing Touchdowns	6	Each RTD
Interceptions	-2	Each INT
Fumbles Lost	-2	Each FUM

Table 1.1: Fantasy points allotted to each component of quarterback rankings.

fantasy point production of the quarterbacks.

1.3 Scoring System

Scoring is another freedom that the league manager can control. Again, I will refer to the standard scoring system provided by ESPN in order to make my rankings as similar to theirs as possible [4]. Quarterback fantasy points are earned by six components. They are: passing yards, rushing yards, passing touchdowns, rushing touchdowns, interceptions, and lost fumbles. The points allotted to each of these are shown in Table 1.1.

As you can see, formulating fantasy points for a quarterback isn't taxing work. There is much discussion about why the point values for yards and touchdowns differ between passing and rushing, however this can be easily explained. Most NFL quarterbacks are pocket passers. These are the ones who stay behind the line of scrimmage using the protection provided by the offensive line to pinpoint a receiver and throw them the ball, resulting in passing yards and a possible passing touchdown, given the receiver makes the catch. Since this is somewhat expected and requires an additional player, the receiver, the credit given to the quarterback is not as great as if the quarterback was to get the yardage and potential score on their own by running the ball, or rushing. Thus, a quarterback who can effectively run the ball, as well as throw, is valued more (in fantasy terms) than one who can not. This leads to the different distribution of fantasy points given to the overall performance of the quarterback. In the NFL, quarterbacks who are also able runners are becoming more and

more prevalent in the strategy of play calling for teams. So, if you have two quarterbacks on your roster, do you play the one who throws the ball more, or the one who decides to run the ball more? I believe this is not a simple decision. You do not usually pick the quarterback who chooses to run more simply because they get more points for doing so. If you are one of those owners, good luck when your quarterback faces the defense that allows the fewest rushing yards in the league. Therefore, the answer lies in the defensive statistics of the team your quarterback is going to war with.

CHAPTER 2
IMPLEMENTING DEFENSIVE STATISTICS AND QUARTERBACK RANKINGS INTO FANTASY PROJECTIONS

2.1 Point Projection

Countless organizations will formulate a prediction for a players production in a given week. Of course, it is almost impossible to correctly predict the future. Nonetheless, it is attempted to do such for each player for each week of the regular season of the NFL. Now, I can only assume that ESPN uses these projections to make a list of players that they believe to be a better option to put in your starting lineup; or rankings for the week at hand. The precise formula(s) that companies use to compute this is not available to the public, however, many choose to expose their positional rankings for team owners in order for them to (hopefully) set the optimal lineup. As stated, I am only dealing with quarterbacks. I use a similar strategy to produce my weekly rankings, beginning with week five of the regular reason and ending with week 15. The first four weeks were used to obtain statistics for an initial rank for the quarterbacks based solely upon fantasy performance thus far by calculating the total amount of fantasy points for each quarterback through these weeks and ordering them from largest to smallest. Please note that the initial rank is only telling us who has had the best performance, in terms of fantasy points. Clearly, this isn't going to be enough for an accurate representation to determine which quarterback you need to put in your weekly lineup if you have the choice between two or more. We simply cannot expect quarterbacks to have identical production week in and week out since their opponent can be treated as variable. Most would agree that even if a team played the same opponent for a sixteen game season, the ranking would change because of coaching stategies, injuries to players, the fact that humans are not robots, etc. So the question becomes: how can we decide between Quarterback A and Quarterback B for our starting lineup? I have decided that when we

Quarterback Category	Defensive Category
Passing Yards	Passing Yards Allowed
Rushing Yards	Rushing Yards Allowed
Passing Touchdowns	Points Given Up
Rushing Touchdowns	Points Given Up
Interceptions	Interceptions
Fumbles Lost	Fumbles Recovered

Table 2.1: Quarterback categories and associated defensive categories

consider fantasy performance for the previous weeks (which is essentially the initial ranking of the quarterbacks) and then pairing the QB's with the defense they will be facing for the upcoming week will provide an approximate representation of what we can expect to occur.

2.2 Defensive Impact

After collecting the necessary defensive statistics [8] for each team (points given up, passing yards allowed, rushing yards allowed, interceptions, and forced fumbles), I associated them with the appropriate quarterback statistic, as shown in Table 2.1.

This is rather apparent, but necessary to show how the points allowed is being used in both the passing and rushing touchdown categories. Thus, the quarterback projection in my system takes into consideration the strengths and weaknesses of the defenses they face by using these weekly updated defensive per-game averages.

2.3 How Defensive Statistics are Applied to Projections

Incorporating these defensive statistics in a fair manner required normalization of the data. Each defensive category is given a scaled z-score that acts as a weight, essentially the strength or weakness of the defense in that particular area, and is implemented into the expected production of the opposing quarterback's per-game averages in the projection formula. The reason these are scaled is because the standard normal distribution z-score will place too much emphasis in the respective categories. Thus, after acquiring the z-score, I took one-third of the value and added one to ensure that the scaled z-scores are centered about one

Peyton Manning	
Passing Yards	376.8
Rushing Yards	−3.0
Passing TD's	4.0
Rushing TD's	0.2
Interceptions	0.2
Fumbles Lost	0.2

Table 2.2: Per-game averages for Peyton Manning through five weeks

while simultaneously reducing the impact of the weight. The number we divide the z-score by can be changed, however, it remained constant throughout my research. It became clear that we could easily place a level of emphasis on each category by using this process. This opens up many options as to which defensive statistic is most important, or relevant, to quarterback success. Unfortunately, I was unable to successfully incorporate this technique into my research but is an aspect that can be manipulated in later work. Note that only in extreme cases, or outstanding defensive statistics in a catergory, will a team result in a negative value for the scaled z-score. We want to avoid this as much as possible to prohibit a possible negative projection for a QB only because they're playing a tougher defense. In order to understand how these projections are made, let us view the following example: Through five weeks of the NFL season, Peyton Manning of the Denver Broncos had accumulated the most fantasy points, 155.86. Without taking defense into account, we could expect him to obtain another 31.17 fantasy points for week six. Peyton Manning's per-game averages through five weeks are shown in Table 2.2.

Using these values for the anticipated fantasy points for the next game are simply configured by multiplying the fantasy point values shown in Table 1.1 by these averages.

$$\left[\frac{\text{Pass Yrds}}{25}\right] + \left[\frac{\text{Rush Yrds}}{10}\right] + [\text{Pass TD} * 4] + [\text{Rush TD} * 6] - 2[(\text{Int} + \text{Fum})]$$

Substituting Manning's numbers:

$$\left[\frac{376.8}{25}\right] + \left[\frac{-3.0}{10}\right] + [4.0 * 4] + [0.2 * 6] - 2[(0.2 + 0.2)] = 31.17$$

	NFL Statistics		**Jacksonville Jaguars Statistics**	
Category	Mean	Standard Deviation	Per-Game Average	Scaled z-Score
Points Allowed	23.00	6.07	32.6	1.53
Passing Yards Allowed	253.41	49.09	222.0	0.79
Rushing Yards Allowed	107.13	18.74	160.6	1.95
Interceptions	0.99	0.48	0.4	0.59
Fumbles Recovered	0.97	0.37	0.8	0.85

Table 2.3: NFL and Jacksonville Jaguars Defense Averages

As stated earlier, this is completely unreliable since the defense changes weekly. In week six, the Broncos played the Jacksonville Jaguars.

