**Determining Which Variables Contribute to Shot Success in Soccer**

**Chapter 1: Introduction**

According to the Nielsen Company, soccer is the uncontestably most watched sport in the world, and is a business for teams worth hundreds of millions of dollars. **In fact, 43% of the sports viewers in the World are interested in watching soccer, compared to 37% from Basketball viewers; and the FIFA World Cup Media rights income budgeted a whopping total of $3.0 billion USD for this event alone** **(World Football Report, 2018, www.nielsen.com/wp-content/uploads/sites/3/2019/04/world-football-report-2018.pdf).** As a result, clubs put a great deal of time and resources towards achieving success **(example and source)**. This includes collecting ever increasing amounts of data about their team’s performances and those of others. Unfortunately, most of these data sets are not publicly available. There are still small data sets that have become publicly available, such as this one obtained by Luca Pappalardo on Figshare. From this small data set we hope to gain some insight into the game and an understanding of how data is coming to be used in soccer.

**Chapter 2: Data Set Overview**

2.1 Data Source

The dataset contains all matches played in Europe’s top five leagues during the 2017/2018 season (380 matches per league for a total of 1900 matches, producing 643,149 match events), the 2016 European Championship (51 matches, producing 78,139 match events), and the 2018 World Cup (64 matches, 101,758 match events). The data was imported by league and then compiled into a single data frame, giving a total of 3,251,294 events and 19 variables. **(Source of the original datasets)**

2.2 Calculating and Adding Event Distance Variable

One variable we are interested in looking at is the distance of assists and key passes and whether this plays a role in the success of the pass and whether it results in a successful shot on goal or not. We have to calculate distance for each event using the x,y-coordinates given in the data set. **(What if we used the typical dimensions of FIFA as an assumption, 120x75 yards, to give an estimate of distance?)**

2.3 Selecting Variables and Subsetting Data

With so many variables available we had to start by narrowing the number to look at. Since we’re interested in what variables effect the success rate of a shot on goal, we selected the variables immediately preceding a goal. These include shots, assists, and key passes, and the x,y-coordinates and event distance for each. Separate data frames were created for each of the following events of interest:

1. Key passes: pass leading to unsuccessful scoring opportunity
2. Assists: pass leading to a goal
3. Shots: unsuccessful shots on goal
4. Goals: successful shots on goal

**Chapter 3: Exploratory Data Analysis: Understanding Selected Independent Variables**

3.1 At a glance

3.2 Event Visualization

Using the ggsoccer library to plot event data on an image of a pitch and bordering the x and y axis with event density plots we were quickly able to understand how each event is distributed on the pitch, shown in Figure 1.

**Before diving into the analysis of the coordinates of the data, it is important to note the following: the X-Y coordinates in our datasets represent “relative” coordinates. This is in the sense that the both width and length of the field are divided into percentiles, and the direction of attack of any team is always given from left to right, regardless of the actual position of a team at a given time of a game. Therefore, the bottom-left corner of the field plot represents the coordinate (0, 0), while the top right corner represents the coordinate (100, 100). Please note that the dimension on a soccer field, per ruling of the FIFA, are NEVER squared, and although dimension may vary, the typical layout is of 120 by 75 yards (excluding? the limit lines) (source: backyardsidekick.com/soccer-field-size-layout-and-dimensions/).**

Several observations can be made from this visualization. First, the x & y-coordinates for both key passes and assists are multimodal and appear to be symmetric across the y=50 line. This makes sense as teams try to attack down both sides of the field. With this data being an average over so many games getting a symmetric split between the two sides of the field is expected. This symmetry could be a factor that varies from team to team, however. Second, the x & y-coordinate distributions for shots and goals is much closer to normal. The exception being the x-coordinate for shots which is bimodal. This is interesting because it indicates that a significant portion of shots are take farther away from goal, however, very few goals are scored from these shots. Despite this, players still seem to take these shots.

The distance distributions for key passes and assists are displayed in Figure 2. Both show fairly normal distributions, despite the fact that neither the x,y-coordinates for these two events show normal distributions.