We are able to see in Table 2.3 that the Jaguars defense gives up more points and allows more rushing yards than the average defense, while allowing less passing yards and causing fewer turnovers. Applying these weights to Manning's expected production:

$$\left\{0.79 * \frac{376.8}{25}\right\} + \left\{1.95 * \frac{-3.0}{10}\right\} + \{1.53 * [4.0 * 4]\}$$

$$+ \{1.53 * [0.2 * 6]\} - 2\{[0.59 * 0.2] + [0.85 * 0.2]\} = 37.06$$

Clearly, this expected production is greater than the production given only by Manning's averages. We are able to conclude this defense is relatively weak since Manning's expected fantasy point value increased.

2.4 Applying the Rank of the Quarterback

The previous section showed how a quarterbacks opponent plays a role in anticipated fantasy points for a given week. The results are satisfactory, but brings up a valid question: Can we say that every quarterback will be equally effective against the same defense in a different week? For instance, should the number one ranked quarterback playing the Jaguars in week six be held to the same expectation as the $25th$ ranked quarterback playing the Jaguars in

week seven? Understand that this should be viewed as if the defensive scaled z-scores have not drastically deviated from one week to the next. Obviously, we can assume that the top ranked quarterback is a better option than the $25th$ ranked quarterback. It would make sense that the better quarterback isn't going to be as negatively effected by a defense as the $25th$ ranked quarterback may be. Therefore, I believe that the rank needs to play a role in the projection as well. A very similar normalization of the quarterback ranking was implemented to obtain a scaled z-score to be applied to the previous computation of the expected fantasy production. The only major difference between the normalization technique used here is that the scaling factor is $\frac{1}{16}$ instead of $\frac{1}{3}$. This is because the expected fantasy points added to the quarterback production was greatly impacted when using a smaller divisor. For instance, Manning was ranked number one after five weeks of play. Using the z-score when scaling by $\frac{1}{3}$ drastically increased his anticipated points from 37.06 to 57.91! Therefore, to avoid allowing a quaterback's rank to give them upwards of 20 extra points in a game (which is absurd), the most efficient way of correcting this issue was to reduce the scaling factor. When calculated using $\frac{1}{16}$, we see that Manning's projection has still risen, which is what we expect to happen considering his rank, but only by almost 4 points to 40.89. This updated weight of the ranking is much more justifiable rather than allowing a quarterback to gain the fantasy value of 5 passing touchdowns before the game even started. As stated with the defensive statistic scaled z-score, the ranking scaled z-score can be altered as well. What we can see is that the divisor of the scaling factor used in my formula to create the rank weight can be perceived as the number of tiers of quarterbacks there are in the league. Though some might argue there are only 3 tiers, there can be some manipulation done to the formula where the impact will not be as dramatic as above. Please note that I am not stating that I believe there are 16 tiers of quarterbacks, despite that this is the decided value chosen to be constant in my ranking weight. I'm simply saying with further construction of the projection formula that includes the rank of the quarterback, there is a case to be

made that quarterbacks could be placed in tiers with a similar strategy I have used in this research. It was necessary for me to make the appropriate change in the weight to reduce the outlying impacts on top and bottom ranked quarterbacks. Again, this is an aspect that can be focused on at a later time.

CHAPTER 3

COMPARING PROJECTIONS TO ACTUAL PRODUCTION

3.1 How Close is Close?

Now that we have established a reasonable, meaningful weekly projection that takes into consideration a few major influential factors, we can compare them to the actual amount of fantasy points the quarterbacks were able to produce. Statistics were gathered from ESPN and Pro-Football-Reference to calculate the actual fantasy points scored by each quarterback [1, 8]. Once the necessary statistics were obtained and production was found, I then ranked the list of quarterbacks based upon these values. This allows us to compare not only the projected production and the actual performance, but also, and more useful to fantasy players, the rank of each. I decided to focus mainly on the similarity between the rankings rather than the calculated value of fantasy point projection. Although the difference between projections would be nice to analyze, viewing the rankings will be ideal considering ESPN makes public their rankings for each position while their formulation for projections along with how they acquired their rank are kept private. We can now illustrate the difference between not only my rankings and the true rankings, but also the difference between ESPN's ranking and the true rank as well. After all rankings for quarterbacks are listed, the issue at-hand becomes how to fairly place an appropriate numerical value that describes closeness, or accuracy, in ordering the quarterbacks in terms of fantasy performance. Keep in mind that the goal of both rankings is not to say which quarterback is playing the best football for their team. The goal of the rankings is to provide fantasy players with a sorted list stating which quarterback should earn your team the most fantasy points for the upcoming week. This will allow team managers to make the decision of the quarterback they should place in their lineup if they have more than one option.

True Rank	Quarterback	My Rank	ESPN Rank
1	Tony Romo	9	10
2	Peyton Manning	3	1
3	Jay Cutler	26	17
4	Russell Wilson	23	14
5	Geno Smith	8	***26***
6	Sam Bradford	12	16
7	Ryan Fitzpatrick	34	***27***
8	Terrelle Pryor	11	12
⋮	⋮	⋮	⋮
25	Cam Newton	10	6
26	EJ Manuel	24	22
27	Tom Brady	18	7
28	Carson Palmer	30	25
29	Brian Hoyer	13	18
30	Jeff Tuel	36	***31***
31	Matt Schaub	19	19

Table 3.1: Week 5 Rankings

3.2 ESPN Rankings

ESPN ranks only the top 25–30 quarterbacks for any given week [1]. This is a vast distinction between their system and mine. I'm sure that whenever they calculated the projections there was indeed value for each quarterback, however, the information that is public does not provide a ranking for every quarterback in the league. In order to successfully compare the two estimated rankings to the true rank, it was necessary to fill in the gaps for ESPN's list. For example, my system ranks each individual based on the projection formula I designed. Once the player's true rank is determined, post-game of course, either predictive method could largely deviate from the true rank. Allow me to illustrate using week 5 via Table 3.1.

This table is not to show the discrepancy in rankings whatsoever, but it is required to explain the missing gaps. Notice the bold, italicized ESPN ranks for Geno Smith, Ryan Fitzpatrick, and Jeff Tuel. In ESPN's rank for week 5, these three QB's did not make their list, as they only included who they believed to be the top 25 performers. The reason I have

filled in the italicized numbers is because they had ranked Matt Schaub, who ended up being the $31st$ best fantasy player in this week, in their top 25. The optimal way of resolving this issue was to give ESPN the benefit-of-the-doubt by giving the highest true-ranked performer that was not listed in ESPN's rank the next available rank. In this week, they ranked 25 players, leading to the next best rank of 26 to be applied to Geno Smith, the quarterback who gained the most fantasy points of those that did not appear in ESPN's ranking while also performing better than several quarterbacks that were on their list. This procedure was utilized for each week when this predicament occurred. Another issue that must be resolved in order to efficiently evaluate the closeness of these values is the number of rankings included in each projection. As you can see, the above table includes the true rank of 31 quarterbacks. My formula is able to rank each quarterback in the NFL. The problem arrives when I have ranked a $2nd$ string quarterback, who has performed well in the amount of playing time they've received, whose production is likely to be larger than a starting quarterback for another team who hasn't performed as efficiently. The solution is pretty straightforward. Why would I insist on starting a back-up quarterback that is very likely not to play in the game at all over a quarterback who might not be as talented, but will nonetheless start the game and have the opportunity to generate fantasy points? These rankings are to show the likelihood of which quarterback should obtain the most fantasy points in the upcoming week. Simply, the starting quarterback is more likely to obtain points than the $2nd$ string quarterback. Thus, my rankings were adjusted only to include starting quarterbacks in the NFL so that I, along with ESPN, will have an equivalent number of rankings for a given week.

As you can see in Table 3.2, there are now only 28 quarterbacks that are ranked. The reason this is fewer is because Nick Foles, who had a performance rank of 14, was not ranked by ESPN or myself since Michael Vick was the Philadelphia Eagles starter for the game and got injured. Brandon Weeden, who had a performance rank of 19, was not the starter for

True Rank	Quarterback	My Rank	ESPN Rank
1	Tony Romo	9	10
2	Peyton Manning	3	1
3	Jay Cutler	26	17
4	Russell Wilson	23	14
5	Geno Smith	8	***26***
6	Sam Bradford	12	16
7	Ryan Fitzpatrick	28	***27***
8	Terrelle Pryor	11	12
⋮	⋮	⋮	⋮
23	Cam Newton	10	6
24	EJ Manuel	24	22
25	Tom Brady	18	7
26	Carson Palmer	25	25
27	Brian Hoyer	13	18
28	Matt Schaub	19	19

Table 3.2: Adjusted Week 5 Rankings

the Cleveland Browns. Jeff Tuel, who had a performance rank of 30, was not the starter for the Buffalo Bills. These quarterbacks were taken out from the performance rank from earlier, along with the projection rankings of my system, since they were not considered to gain more points than a starter should produce. This is entirely necessary to make the comparisons to the ranking list provided by ESPN.

CHAPTER 4

DEFINING DISTANCE

4.1 What is Distance?

Distance is a term that often has a singular meaning: the space between two objects. In most cases, this definition suffices, however, I have researched the term and found that many mathematicians and statisticians have developed their own ideas as to what a distance acutally describes. For each week projections were made, I have compared them to the actual production of the quarterbacks for both ranking systems. The following distances were computed for 11 total weeks, week 5 through 15, to compare my rankings to the true rankings, along with ESPN's rankings to the true rankings. Ideally, the closer to zero the distance is in each definition below, the more accurate the predictive ranking was to the true performance ranking. So, for each week that comparisons are made, the smaller numerical value of distance between my rankings and ESPN rankings was the better predictor for the week at hand. Keep in mind that the true ranking is simply a list of numbers $\{1, 2, ..., n\}$ in increasing order.

4.2 Spearman Footrule

The Spearman Footrule definition was found in *Metrics on Permutations, a Survey* [2]. Whenever there are only two values, $n = 2$, this is referred to as the *Manhattan* or *taxi-cab distance*. The computation formula is as follows:

$$D(a, b) = \sum_{i=1}^{n} |a(i) - b(i)| ,$$

where $D(a, b)$ is the distance between rankings a and b for n ranked items. This can be viewed as a distance in which only horizontal and vertical movements can be made to get from one point to the other.

4.3 Spearman Distance and Rank Correlation

Spearman's distance is commonly known as the standard Euclidean distance [5]. An advantage of using this calculation is that it can easily be used to find a correlation between the two lists being compared. The formulation of the distance is:

$$D(a,b) = \sqrt{\sum_{i=1}^{n} [a(i) - b(i)]^2}$$

In order to apply this distance in a correlation, we must first identify the maximum possible distance between the sum of the squares of the difference between the rankings [7], $\frac{n(n^2-1)}{3}$. After this is obtained, the correlation coefficient is evaluated as:

$$\rho = 1 - \frac{2 * \sum_{i=1}^{n} [a(i) - b(i)]^2}{\left(\frac{n(n^2-1)}{3}\right)} = 1 - \frac{6 * \sum_{i=1}^{n} [a(i) - b(i)]^2}{n(n^2-1)}$$

The range of this value is from -1 to 1, with -1 showing a perfect negative relationship and 1 showing a perfect positive relationship. Thus, a correlation of 0 identifies no relationship existing between the two lists being compared. Obviously, we would like to steer clear of negative values and near-zero values for the correlation coefficient. The correlation coefficient that is the largest positive value will be the better predictive rank between my projection and ESPN's projection for the given week.

4.4 Lee Distance

The Lee distance is used frequently in modulation [2]. I think of it as 'the best case scenario' distance considering it involves utilizing the minimum space between the two ranks. The Lee distance can often be utilized when computing the minimum possible error in data sets.

$$D(a,b) = \sum_{i=1}^{n} \min\{|a(i) - b(i)|, n - |a(i) - b(i)|\}$$

This definition of distance closely resembles the previous two, however invoking the minimum function enables another comparison to be made.

4.5 Hamming Distance

The Hamming distance is often used in transmission [2]. It's derivation can be seen as somewhat straightforward.

$$D(a,b) = n - |\{i|i \in \{1,2,...,n\}, a(i) = b(i)\}|$$

where $|\{i|i \in \{1,2,...,n\}, a(i) = b(i)\}|$ is the cardinality of the set. Basically, Hamming's distance is the difference between the total number of items being ranked and the number of rankings that agree with one another in the two ranking lists being compared.

4.6 Kendall's Rank Correlation

Kendall uses a difference approach to his correlation coefficient by looking at the list and describing how 'out of order' it is compared to the correct order [6]. He gives multiple techniques in formulating this number, however I will only describe the approach I used. Consider a set of any permutation of the integers 1 to n (representing a possible list of prediction ranks in my research). Now, working with the first value (rank) on this list, count the number of values to the right of it on this list which are greater than this first value. Proceeding in like manner, you get the counts with respect to the second value (rank) on this list, the third, etc. Let C denote the sum of these counts that you find. C represents the number of concordant pairs, which corresponds to the number of pairs formed from your list of prediction ranks linked with {1,2,...,n} which are in the correct order. By Kendall [6], the maximum value for C is $\frac{n(n-1)}{2}$ (which will occur if and only if your list of prediction ranks is in the linear form {1,2,...,n}). Let $D = \frac{n(n-1)}{2} - C$. D denotes the number of discordant pairs, which represents the numbers of pairs formed from your list of prediction ranks linked with {1,2,...,n} which are not in correct order. The statistic, $\sum = C - D$, will be used to compute Kendall's correlation coefficient, τ, using a similar combination of the maximum as done in the Spearman rank correlation calculation.

$$\tau = \frac{\sum}{\left(\frac{n(n-1)}{2}\right)} = \frac{2 * \sum}{n(n-1)}$$

Again, as in the Spearman correlation, the values have the same range and meaning in that the greater positive values yield the better predictor.

4.6.1 Example of Kendall Rank Correlation

A short example with $n = 5$ will illustrate the process:

Let $a = [1\ \ 2\ \ 3\ \ 4\ \ 5]$ and $b = [3\ \ 1\ \ 2\ \ 5\ \ 4]$

$b(1) = 3$ and there are 2 numbers greater than 3 to the right.

$b(2) = 1$ with 3 values greater than 1 on the right.

Similarly we find, $b(3) = 2$ with 2, $b(4) = 5$ with 0, and clearly $b(5) = 4$ with 0.