3.3 Differences in Event Distributions

From looking at Figures 1 and 2, we already see several points that are outliers. For example, when looking at the figure showing shot events several shots can be seen to occur in the defensive half of the field. When looking at the bordering density plot, we see that these events, while they do occur, are rare compared with the majority of shots taken. From this we felt safe cleaning our events to remove these sorts of outliers before taking a deep dive into the distributions.

3.3.1 Fitting Event Distributions

3.3.2 T-tests: Comparing Assists vs Key Passes and Shots vs Goals

The t-tests were done assuming a normal distribution of the event variables despite most of the distributions not being normal. This was quick and easy, even though there's room for error it still allows us to get a sense of the differences in variables the determine success or failure.

Assists vs Key Passes:

T-tests with a 95% confidence level were run on the assist and key pass variables, x-coordinate, y-coordinate, and distance. For each of these variables the null hypothesis was set as no difference between the variable means for assists and key passes.

Below is the result for the x-coordinate. The resulting p-value is on the order of 1e-07 signifying a statistically significant difference in the x-coordinate between assists and key passes. This result shows that, on average, final passes made further up the field are more likely to result in an assist than a key pass.

When looking at the y-coordinate a p-value of 0.5 is obtained which would indicate no difference between assists and key pass. Since these distributions are not actually normal and symmetric around the y=50 line, when we assume a normal distribution, we get an inaccurate result.

The last variable to be looked at was the distance variable. The t-test here resulted in a p-value < 2e-16. So there is a significant difference between the distance covered by an assist vs a key pass, with assists having an average distance of 29.2 with a confidence interval from 28.7 - 29.8, and key passes having a mean distance of 33.2. This shows that final passes that have to cover a shorter distance are more likely to result in an assist.

Goals vs Shots:

Next, t-tests with a 95% confidence level were run on the goals and shots variables, x & y-coordinates. For these variables the null hypothesis was again set as no difference between the variable means for assists and key passes.

Below is the result for the x-coordinate. The resulting p-value is < 2e-16, meaning there is a statistically significant difference between goals and shots. With the shot x-coordinate mean equal to 84.1 and lying outside the confidence interval for goals, 90.7 - 90.9, we can conclude that attempts on goal take further up the field are more likely to result in a goal.

Looking now at the results for the y-coordinate, a p-value of 0.005 is obtained, still indicating a statistically significant difference of this variable between goals and shots. The shot mean y-coordinate is 49.2 and sits just outside the confidence interval of 49.3 - 49.8 for the goals y-coordinate. This is an interesting result as we expected for there not to be a difference in the y-coordinate. This is because shots are taken from both sides of the field in about equal measure, yet it seems that perhaps the shot distribution favors the right side more than the left, but more goals are scored from a more central location. It could be that while this result is statistically significant, in reality though it probably isn't. For example, an average professional soccer pitch is about 70 meters wide. So, a difference of 0.1% in the y-coordinate is a difference of 0.07 meters, which is not really a significant difference.

**Chapter 4: Smart Questions**

4.1 SMART Question 1: Which match variables result in the highest probability of a shot on goal being successful? Given the variables Key Pass, Shot, Assist, and Goal within the data from the 2016 European Championship, the 2017/2018 Europe’s top five leagues, and the 2018 World Cup, which configuration of the variables result in a higher probability of a goal being scored?

4.2 SMART Question 2: How do these variables and configuration vary with different teams? And with different leagues?

**Chapter 5: Modelling Shot Success**

To model successful goals, we had to assign a Boolean to each event, determining if the event resulted in a successful conversion to a goal or not: we assigned a value of 1 (one) to those events which were successful, and a value of 0 (zero) otherwise.

We also made an estimation of the distance that the ball travelled with each event by using the typical field FIFA dimension of 120 by 75 yards. Applying this to our X,Y coordinates, we then used the Pythagoras theorem. In essence:

Finally, we proposed three models to determine a probability of success for each variable of interest.

Model 1

The probability of success is a function of the starting coordinates of X, Y.

Model 2

The probability of success is a function of the starting and ending coordinates of X, Y.

Model 3

The probability of success is a function of the starting and ending coordinates of X, Y, and the distance traveled by the ball for each event.

The following table shows the summary of each model. As the Adjusted R2 and BIC coefficients show, Model 3 is the best fitted model.



**Chapter 6: Conclusions**