We then take the sum of these values: $2 + 3 + 2 + 0 + 0 = 7 = C$

Now, $max = \frac{5(5-1)}{2} = \frac{20}{2} = 10$

So, $D = max - C = 10 - 7 = 3$ and $\sum = C - D = 7 - 3 = 4$

Computing Kendall's Rank Correlation:

$$\begin{aligned} \tau &= \frac{2 * \sum}{n(n-1)} \\ &= \frac{2 * 4}{5(5-1)} \\ &= \frac{8}{20} \\ &= 0.4. \end{aligned}$$

CHAPTER 5

VIEWING THE RESULTS

5.1 Graphing the Distances

This section will offer a visual representation of the computations of the distances and correlations defined. In the distance graphics, I have labeled my rankings as the X variable and ESPN's rankings as the Y variable. There has been a line placed on the scatter plots to indicate the discrepancy between my rankings and ESPN's rankings. So, if my rankings were identical to ESPN's for each week, the points would be collinear. One thing that is necessary to point out is that each point lying above the line exhibits a week where my projection was closer to the true rankings than ESPN and vice versa. In most of the visuals, it is easily seen that there truly isn't much difference between the two ranking systems. The major point to be noticed is that neither system had values near zero, however the values obtained from each method are quite similar.

5.2 Graphing the Correlations

The correlation graphs offer a different insight to the overall research. These correlations describe the relatedness of the predictive rankings to the true rankings. Now, as stated, the goal is to have coefficients around 1. The closest either system came to this through 11 weeks worth of rankings happened in week 10, when my system obtained a Spearman Rank coefficient of 0.498! These graphs show the correlations for each system over time. Unfortunately, we can see that there is no single trend in the data despite the effort to have weekly increasing correlations. What we are able to see is that whenever, and for whatever reason, ESPN had an 'off' or 'poor' predictive ranking, I happened to follow in their footsteps. The increases and decreases in the following line graphs tell us that ESPN and I have ranking systems that are effected by similar factors since these jumps and falls occur during the same

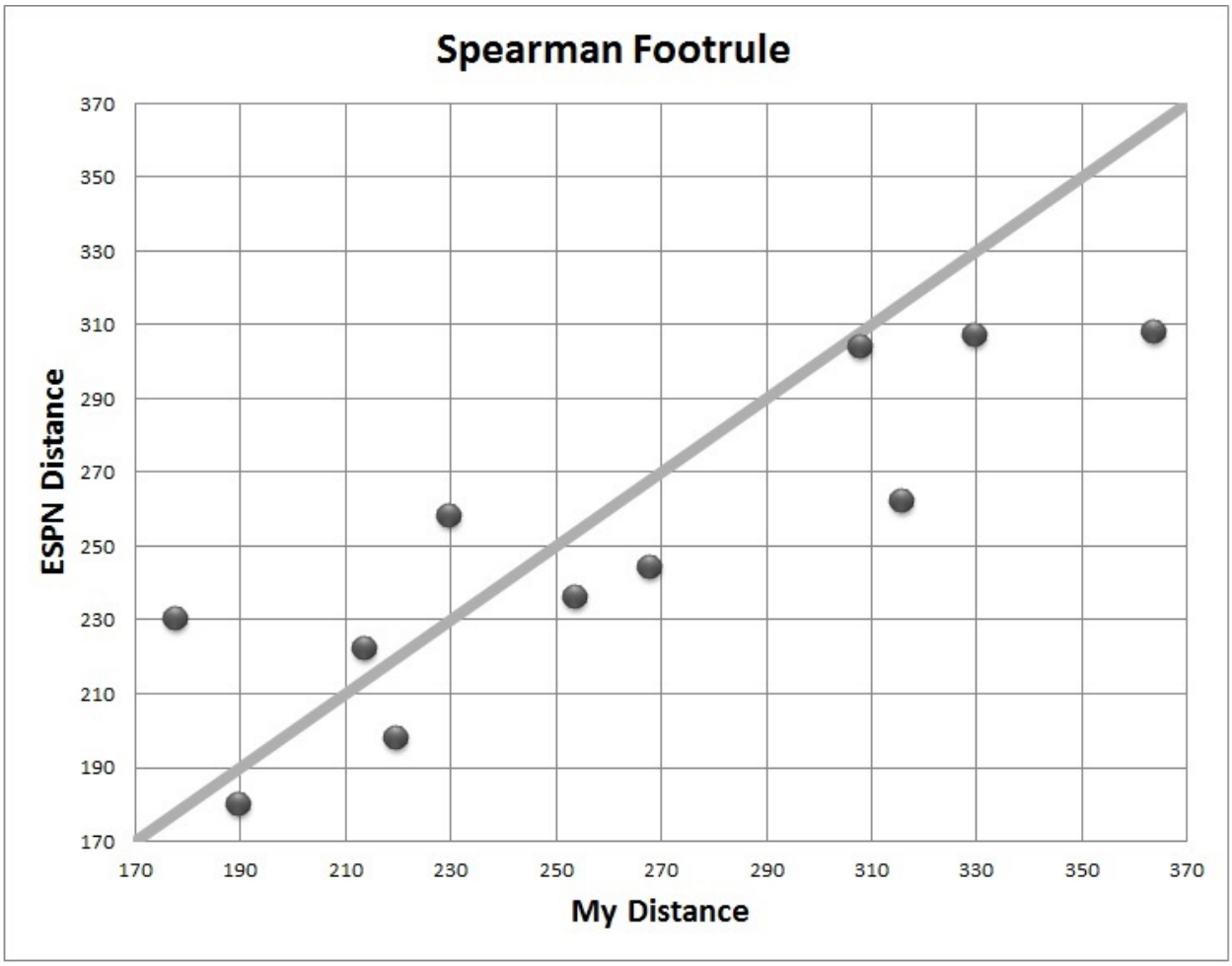

Figure 5.1: Spearman Footrule

week. There are only two weeks out of the eleven where the systems have opposite changes in direction. From week 10 to 11, and week 11 to 12, my correlation coefficients decreased while ESPN obtained increasing correlation coefficients. The remaining weeks, both systems increased or decreased from one week to the next at the same time.

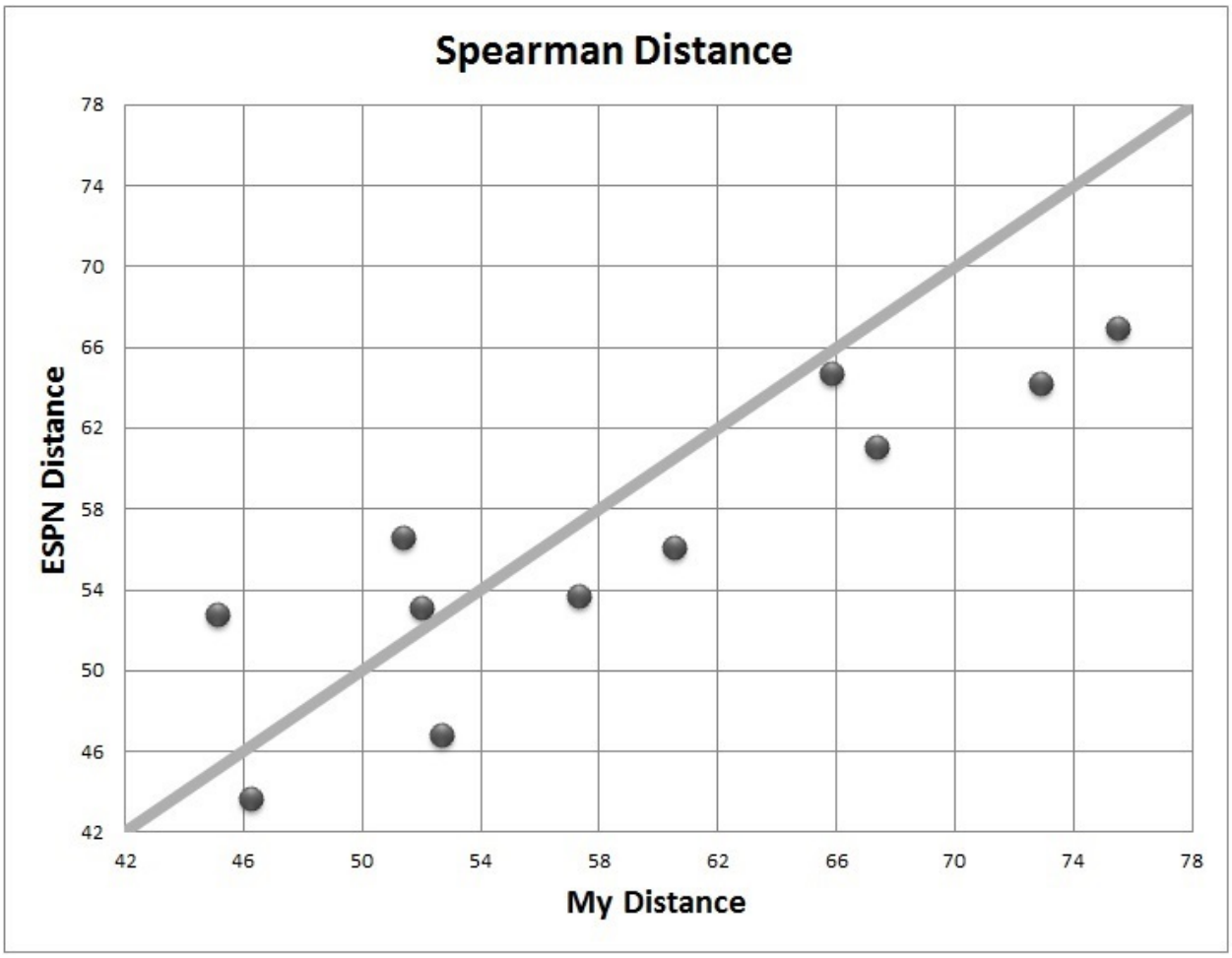

Figure 5.2: Spearman Distance

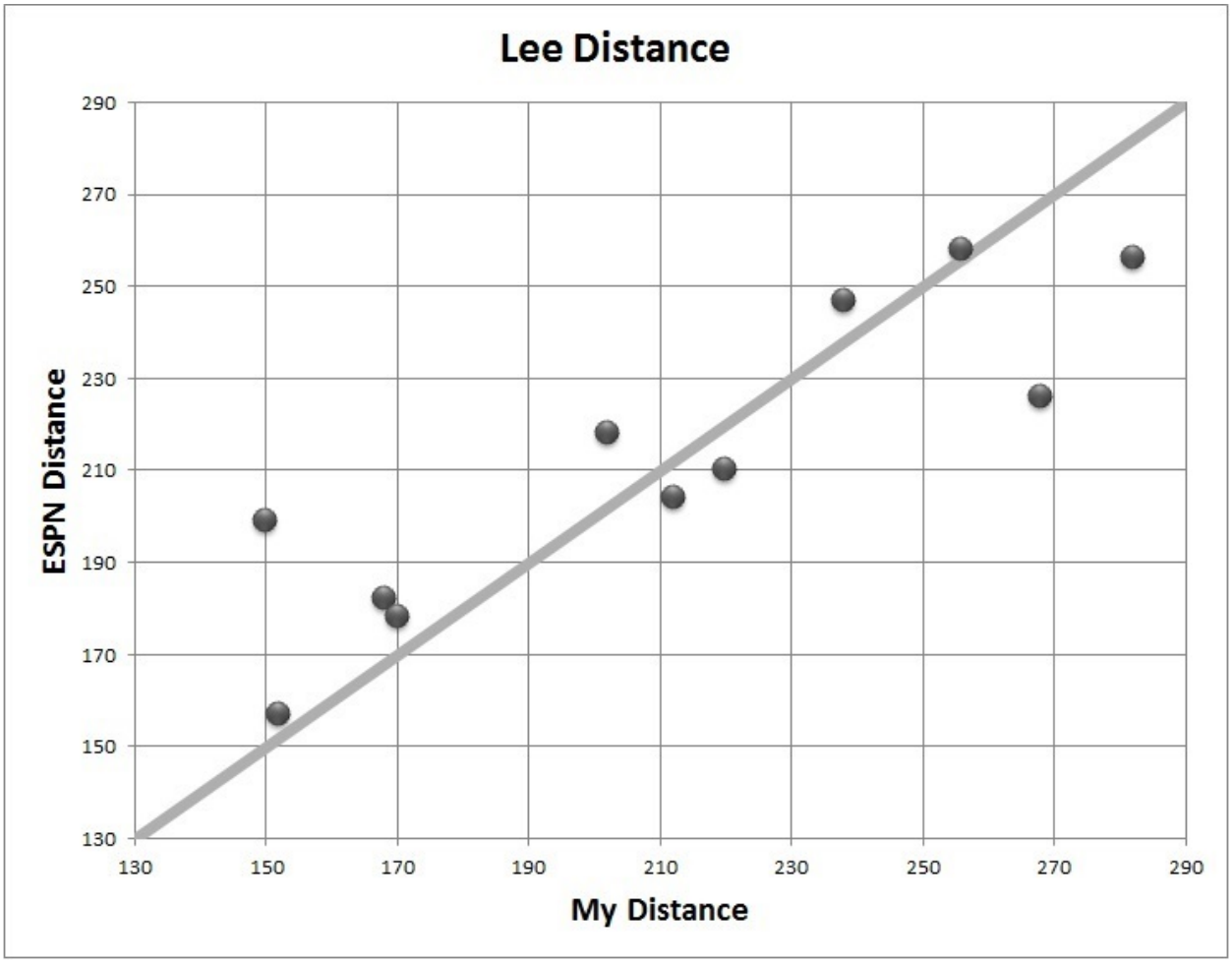

Figure 5.3: Lee Distance

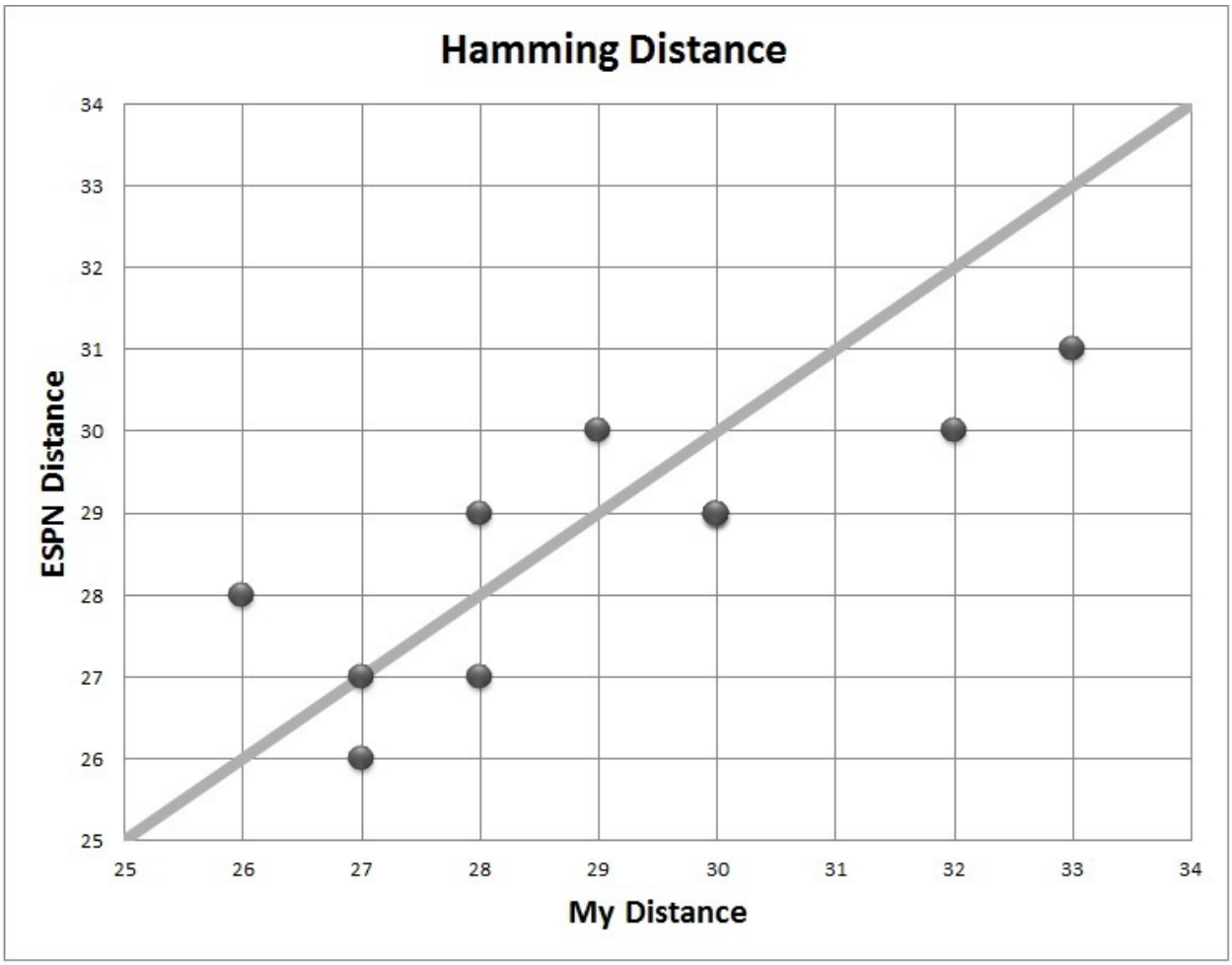

Figure 5.4: Hamming Distance

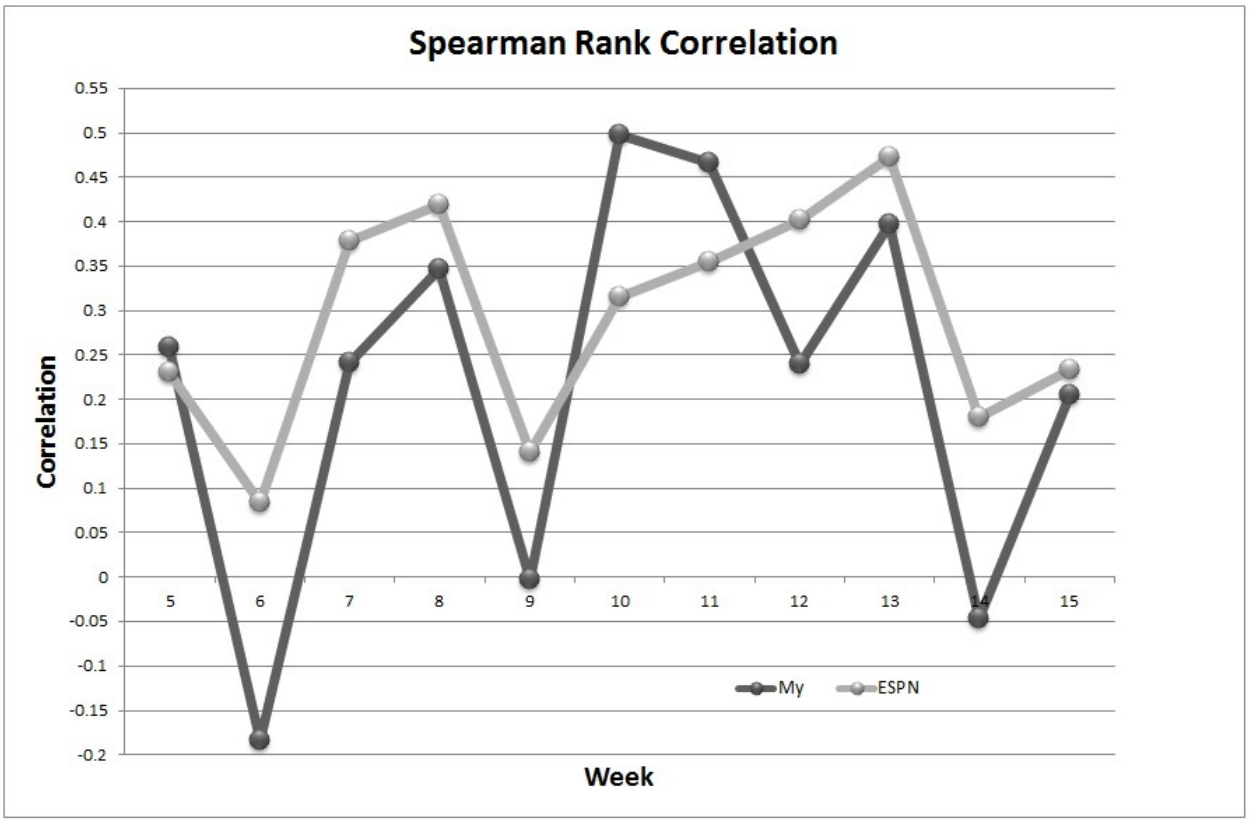

Figure 5.5: Spearman Rank Correlation

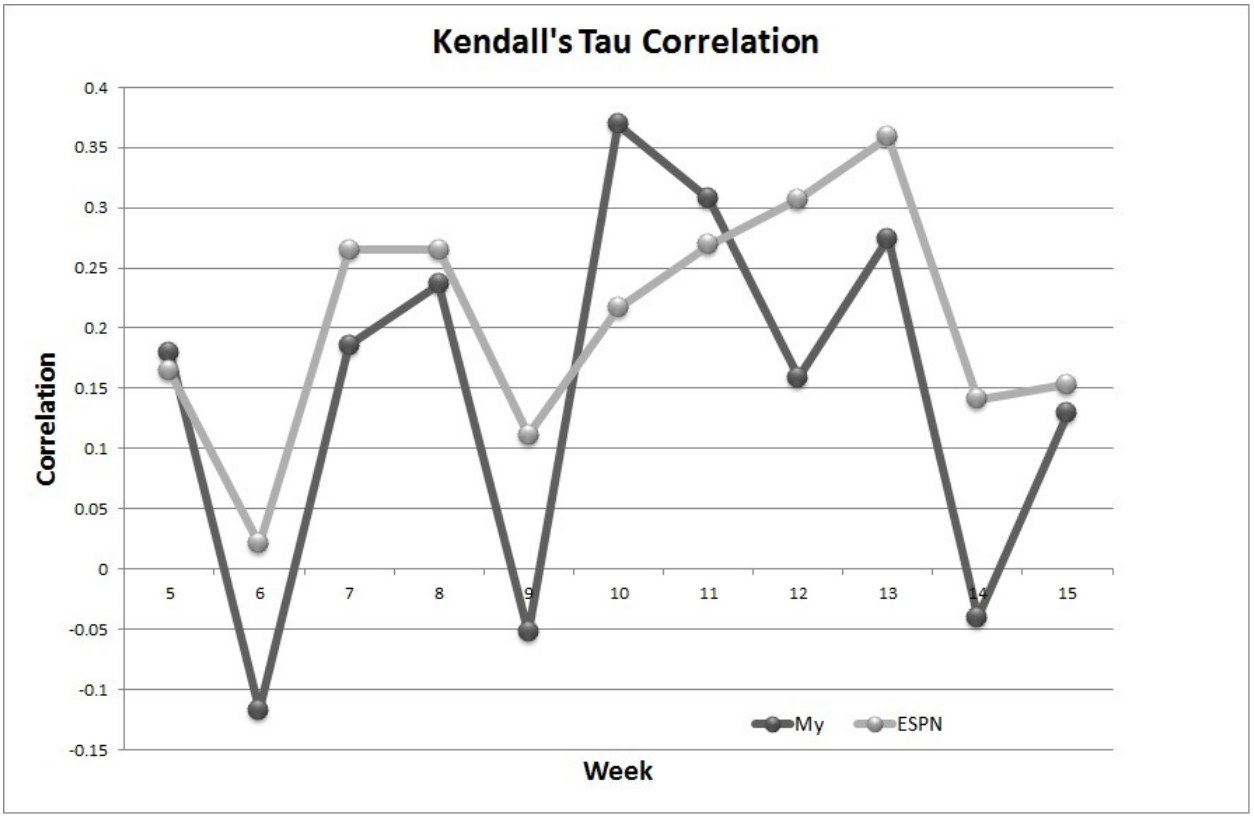

Figure 5.6: Kendall's Tau Correlation

CHAPTER 6
ANALYSIS AND CONCLUSIONS

6.1 Best Method

In viewing the graphs of the distances, it can be seen that I have consistently predicted at least three out of the eleven total weeks closer to the actual production than ESPN. When using the Lee definition, I had the more accurate model for seven weeks. As much as I would like to say that the Lee distance is the most adequate method for stating which system was the better predictor, I am unable to do so considering the other techniques clearly tell another story. However, I believe the best definition of distance used in this research is indeed the Lee definition. Considering that neither system was anywhere close to being perfect, being close to arguably the most popular source for sports information in the country and the fantasy football analysts at ESPN, will suffice for this research. Since both systems are exposed to the minimum function, they both have a more likely chance to reach a smaller computed value, obviously not in the neighborhood of zero, but indeed less than or equal to that of the Spearman Footrule. Also, the scatter plot of the Lee distance shows less extreme deviations from my distance to ESPN's distance. Thus, in order to say that I have generated a more effective weekly projective ranking model than ESPN, Lee's definition must be used. Overall, I can say that the created projective system I have come up with is a somewhat similar model to that used by the analysts at ESPN no matter which definition is used. Again, the formulation of their rankings is not publicly known. This leads to my assumption that the variables I used in my formula are the also included in theirs in some way considering the weekly trends and distances that arose throughout my research. Though this may be the case, a very likely explanation for the differences between my model and ESPN's model is the number of variables that are taken into account in forming these rankings.

6.2 Future Research

As stated in earlier sections, there is much room for possible improvement of my formulation of projections to gather the weekly rankings. My model consists only of data from this season for the quarterbacks and the defenses. It can be claimed that in order to create a more accurate rank, we could observe previous seasons. For instance, if a quarterback has performed exceptionally well against an opponent in the past, or in perhaps rivalry games, there could be reasoning to include a positive weight to the projection to account for history. Along with this, the weights that are placed on the defensive statistics to obtain the scaled z-scores could be vastly adjusted. Which defensive statistic is the most important? This is debatable, yes, but in my research I have not yet had this question play a role in the computation. Similarly, the weight of the quarterback rank heading into a particular week could be adjusted as well. Another huge factor that effected both my ranking and ESPN's ranking is the weather. I am able to say this simply because of one game in week 14. The Detroit Lions and the Philadelphia Eagles played in what some would call a snowglobe and one of the most memorable games of the 2013 NFL season. Despite this fact, my ranking heading into the week had Matthew Stafford, the Lions quarterback, at number 1 overall while ESPN placed him at number 2 on their list. Nick Foles, the Eagles quarterback, was ranked at 5 and 6, respectively. Foles ended up being ranked $15th$ and Stafford earned a rank of $31st$ once all games for week 14 had concluded. They could barely hold onto the ball in the weather they were playing in! Surely, weather is a topic that is likely to have a great effect on the ranking system and should be a factor to consider in future work. Lastly, in my research on college football rankings in previous years, I found that home-field advantage played a large role in the outcome of the games. Though maybe not as influential at this level of competition, I believe that it indeed plays a role in the NFL as well. This leads to an obvious factor that should be thought upon for inclusion in the formula.

6.3 Conclusion

There are many aspects to fantasy football. The obvious and most important statement to be made is that it is entirely unpredictable. Placing a numerical value on the future performance of an athlete can incorporate many factors and variables within the structure of the estimate. The human factor is one that a value cannot be placed, no matter the repetitive efforts of sports fans, statistical analysts, and gamblers across the world wish not to be circumstance. I do not believe there will ever be a predictive system in place that is undoubtedly superior to another because of this. There will never be a system that correctly identifies the order of which these NFL players will perform week in and week out. However, statistical inference can go a long way into making the next best ranking model to give advice to fantasy football team owners in need to make the best decision for their teams.

REFERENCES

[1] Fantasy Staff at ESPN, *Top quarterbacks for week 5-15*, The rankings were obtained from the same webpage each week as staff updated their weekly rankings.

[2] M. Deza and T. Huang, *Metrics on permutations, a survey*, Journal of Combinatorics, Information and System Sciences (1998), 3–5.

[3] ESPN, *Roster settings*, Rosters are explained in the URL: http://games.espn.go.com/ffl/resources/help/content?name=roster-settings-standard.

[4] _____, *Scoring settings for standard leagues*, Scoring is explained in the URL: http://games.espn.go.com/ffl/resources/help/content?name=scoring-settings-standard.

[5] M. Hollander and D. A. Wolfe, *Nonparametric statistical methods*, vol. 2, A Wiley-Interscience Publication, 1999.

[6] M. G. Kendall, *A new measure of rank correlation*, Biometrika **30** (1938), 81–93.

[7] Jr. Perry E. Jacobson, *Introduction to statistical measures for the social and behavioral sciences*, The Dryden Press, a Division of Holt, Rinehart and Winston, 1976.

[8] Pro-Football-Reference.com and Sports Reference LLC, *2013 nfl weekly league schedule*, Each statistic for quarterbacks and defenses came from the boxscore links on the following URL: http://www.pro-football-reference.com/years/2013/games.htm.

APPENDIX A
LETTER FROM INSTITUTIONAL RESEARCH BOARD

Office of Research Integrity

April 7, 2014

Evan Boyd
2403 Ontario Street
Flatwoods, KY 41139

Dear Mr. Boyd:

This letter is in response to the submitted thesis abstract entitled *"A New Method for Ranking Quarterback Fantasy Performance with Assessment Using Distances Between Rankings."* After assessing the abstract it has been deemed not to be human subject research and therefore exempt from oversight of the Marshall University Institutional Review Board (IRB). The Code of Federal Regulations (45CFR46) has set forth the criteria utilized in making this determination. Since the information in this study does not involve human subjects as defined in the above referenced instruction it is not considered human subject research. If there are any changes to the abstract you provided then you would need to resubmit that information to the Office of Research Integrity for review and a determination.

I appreciate your willingness to submit the abstract for determination. Please feel free to contact the Office of Research Integrity if you have any questions regarding future protocols that may require IRB review.

Sincerely,

APPENDIX B
WEEKLY RANK RESULTS AND DISTANCES

The following two weeks show the best week and the worst week in terms of predicting correctly. Week 10 is interesting considering my predictive rankings for this week were the closest to the true rankings among weeks 5 through 15 for all but the Hamming definition. It is also the week providing the best overall prediction that either system projected for all but the Hamming distance as well. Note that ESPN rankings are based on an average of four people's rank of each quarterback. Jay Cutler and Josh McCown both play for the Chicago Bears and both appeared on their top 27 rankings because there was not a clear decision as to who the Bears were going to start at quarterback this week. Also, Jake Locker got injured during the game after a few bad plays, resulting in negative fantasy points.

My Point Projection	**Fantasy Production**	**True Rank**	**Quarterback**	**My Rank**	**ESPN Rank**
33.46	31.68	1	Drew Brees	2	2
23.48	27.64	2	Robert Griffin III	6	9
33.95	27.10	3	Peyton Manning	1	1
17.86	22.92	4	Nick Foles	13	11
22.90	21.38	5	Russell Wilson	8	4
24.43	19.34	6	Case Keenum	5	19
26.47	18.66	7	Matthew Stafford	4	3
3.97	16.08	8	Kellen Clemens	29	***28***
12.94	15.36	9	Ryan Tannehill	21	22
17.00	15.16	10	Andy Dalton	15	15
22.06	14.26	11	Christian Ponder	9	25
6.20	13.44	12	Carson Palmer	26	27
30.02	13.42	13	Phillip Rivers	3	8
6.04	12.33	14	Matt Ryan	27	16
17.87	12.00	15	Jay Cutler	12	23
20.72	11.82	16	Andy Luck	10	6
17.22	10.16	17	Ben Roethlisberger	14	14
11.10	9.90	18	EJ Manuel	22	26
13.55	9.12	19	Tony Romo	20	7
16.77	8.78	20	Terrelle Pryor	16	13
10.94	8.00	21	Joe Flacco	23	17
15.95	7.30	22	Eli Manning	17	18
15.49	7.22	23	Mike Glennon	18	21
20.14	6.48	24	Josh McCown	11	20
14.21	6.26	25	Cam Newton	19	5
7.16	3.24	26	Colin Kaepernick	24	10
6.31	3.10	27	Chad Henne	25	***29***
4.77	1.00	28	Seneca Wallace	28	24
23.33	−1.24	29	Jake Locker	7	12

Table B.1: Week 10 Results

My Point Projection	**Fantasy Production**	**True Rank**	**Quarterback**	**My Rank**	**ESPN Rank**
22.54	37.52	1	Josh McCown	4	7
11.66	32.24	2	Andy Luck	24	17
21.42	31.78	3	Peyton Manning	7	1
9.41	30.34	4	Jason Campbell	27	***27***
16.16	30.10	5	Andy Dalton	14	20
9.82	28.82	6	Drew Brees	26	5
13.46	26.76	7	Ben Roethlisberger	19	13
14.71	23.60	8	Ryan Tannehill	17	22
12.27	21.76	9	Geno Smith	23	***28***
13.13	20.82	10	Tom Brady	20	3
19.76	19.96	11	Phillip Rivers	10	11
7.49	19.20	12	Matt Cassel	30	***29***
23.10	18.00	13	Joe Flacco	3	15
13.11	17.80	14	Matt McGloin	21	26
21.81	17.46	15	Nick Foles	5	6
20.67	16.06	16	Tony Romo	9	9
5.33	15.98	17	Chad Henne	32	***30***
15.10	15.20	18	Cam Newton	15	4
15.08	14.66	19	Carson Palmer	16	19
24.09	14.18	20	Alex Smith	2	10
8.50	13.12	21	Matt Flynn	29	***31***
21.31	12.24	22	Matt Ryan	8	14
5.34	12.10	23	Colin Kaepernick	31	16
16.34	11.46	24	Robert Griffin III	13	12
17.09	10.36	25	Eli Manning	12	24
10.92	10.16	26	Russell Wilson	25	8
19.33	9.66	27	Case Keenum	11	23
21.80	9.28	28	Ryan Fitzpatrick	6	18
14.21	7.60	29	Mike Glennon	18	25
9.24	4.24	30	Kellen Clemens	28	***32***
31.39	3.94	31	Matthew Stafford	1	2
12.86	2.26	32	EJ Manuel	22	21

Table B.2: Week 14 results

Definition	My Ranking	ESPN Ranking
Spearman Footrule Distance	178	230
Spearman Distance	45.144	52.726
Lee Distance	150	199
Hamming Distance	28	29
Spearman Rank Correlation	0.4980	0.3153
Kendall's Rank Correlation	0.3695	0.2167

Table B.3: Week 10 distance and correlation comparisons to ESPN

Definition	My Ranking	ESPN Ranking
Spearman Footrule Distance	364	308
Spearman Distance	75.565	66.888
Lee Distance	282	256
Hamming Distance	32	30
Spearman Rank Correlation	−0.0470	0.1800
Kendall's Rank Correlation	−0.0400	0.1411

Table B.4: Week 14 distance and correlation comparison to ESPN

Evan Boyd

Born August 9, 1989 in Flatwoods, KY
Phone 606-465-3026
Email pikapp8989@gmail.com

Education

- Master of Arts - Mathematics with an Emphasis in Statistics. Marshall University, May 2014. Thesis Advisor: Dr. Laura Adkins.
- Bachelor of Science - Mathematics with a Teaching Option. Morehead State University, May 2012. Thesis Advisor: Dr. Christopher Schroeder.

Research

1. *Manipulating the College Football Quarterback Rating System.* Undergraduate thesis, Morehead State University, May 2012. Formed a rating system to accurately represent player rankings according to statistics and strength of schedule.
2. *A New Method for Ranking Quarterback Fantasy Performance with Assessment Using Distances Between Rankings.* Master's thesis, Marshall University, May 2014. Created a weekly point projection for quarterbacks and compared them with ESPN rankings using multiple definitions of distance.